Improving Biosecurity in the United Kingdom Overseas Territories

Identification service for invasive invertebrate plant pests

2022-2023

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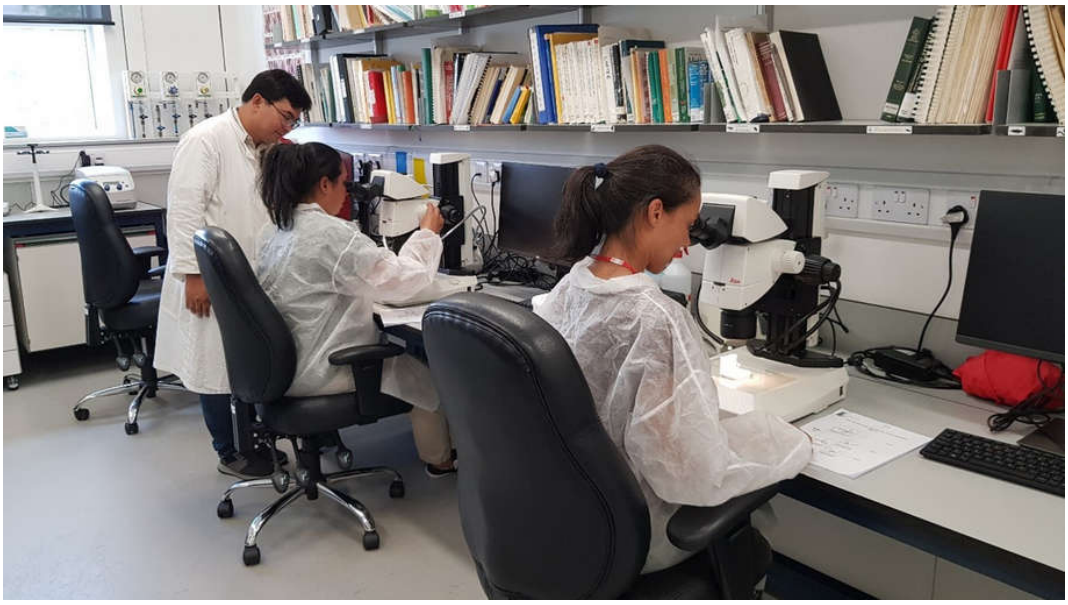

Figure 1. [redacted] training visitors from St Helena at the Fera laboratory to identify invasive ants © Fera

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POTENTIAL THREATS TO BIODIVERSITY AND AGRICULTURE IN THE UKOTS IDENTIFIED DURING 2022-23

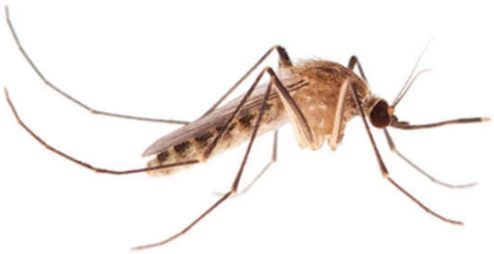

Figure 2 *Culex pipiens* complex (Culicidae) new for Tristan da Cunha © [redacted] University of Florida

Figure 3 *Steatoda nobilis* (Theriidae) male collected on Tristan da Cunha © Fera

Figure 4 *Steatoda capensis* (Theriidae) juvenile collected on Tristan da Cunha © Fera

Figure 5 *Nephus reunioni* (Coccinellidae), a scale insect predator, new for Tristan da Cunha © Fera

Figure 6 *Oligonychus perseae* (Tetranychidae) from Gibraltar © Fera

Figure 7 *Bemisia tabaci* (Aleyrodidae) pupa, new for BIOT [redacted]

Figure 8 *Bemisia tabaci* adult, a major vector of plant pathogenic viruses © Fera

Figure 9 *Paraleyrodes pseudonaranjae* (Aleyrodidae) from Diego Garcia, BIOT © Fera

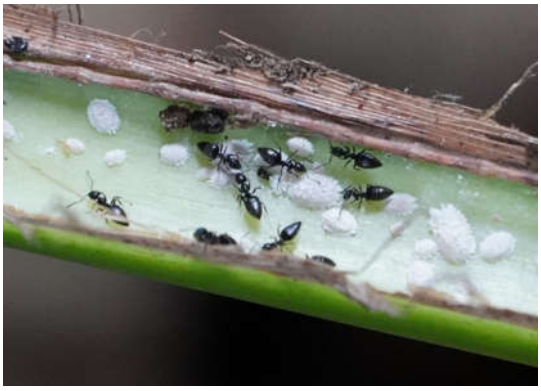

Figure 10 *Technomyrmex albipes* (Formicidae) ants attended a mealybug *Dsymicoccus finitimus* (Pseudococcidae) on coconut, BIOT [redacted]

Figure 11 Hemispherical scale *Saissetia coffeae* (Coccidae) on *Cordia subcordata*, new for BIOT [redacted]

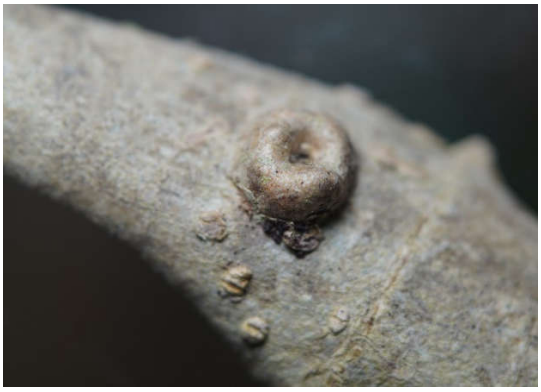

Figure 12 Gall formed on *Ficus benghalensis* by oleander pit scale *Russellaspis pustulans* (Asterolecaniidae), new for BIOT [redacted]

Figure 13 Rusty plum aphid *Hysteroneura setariae* (Aphididae) on *Paspalum vaginatum* [redacted]

Figure 14 *Trogoxylon* sp. (Bostrichidae) wood-boring beetle from the Cayman Islands © Caymans Department of Agriculture

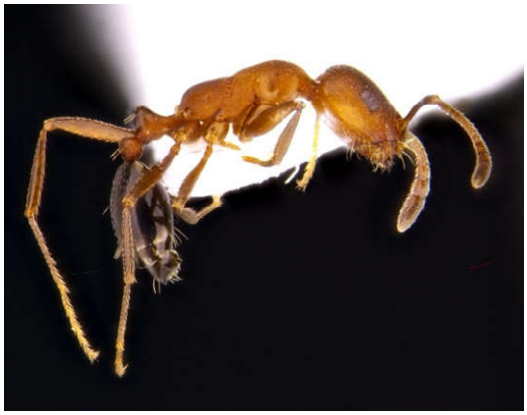

Figure 15 *Monomorium subopacum* (Smith) (Formicidae) from Ascension Island © Fera

Figure 16 *Pheidole megacephala* (Formicidae), an invasive ant established on Ascension Island and Saint Helena © Fera

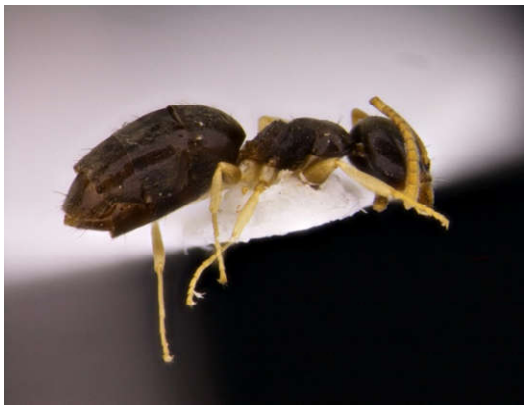

Figure 17 *Technomyrmex pallipes* (Smith) (Formicidae), new for Saint Helena © Fera

Figure 18 *Pimenta racemosa*, bay rum tree, observed with apparent disease symptoms on BVI. No virus has been detected © [redacted] Kew

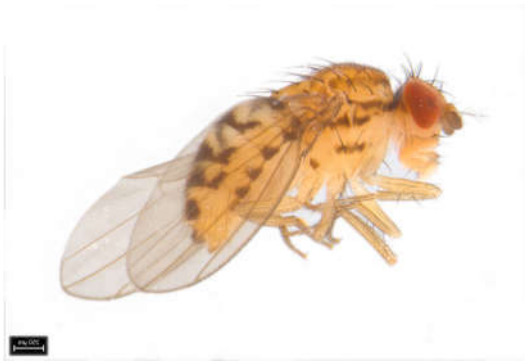

Figure 19 *Drosophila busckii* (Drosophilidae), new for Tristan da Cunha © Fera

Contents

Executive summary

Biodiversity in the UK Overseas Territories (UKOTs) is globally significant and is recognised as being under threat from invasive alien species. [redacted] Rapid and accurate identification of potential invasive alien species is the essential first step. The Plants Programme at Fera Science Ltd. provides statutory diagnostic and training services for the England and Wales Plant Health Service and has a wealth of experience and expertise in the identification of all plant-feeding insects, mites and nematodes, as well as plant pathogens. The Invertebrate Identification Team has led a Defra-funded project to provide an identification service for invasive invertebrate plant pests for the UKOTs since November 2009. During 2022/23, representatives from seven territories (Ascension Island, British Virgin Islands, British Indian Ocean Territory, Cayman Islands, Gibraltar, Saint Helena, and Tristan da Cunha) used the service for identifications and biosecurity advice. During the reporting period, a total of 1346 samples (including more than 15 photographs) were submitted to Fera for diagnosis.

The pest records accumulated through sample submissions and surveys feed into checklists and provide essential baseline data by which future faunistic changes can be monitored and accurately assessed. Early detection of invasive pests increases the chance of effective and efficient eradication, therefore lessening the impact on the environment, biodiversity and local economy. The data is also useful in terms of monitoring the spread of invasive species and identify potential future threats to the other UKOTs. Measures can be put in place to reduce the risk of pest entry, and to develop contingency plans to determine appropriate management actions should the pest be detected.

Key achievements of the 2022/2023 project include:

- 1346 samples were received during 2022/23 from eight territories (Ascension Island (610), British Virgin Islands (2), Cayman Islands (1), British Indian Ocean Territory (329), Gibraltar (5), Saint Helena (345) and Tristan da Cunha (54).
- At least 180 invertebrate taxa were identified.
- Approximately 55,000 individual specimens and photographs were examined, this figure is predominantly made up of ants.
- Eighteen species were recorded from Tristan da Cunha for the first time, the most significant finding was the mosquito in the *Culex pipiens* complex (Fig. 2), as it is a potential vector of human and bird pathogens. See attached report (Appendix 2)
- In January 2022 we dealt with an urgent report of a biosecurity breach in Tristan da Cunha when spiders thought to be non-native species were discovered. We were unable to accurately determine the species of the spiders from photographs, but specimens were received in April 2022. We were then able to confirm the identity of *Steatoda nobilis* (Fig. 3), the noble false widow spider, a first record from Tristan da Cuhna. Through morphological examination of external characters, genital dissection

and DNA sequencing analysis we were able to confirm the presence of a second new species, the black cobweb spider, *Steatoda capensis* (Fig. 4).

- The presence of the scale-feeding ladybird *Nephus reunioni* (Fig. 5) on Tristan da Cunha is also significant as it may help supress the populations of brown soft scale *Coccus hesperidum* that are damaging the *Phylica arborea* and threatening the existence of Wilkins's finch on Nightingale Island.
- *Oligonychus perseae* (Tetranychidae) (Fig. 6), the 'Persea mite', was recorded for the first time from Gibraltar. This tropical species has spread from Central America to other parts of the world including southern Europe. Where it is invasive it is considered a major economic pest, with a preference for avocado, but attacking plants in 20 genera and 17 families.
- Further samples of two species of undescribed whitefly have been identified on endemic plants in Saint Helena and are currently being studied.
- At least 22 species and 4 families of insect were recorded from Diego Garcia in the Chagos Archipelago (British Indian Ocean Territory) for the first time. This included 4 species of whitefly (Hemiptera: Aleyrodidae): *Bemisia tabaci* (Figs 7-8)**,** *Dialeurodes kirkaldyi*, *Minutaleyrodes minuta*, and *Paraleyrodes pseudonaranjae* (Fig. 9). All four species are polyphagous and potential host plants are widely available. Two of the species are of concern as they have the potential to become invasive. *Bemisia tabaci* is one of the most economically important agricultural and horticultural pests in the world, mainly due to the plant pathogenic viruses it can vector. Currently there is no commercial agricultural activity in the archipelago but if this were to change in the future, *B. tabaci* could have a significant impact and limit crop production. *Paraleyrodes pseudonaranjae* is a pest of avocado, citrus and coconut in parts of China, and could become invasive if it spreads to coconut, a keystone species, in Diego Garcia. Coconuts are essential for the coconut crabs (*Birgus latro*), the largest terrestrial crab in the world and an *IUCN Red List vulnerable species*. Examples of scale insects new for the Territory are *Dsymicoccus finitimus* (Fig. 10), *Saissetia coffeae* (Fig. 11), and *Russellaspis pustulans* (Fig. 12); and the aphid, *Hysteroneura setariae* (Fig. 13).
- We conducted two separate two-day training sessions with conservation and biosecurity staff from the St Helena National Trust in August and September 2022 (Fig. 1). Staff were trained in the identification of ants (see Figs 15-17), fruit feeding and leaf mining flies, invasive spiders, and collection curation. Developing the diagnostic capacity of the conservation staff in St Helena will help them identify potentially invasive species so that appropriate action can be taken to mitigate the impact and protect the unique environment and biodiversity of the territory.
- A possibly undescribed species of *Solenopsis* was collected in Saint Helena. Fera is conducting morphological and molecular analysis.

- Three scientific papers were prepared and are currently awaiting approval for submission.

Introduction and Aims

Biodiversity in the UKOTs is globally significant; the OTs support unique ecosystems and a large number of rare and threatened species, many of which are found nowhere else in the world. This rich biodiversity is under threat from the introduction of alien species, a major cause of the loss of biodiversity globally, and island ecosystems are particularly vulnerable (Cheesman *et al*., 2003; Varnham, 2006).

[redacted] Effective conservation of biodiversity in the UKOTs is essential if the UK is to meet Biodiversity Targets, as well as commitments under other relevant Multilateral Environmental Agreements (MEAs).

[redacted] accurate and rapid species identification for suspect alien species is fundamental to the enforcement of eradication and quarantine measures.

The Plants Programme at Fera provides diagnostic and training services for the Plant Health and Seeds Inspectorate within the Animal and Plant Health Agency (APHA) and has a wealth of experience and expertise in the identification of all plant-feeding insect orders, plant-feeding mites, plant-parasitic nematodes and plant pathogens.

Fera has over 50 scientists dedicated to providing fast and accurate identifications of plant pests and diagnosis of plant diseases to an international standard. This project was managed and largely delivered by the entomologists in the Invertebrate Identification Team.

The results of the project feed directly into the conservation work carried out by the Royal Botanic Garden's UK Overseas Territories programme and the project entitled 'Tackling Invasive Non-Native Species in the UK Overseas Territories' which forms part of the Conflict, Stability and Security Fund (CSSF).

This Defra-funded project was divided into three sections or work packages:

- Work Package 1 (WP1): *Identification Service for Invasive Invertebrate Plant Pests* made up the largest section and was conducted to provide an identification service for invasive invertebrate plant pests that may threaten biodiversity and agriculture in all of the UKOTs.
- Work Package 2 (WP2) *Identification of invasive ants (Hymenoptera: Formicidae) in the UKOTs* is a continuation of the initial 'proof of concept' study with a focus on the invasive ants of Ascension Island and Saint Helena (ODA) and identify potential future threats. In year two, expand the project to two territories within the Caribbean (Montserrat (ODA) and Cayman Islands). In year three, expand the study to two further territories (to be agreed).

- Work Package 3 (WP3): *Identification of Plant Pathogens on Endemic and Endangered plants in the UKOTs* was a pilot study to expand the identification service offered to UKOTs to include identification of pathogens on endangered and endemic plants.
- Work Package 4 (WP4): *Gut content analysis of invasive predatory invertebrates in Saint Helena*. Support Saint Helena National Trust's endemic invertebrate recovery project (Darwin Initiative) in determining whether two invasive species, the common wasp (*Vespula vulgaris)* and the springbok mantis (*Miomantis caffra*) are preying upon SH's endemic invertebrates, such as the spiky yellow woodlouse, *Pseudolaureola atlantica.*

The aims of the project were to strengthen biosecurity in the UK Overseas Territories by delivering the following objectives:

WP1: Identification Service for Invasive Invertebrate Plant Pests

- Provide an identification service for invasive invertebrate plant pests for all of the UKOTs; including invasive non-native invertebrate plant pests, which impact on biodiversity and commercial interests.
- Provide rapid advice, wherever possible, when bio-security threats are detected, in the form of guidance on appropriate measures.
- Provision of remote (e.g. online) basic training to colleagues in overseas territories so that local capacity is developed where resources permit this.

Work Package 2: Identification of invasive ants (Hymenoptera: Formicidae) in the UKOTs

- Provide a protocol for collection, preservation, and submission of ant samples to Fera.
- Provide training on ant collection, preservation methods and identification to UKOT biosecurity officers, increasing in territory capacity to identify non-native ants.
- Produce a written report detailing ant species identified and a field-guide to the ant species.
- Update checklists of invasive ants in the UKOTs to enable future potential threats to be identified.
- Pin, label and photograph ants identified. Set up reference collections of validated specimens for the UKOTs.

Work Package 3: Identification of Plant Pathogens on Endemic and Endangered plants in the UKOTs

- Provide identifications of pathogens on endangered and endemic plants in the UKOTs. Photographs of plants with suspected disease symptoms will be submitted to Fera, from which pathology diagnosticians will determine whether submission of a sample is necessary.

Work Package 4: Gut content analysis of invasive predatory invertebrates in Saint Helena

- Provide a written report detailing:

- Outcome of gut content metabarcoding analysis for each sample
- Details of identifications of prey contents to species (for those represented on DNA databases) and to genus or family (for those not represented) and give approximate figures for the total number of species (identified and unidentified)

WP1: Identification Service for Invasive Invertebrate Plant Pests

1.0 Methods

1.1 Service launch and publicity

The main contacts within the UKOTs that have used the service previously were notified that the pest identification service had secured Defra funding for 2022/2023. The identification service is promoted on the GB non-native species secretariat website and through the UKOT Conservation Forum.

1.1.2. Project delivery

All samples submitted by the UKOTs were scanned and triaged, and those representing plant-feeding groups that might pose the greatest economic or biodiversity threat were identified as a priority. Incidental invertebrates were not identified beyond family. In addition, the reports were shortened, and pictures were not always included.

2.0 Results

2.1 The number of samples received, and identifications made

A total of 563 samples, consisting of over 1500 specimens and photos were received from 5 territories between April 2022 and March 2023: Ascension Island (134), Cayman Islands (1), British Indian Ocean Territory (329) Gibraltar (5), Saint Helena (38) and Tristan da Cunha (56).

The results are included in the summary below and detailed in Appendix 1.

2.2 Summary of findings

Approximately 173 distinct taxa of invertebrates were identified at Fera during 2022-23, of which more than 127 were identified to at least generic level. A number of samples of Thysanoptera, Diptera and Hemiptera were still being processed from Saint Helena and Ascension Island at the time of compiling this report and have therefore not been reported here. Once analysis of these specimens has concluded the results for the samples will be compiled for and reported in the Year 2, March 2024.

The organisms identified so far belonged to the following classes and orders:

ARANEAE (7 spp.)

ACARINA: Trombidiformes (2 spp.)

BRANCHIOPODA: Anomopoda (1 sp.)

CHILOPODA: Lithobiomorph (1 sp.); Geophilomorpha (1 sp.)

DIPLOPODA: Julida (1 sp.); Polydesmida (1 sp.)

ENTOGNATHA: Collembola (1 sp.)

INSECTA: Blattodea (32 spp.); Coleoptera (9 spp.); Dermaptera (1 sp.); Diptera (15 spp.); Hemiptera (69 spp.); Hymenoptera (14 spp.); Lepidoptera (4 spp.); Mantodea (1 sp.); Neuroptera (1 sp.); Orthoptera (2 spp.); Psocoptera (3 spp.); Thysanoptera (4 spp.)

MALACOSTRACA: Isopoda (1 sp.)

MOLLUSCA: Stylommatophora (2 spp.)

In terms of the number of species identified, the dominant group were the Hemiptera. This is not surprising as they are one of the most commonly transported groups of insects in plant trade and one of the most successful invasive alien insect groups (Miller & Miller, 2003; Pellizzari & Dalla Montá, 1997; Smith *et al*., 2007; Thomas, 2006).

A full list of the taxa identified during the reporting period can be found in Appendix 1 'WP1: Summary of invertebrate identifications 2022-2023'. Some taxa are still being studied or are awaiting DNA sequencing results and have not been listed at species level. For certain invertebrate groups, world specialists were consulted when reliable keys or descriptions were not available. Further details regarding the individual samples, such as collector's name, location, date collected, has been recorded through Fera's Plant Health Information Warehouse Diagnosis Database and may be obtained by contacting the authors.

2.3 New geographical records and potential invasive threats

Published faunistic catalogues, regional checklists and taxonomic literature were examined to determine the validity of the new geographical records. For some groups, for example the scale insects and whiteflies (Hemiptera: Coccoidea and Aleyrodidae), there are accurate, up-to-date catalogues available online to check the distribution of species, whereas for some groups, the data is disparate and unreliable.

2.3.1. Ascension Island

One hundred and thirty-four samples were received from Ascension Island for identification, the majority of these were submitted by the Ascension Island Government Invertebrate Project Officer. Most of these samples are still being studied. A significant number require slide preparation, and some were collected on sticky traps therefore have arrived in poor condition, both factors increase the time needed to process and identify them.

2.3.2. Cayman Islands

A series of photographs of a beetle were submitted by the Cayman Islands Department of Agriculture for identification. From the photographs submitted, this beetle could be identified as a Lyctine powderpost beetle in the genus *Trogoxylon* (Fig. 14)

These beetles bore inside a wide variety of dead wood and are known to infest furniture and buildings as a woodworm pest. The species could not be confirmed from the photographs, therefore a physical sample was requested and we are awaiting this.

2.3.3. British Indian Ocean Territory – Diego Garcia

[redacted] joined a Darwin-Plus funded project entitled 'Building knowledge on invasive non-native species in Diego Garcia' led by the UK Centre for Ecology & Hydrology (UKCEH). He collected 314 samples and documented a further 167 invertebrates in Diego Garcia in June 2022. An additional 15 invertebrate samples collected in Diego Garcia were received from UKCEH. The samples are still being processed but so far 22 species of scale insect, 2 species of

aphid, 4 species of whitefly, 2 psyllids and 4 thrips have been identified. 22 species are recorded as new for the Chagos Archipelago. The number of non-native introduced species recorded is low due to the restricted access to protect the large military base on Diego Garcia. There are no industrial, tourist or commercial agricultural developments on the islands and consequently there are fewer pathways for the introduction of non-native invasive species in comparison to most tropical archipelagos that rely on tourism and agriculture for their economy.

2.3.4. Gibraltar

Five photographic samples were received from Gibraltar for identification. *Oligonychus perseae* (Tetranychidae) (Fig. 9), the 'Persea mite', was recorded for the first time from Gibraltar. This tropical species has spread from Central America to other parts of the world including southern Europe. Where it is invasive it is considered a major economic pest, with a preference for avocado, but attacking plants in 20 genera and 17 families.

The mealy plum aphid, *Hyalopterus pruni* was also reported from Gibraltar for the first time. This cosmopolitan pest may have many geographical races or subspecies. It alternates between its winter host - *Prunus* species (mainly plum but also especially apricot, and perhaps peach or almond) and its summer host - mainly reeds (*Phragmites*), but also giant cane (*Arundo donax*) and some other wetland grasses. Some remain on plum all the year round. Feeding damage from *H. pruni* weakens fruit trees, reducing vigour and sugar content of fruit and sometimes causing slight curling of the leaves. Honeydew excreted by aphid can crack fruit and encourage the growth of sooty mould. *Hyalopterus pruni* has been implicated in the spread of plum pox potyvirus, potato Y potyvirus and millet red leaf luteovirus.

2.3.5. Saint Helena

Thirty-eight samples were received in total from the St Helena, a number were received via [redacted] the Species Recovery Trust and a further batch were collected by the last author. These samples (mostly thrips) are still being processed. The samples include two species of whitefly that appeared to be new to science (see section 2.5).

2.3.6 Tristan da Cunha

Fifty-six samples were received in total from Tristan da Cunha, the majority were samples collected [redacted] during February and March 2022. Eighteen species were recorded from Tristan da Cuhna for the first time. There appears to be no previously published records for the following 18 species which are therefore considered here to be new geographic records:

Class	**Order**	**Family**	**Species**
Arachnida	Araneae	Araneidae	*Zygiella x-notata* (Clerck)
Arachnida	Araneae	Pholcidae	*Pholcus* sp.
Arachnida	Araneae	Theridiidae	*Steatoda nobilis* (Thoreel) (Fig. 3)
Arachnida	Araneae	Theridiidae	*Steatoda capensis* Hann (Fig. 4)
Arachnida	Trombidiformes	Tetranychidae	*Tetranychus urticae* Koch
Entognatha	Collembola	Tomoceridae	*Tomocerus minor* (Lubbock)
Insecta	Coleoptera	Coccinellidae	*Nephus reunioni* (Fürsch) (Fig. 5)
Insecta	Dermaptera	Forficulidae	*Forficula auricularia* L.

Insecta	Diptera	Culicidae	*Culex pipiens* L. complex (Fig. 2)
Insecta	Diptera	Coelopidae	*Coelopa ursina* (Wiedemann)
Insecta	Diptera	Drosphilidae	*Drosophila busckii* Coquillett (Fig. 19)
Insecta	Hemiptera	Aphididae	*Acyrthosiphon malvae* (Mosley)
Insecta	Hemiptera	Aphididae	*Aphis gossypii* Glover
Insecta	Hemiptera	Coccidae	*Saissetia coffeae* Walker (Fig. 11)
Insecta	Lepidoptera	Tineidae	*Opogona omoscopa* (Meyrick)
Insecta	Neuroptera	Chrysopidae	Undetermined
Insecta	Thysanoptera	Thripidae	*Parthenothrips dracaenae* (Heeger)
Insecta	Thysanoptera	Thripidae	*Heliothrips haemorrhoidalis* (Bouche)

The most significant finding was the mosquito in the *Culex pipiens* complex (Fig. 2). Female *Culex pipiens* obtain blood meals primarily from birds or mammals and plays a critical role in the transmission of pathogens to wildlife, livestock, and humans. Pathogens transmitted by this species include viruses (e.g., Western Nile Virus, Rift Valley fever virus, St. Louis encephalitis, Sindbis *virus*), filarial worms (e.g., canine heartworm, human filarial nematodes), and protozoa (e.g., protozoans that cause avian malaria). *Culex pipiens* is native to Africa but has been introduced to many regions throughout the world.

The presence of the scale-feeding ladybird *Nephus reunioni* (Fig. 5) on Tristan da Cunha is also significant as it may help supress the populations of brown soft scale *Coccus hesperidum* that are damaging the *Phylica arborea* and threatening the existence of Wilkins's finch on Nightingale Island.

See accompanying report for further information on the species identified (Appendix 2)

2.4 Biosecurity advice provided

A summary of the distribution, host range, biology and economic importance is provided to the UKOTs when new pests are recorded. This information will assist the UKOTs to make a rapid assessment of the potential risk posed by the organism. If available, photographs of the pest and symptoms are also provided to aid detection and identification.

We dealt with an urgent reports of a biosecurity breaches in Tristan da Cunha when spiders thought to be of non-native species were discovered by the biosecurity officer. Photos of the suspected invasive species were submitted to Fera for identification, and we were immediately able to identify them as two non-natives species of false widow spider *Steatoda* (Theridiidae). It was not possible to determine species from the photographs alone, but they are highly suspected to be the 'noble false widow spider' (*Steatoda nobilis* Thorell) and the 'black cobweb spider' (*Steatoda capensis* Hann). These two species have been spread by human activities around the world, and *S. nobilis* is regarded to be one of the world's most invasive species of spider. Fera provided the territory with a previously prepared factsheet on invasive *Steatoda* spp. to assist the biosecurity officers with future monitoring efforts, as well as sections of a newly drafted *Steatoda* contingency plan. We provided a detailed sample report discussing the potential human health and biodiversity impacts following the successful establishment of invasive *Steatoda* species.

2.5 New species to science

Whitefly (Aleyrodidae)

Whitefly were found in Saint Helena on two endemic plants, dogwood (*Nesohedyotis arborea*) and whitewood (*Petrobium arboretum*). These appear to represent two undescribed species which are currently being studied. One of them appears to belong to the genus *Aleuroplatus*. There are 78 species currently assigned to this genus and the majority are found in Africa. There is no comprehensive diagnostic key to this genus and many of the descriptions are in relatively inaccessible journals, so it will take time to study these species.

2.6 Scientific publications

Three scientific papers are in the process of being prepared for submission:

[redacted] 2023. *Nephus reunioni* (Coleoptera: Coccinellidae) new for Tristan da Cunha

[redacted] 2023. Four species of whitefly (Hemiptera: Aleyrodidae) new for the Chagos Archipelago (British Indian Overseas Territory)

[redacted] 2023. Aphids (Hemiptera: Aphididae) of the Chagos Archipelago (British Indian Overseas Territory)

2.7 Building diagnostic capacity in the UKOTs

As well samples and photos of invertebrates to diagnose we routinely receive other enquiries from our biosecurity contacts seeking diagnostic keys and descriptions of pests to assist them in making species determinations. We have provided advice to a few of the UKOTs on camera and microscope equipment to enable them to better study and image pests.

2.7.1. Training

We conducted two separate two-day training sessions with conservation and biosecurity staff from the St Helena National Trust in August and September 2022 (Fig. 1). Staff were trained in the identification of ants, fruit feeding and leaf mining flies, invasive spiders, and collection curation. Developing the diagnostic capacity of the conservation staff in St Helena will help them identify potentially invasive species so that appropriate action can be taken to mitigate the impact and protect the unique environment and biodiversity of the territory.

3.0 Conclusions

[redacted] Accurate and rapid species identification for suspect alien species is fundamental to the enforcement of eradication and quarantine measures to protect biodiversity and agriculture.

We have received a great number of enquiries and photographs of suspected biosecurity threats, which demonstrates that there continues to be a clear demand for an identification service for invasive invertebrate plant pests to improve biosecurity and support the preservation and conservation of biodiversity in the UKOTs. It has, however, always been

required that if this service was to continue to be funded it should not only provide inventories of pests present in each territory, but demonstrate that the service has practical benefits. These benefits demonstrated during the 2022/23 reporting period include:

1. The service helped identify and evaluate immediate threats so that appropriate action could be taken.
2. The service helped identify potential threats and prioritise conservation efforts in some of the UKOTs.
3. At least eighteen species are recorded from Tristan da Cunha for the first time, 22 species are recorded new for Chagos Archipelago (British Indian Ocean Territory), and two new species for Gibraltar. These include some highly invasive pests that may continue to spread in the UKOTs.
4. In each case where a new pest is recorded, a summary of the distribution, host range, biology and economic importance is provided to assist with the UKOT making a rapid risk assessment and deciding upon appropriate action.
5. The presence of natural enemies in the samples have been recorded which over the longer term may be investigated and used to help suppress the numbers of invasive pests.
6. The service has provided data for the compilation of checklists of species for each Territory. Such checklists provide essential baseline data by which future faunistic changes, due to factors such as international trade, tourism and climate change, can be monitored and accurately assessed. The early detection of exotic introductions improves the chances of eradication and can thus protect the environment, biodiversity and local economy.

Since the identification service was launched in February 2010, eleven UKOTs have made use of the service and submitted more than 1800 samples. More than 100 of the invertebrate species examined to date have never before been reported from the UKOTs. A total of twenty species apparently new to science have been observed and are being studied further. One new species from the Cayman Islands has been described: *Scirtothrips cocolobae* Collins & Evans (Collins & Evans, 2013) and one new species from Montserrat: *Schoenlandella montserratensis* Kang, (Hymenoptera, Braconidae) Kang I, Sharkey MJ, Diaz R (2021).

In conclusion there is a continued high demand for the identification service and the project continues to fulfil its aims.

WP2: Identification of invasive ants (Hymenoptera: Formicidae) in the UKOTs

The introduction of non-native ants can be ecologically disastrous and economically damaging throughout the world, and island ecosystems are particularly vulnerable. Invasive ants in natural ecosystems can lead to the displacement and/or loss of native ant species. In addition, non-native ants affect other organisms including the human population and alter ecosystem processes both directly and in-directly. The absence of their natural predators results in an uncontrolled abundance in their introduced range and they may outnumber native species. Moreover, invasive ants compete with and prey upon different organisms, including some vertebrates, and consequently disrupt mutualistic interactions with numerous plants and other organisms. The introduction of invasive ants will result in a change to the biogeographical pattern as well as a loss in biodiversity, especially in oceanic islands with few or no native ant species, such as many of the UKOTs. Mutualistic relationships between invasive ants and invasive honey-dew egesting hemipterans (aphids, psyllids, scale insects and whiteflies), can increase the population density and negative impact of both species.

1.0 Methods

1.1 Protocol for collection, preservation, and submission of ant samples

A protocol for the collection, preservation, and submission of ant samples was drafted and submitted to the contacts in the UKOTs (Saint Helena National Trust Invertebrate Team and Ascension Island Government Invertebrate Project Officer). Different sampling methods were presented to sample ants across different habitats when applicable. The sampling methods within the protocol aim to provide information on the different native and non-native ant species as well as potentially monitoring the presence or potential entry of any invasive species that may impact the environment of the territories in question. The sampling methods are also useful in monitoring the effectiveness of treatments or control measures on the population density of target invasive ant species. Furthermore, the sampling protocols can also be used to address research objectives relating to the understanding of ant species diversity, functional diversity, population genetics, island of biogeography and conservation studies. Please see Annex 5 for the details of the sampling protocol.

Samples collected in the UKOTs were catalogued, preserved in 70% ethanol and sent to Fera for analysis. Some individual specimens were mounted on card points for study, photography and dry preservation, while other specimens were preserved in 95% for molecular analysis.

1.2 Training

1.2.1 Ascension Island

Prior to the posting of [redacted] as Invertebrate Project Officer at Ascension Island Government Conservation and Fisheries Directorate, he visited Fera in October 2021 and received training from [redacted] in the collection, preservation and identification of ants. During [redacted]'s fieldwork in Ascension Island, he received further online training, consultation and advice via emails and virtual meetings regarding ant identification, observation on ant

behaviour and ecology and environmental data gathering. In November 2022, [redacted] visited Fera and met with [redacted] to discuss data analysis and the writing of a joint manuscript for publication.

1.2.2. St. Helena Island

In August and September 2022 four members of staff from the St Helena National Trust Conservation Department visited Fera and received training in ant survey techniques, deployment of Winkler traps, discussion of ant survey protocol, ant identification and curation (link). On 4th-5th August 2022, [redacted] visited followed by a visit by [redacted] on 26th- 27th September 2022.

In conjunction with the current Darwin Project DPLUS104 and the Cloud Forest Project in St. Helena, staff of the St. Helena National Trust invited [redacted] to conduct training on the ant collection, identification, and management of invasive ant species. Consequently, on 7th-22nd January 2023, [redacted] went to St. Helena Island and surveyed ants in various habitats particularly in the cloud forest. He also conducted ant identification training for the biosecurity officers and staff of St. Helena National Trust and designed a monitoring strategy on the further control of invasive ant species (i.e *Pheidole megacephala*). See Appendix 4 for a study visit report

2.0 Results

2.1 The number of samples received, and identifications made

A total of 783 samples and seven photos were received from Ascension Island and Saint Helena. Twenty-five species of ants belonging to 12 genera and four subfamilies of ant were identified (see Appendix 3). Most of the species collected are considered non-native of which two are listed as known invasive species. The majority of ant species were from the subfamily Myrmicinae, the most diverse group among the Formicidae.

The samples were identified under a dissection microscope to generic level and then pinned to identify to species. They were determined by using published keys and descriptions, and by comparison of images through online resources such as www.antweb.org and www.antwiki.org. To determine the geographical distribution of each species, we compared the list to previous published literature (e.g. Wetterer, 2007) and online resources. Four specimens were sent for molecular sequencing to ascertain the species identification due to lack of keys and to somehow establish a link of their possible origin.

Samples were preserved in 70% ethanol, some individuals were mounted on card points for study and deposited in collections held by Fera Ascension Island and St Helena National Trust.

The results are included in the summary below and detailed in Appendix 3

2.2 Summary of findings

2.2.1 Ascension Island

A total of 476 ant samples and seven photographs were received from Ascension Island. The samples were collected from a wide range of habitats, such as in lowland areas, mountain

sites, rocky, coastal, barren terrain, orchards, and houses/buildings. A combination of sampling techniques was used when applicable such as baited pitfall traps, litter extraction, vegetation beating and hand collection. Further details on the sampling sites and collection methods are shown in Appendix 5.

Seventeen species of ant were identified, of which eight species were new records for the island. Many of the species collected were from the lowland site where most of human settlements are found including the invasive species - *Pheidole megacephala* (F.) and tramp species like *Monomorium subopacum* (Smith)*, Paratrechina longicornis* (Latreille)*, Plagiolepis alluaudi* (Emery) and *Tapinoma melanocephalum* (F.). The most numerous species was *P. megacephala*, with 30,797 individuals. The least were *Nylanderia bourbonica* (Forel), *Monomorium cf. butteli* (Forel) and *Solenopsis cf. molesta* (Say), for which we collected a single individual of each only.

Ant data were analysed using variety of statistical analysis addressing questions on island-scale invasion which would serve as general rules of thumb applicable to other islands. The data provides information on why invasive ant species spread at a general linear rate, and if they do radiate from human settlement. Quantifying on how multiple ant invasive species had coexisted on the model island over the moderate- to long-term (> 50 years) was also addressed. The data also quantified the extent to which island-scale habitat separation between species, separation in fine-scale foraging behaviour, and climatic heterogeneity were facilitating high diversity in the invasive ant assemblage. From our results, we have identified the most significant drivers of invasive ant coexistence and inferred conservation implications for oceanic islands globally.

Further results showed that non-native ant species achieve optimal niche separation through both resource partitioning and climatic variation. *Cardiocondyla emeryi* (Forel) found distinct niche space by targeting our lean protein baits at low abundance, thus avoiding competition with the abundant and aggressive *P. megacephala*, and doing so during periods of low sun exposure and air temperatures. *M. subopacum* also avoided high temperatures but was more generalist in foraging behavior than *C. emeryi*. *P. alluaudi* foraged in lowest abundance and made more equal usage of ground- and tree-level strata than other species, while uniquely being most active on clear days. *P. longicornis* avoided competition with *M. subopacum*, *P. alluaudi* and *P. megacephala* through the species' strong attraction to sweet baits at ground-level. *P. megacephala* exhibited the greatest overlap on foraging niche space of other species and appeared to compete by foraging at great abundance in humid conditions. In contrast to this behavior, *S. globularia* exploited arid weather, choosing to forage predominantly at ground-level and target lean protein sources.

Other non-native species have been accidentally introduced due to international trade and have naturalised but so far, no records of negative impacts have been reported on the island. Among the species collected, the African big-headed ant *Pheidole megacephala* seems to be the most abundant and widely distributed in Ascension Island. Further investigation on their impact and control should be taken into consideration as previous studies have shown that the species contributes to biodiversity loss. In addition, *P. megacephala* has a close association

with some Hemipteran pests due to their consumption of honeydew as one of their major food sources. As a result, the invasive ant can encourage the population of Hemipteran pests to increase, and this may result in further infestations. For example, [redacted] reported five species of invasive mealybug (Pseudococcidae) new for Ascension Island. Mealybugs egest honeydew and are frequently attended by ants, and two of the infested plants, *Euphorbia origanoides* and *Sporobolus caespitosus*, are endemic to Ascension Island and classed as 'Critically Endangered' on the International Union for the Conservation of Nature (IUCN) Red List.

2.2.2 Saint Helena

A total of 307 samples were analysed from Saint Helena. 181 samples were received from Saint Helena National Trust [redacted]. A further 126 samples were collected [redacted] during his training visit to the island. The samples were collected from range of habitats such as in semi desert, open-semi desert and forest using baited pitfall traps, hand collection and Winkler extraction. More samples are expected to be sent to Fera in the next coming months due to the ongoing monitoring of non-native invertebrate survey being undertaken by the St. Helena National Trust. Data will be analysed and presented in due course thus which will lead to writing up of manuscript for a potential publication in a peer-reviewed journal.

To date, a total of 19 species were collected since the start of the project in 2021 and four species were new ant records since 2007. The new ant records are *Cardiocondyla mauritanica* Forel, *Lepisiota incisa* (Forel), *Solenopsis* sp. 1 (near *castor* Forel), *Solenopsis* sp. 2 (near *molesta* (Say)) and *Technomyrmex pallipes* (Smith). These species were probably introduced through imported goods and accidentally brought in by people travelling to the island from perhaps their personal belongings.

Similar with the ants in Ascension Island, *P. megacephala* remains to be the most abundant and well-established in most habitats except in the peaks of the Cloud Forest. This may be due to the moist forest floor and higher ground cover in the Cloud Forest which may not be a suitable habitat for *P. megacephala* in contrast with the surrounding habitats with dry and very disturbed features. However, based on the latest diversity data, only four species were collected in the cloud forest within the 3km transect (10 sampling sites). From 700m to 800m asl, only two species were collected i.e *Solenopsis* sp. 1 and *Hypoponera eduardi* (Forel) which are mainly soil/leaf litter nesters and not known as invasive species. Following the result of the molecular sequencing of *Solenopsis* sp. 1, the species did not match to any of the existing sequences from any of genomic database's references. This has raised the suspicion that *Solenopsis* sp. 1 may be a described species but not sequenced yet or indeed could be a new species. Morphological studies and consultation with the genus experts are being carried out to validate the identification.

The other two species collected in the cloud forest were near the base and around the nursery area. These species were *Paratrechina longicornis* and *Plagiolepis alluaudi* both known to be tramp species and are associated with human settlement. So far, their presence in the cloud

forest has not yet indicated any threats to other invertebrates but requires a close monitoring. The ant diversity in the cloud forest should stay as low as possible as most of the ants present on the island are all introduced species and may cause ecological problem by excessive predation and may aid the increase of the population of honey-dew producing pest in exchange of excreting sugars as one of their food sources.

Ant survey in the cloud forest should be carried out every year to ensure that more aggressive non-native species are not establishing any colony or to identify any endemic ant species that can survive in that type of habitat.

Aside from *P. megacephala*, ants collected from other habitats (e.g. Depo, High Peak, Peak Dale, Millenium Forest, Pipe Ridge, Halley's Forest) including within the human settlement (e.g. Jamestown and Scotland Nursery) showed relatively dominance of known tramp ants *Cardiocondyla emeryi*, *Paratrechina longicornis*, *Solenopsis globularia*, *Nylanderia bourbonica* and *Tapinoma melanocephalum* but no report of any serious ecological and economic threats.

2.3. Field-guide to the ant species in Ascension and Saint Helena

A field guide is being drafted to assist in the identification of ants in the UKOTs with brief diagnostics feature, behaviour and ecology. The guide is being developed to incorporated ant species from all UKOTS studied as parted of this project. A completed field-guide will be submitted at the end of the project term (March 2025).

2.4. Setting up of reference collections of validated specimens for Ascension and Saint Helena

Several species collected have been curated and photographed. A reference collection of validated specimens will be given back to appropriate UKOTs. This is on-going process and will be completed at the of the project.

3.0 Conclusions

The ant species collected in Ascension Island and St. Helena are primarily introductions to the islands because of human activities, particularly international trade. Some of the ants are considered invasive and studies on their negative impact, particularly on biodiversity, should be taken into consideration. The presence and survival of non-native ants is influenced by human activities of which some species possess a high risk of negative impact on the island's ecosystem. As shown by the ant data in Ascension Island [redacted], the establishment of non-native ants on the island is also affected by species coexistence, spatial and climatic heterogeneity, foraging behaviour and habitat quality. Ant data in St. Helena will provide similar result especially using the same sampling methodology and efforts.

The data gathered in Ascension and St. Helena had validate the importance of using different collection method in various habitats that represent the different strata of the island's ecosystem i.e. from ground-dwelling ant groups, understory groups and canopy groups.

From this year's output, we have identified the most significant drivers of invasive ant coexistence and inferred conservation implications for oceanic islands globally. Because of this, it is likely that non-native ants can potentially persist at diversities far greater than we

currently observe on oceanic islands, and, may never become self-limiting as a result of saturated niche space. For this reason, we stress that prevention of future invasions is critical to avoid negative impacts on native biodiversity, even on islands where many non-native ant species are already established.

4.0 Recommendations and Future outcomes

The data generated from this short study will serve as baseline data for research on ant diversity in the South Atlantic Islands. Further data analysis will reveal the factors affecting species diversity such as habitat quality, climate, and human activities. We have produced an updated checklist of the ants species of Ascension Island and Saint Helena and have identified nine new ant records in both islands. Using sample efforts from Ascension Island, we are hoping to determine if the process of ant invasion is similar or different on St. Helena, as well as what factors influence the results.

An annual ant survey in both islands should be carried out particularly in areas where there is a high diversity of endemic invertebrates. The purpose of this study is to determine whether any non-native ants will pose threats to endemic species as well as to increase conservation efforts against their negative impacts. There is also a need to strengthen the taxonomic capacity of biosecurity staff in detecting all possible invasive species to the island by providing continuous training and upgrading equipment in identification such as microscope with higher magnification. In addition, a key to the ant species of the South Atlantic was drafted, (Appendix 6), and will continue to be developed as the ant diversity of the islands are studied.

Furthermore, there is a need to consider potential for targeting multiple non-ant species with local eradication by identifying key sites in which they coexist. This could be through chemical control, which is currently being tested on St Helena Island. Conversely, ecological control may be more long-lasting and low risk especially in a more complex native ecosystem. To prevent further contamination of important conservation areas, such as water catchments, natural ingredients should also be considered for suppressing invasive species. Ecological control and use of natural ingredients would naturally accommodate high diversities of specialist species which have previously evolved to occupy at least most of the available niche space. Supporting those specialists, either through restoring disturbed habitats or otherwise species-centric conservation methods, should theoretically instigate competitive challenges against non-native ants that would in turn reduce their occurrence.

Is it therefore recommended that immediate action is necessary to safeguard island biodiversity from the threats posed by non-native ants. There is a potential for significant and continuing invasion threats to islands, particularly with climate change contributing to invasive species' distribution and movement. In consideration of this, we recommend that future research on ant invasion ecology extends to the other islands.

WP3: Identification of Plant Pathogens on Endemic and Endangered plants in the UKOTs

1.0 Methods

1.1 Service launch and publicity

In June 2022 the main contacts within the UKOTs were notified that the Fera Plant Pathology teams were conducting a pilot study offering identification of diseases on endemic and endangered plants.

1.1.2. Project delivery

All samples submitted by the UKOTs were initially submitted as photographs of disease symptoms. The territories that wished to submit samples were first issued with Fera's Pathogen Licence Letter of Authority (issued by Defra), this enabled them to submit plant samples exhibiting disease symptoms to Fera under licence. The samples were scanned and triaged and sent to the most appropriate pathology team for analysis.

2.0 Results

2.1 The number of samples received, and identifications made

A total of 2 samples and 6 photos were received from British Virgin Islands

2.2 Summary of findings

2.2.1 British Virgin Islands

In June 2022, a series of photographs of apparently diseased leaves of *Pimenta racemosa* (Fig. 18), *Ilex urbaniana* and *Philodendron* on Sage Mountain on the Island of Tortola were submitted by [redacted] (Kew). The photos were analysed by Fera plant pathologists and samples were requested by the virology team. Two leaf samples were received and analysed by high throughput sequencing. No viruses were detected and it was determined that the observed symptoms were most likely a result of environmental damage.

2.3 Further samples

We have received queries from contacts in the Falkland Islands and Saint Helena with regards to providing diagnosis of observed fungal pathogens on endemic plants. We have yet to receive these samples, but will report results in due course.

3.0 Conclusions

Invasive non-native plant diseases are a significant threat to the biodiversity within the UK Overseas Territories. Early detection and identification of invasive alien species can enable effective and appropriate measures to be taken in a timely manner to eradicate, contain and/or manage the disease.

We have over the past 5 years received an increasing number of enquiries from the UKOT governments, National Trusts, and the UKOT Conservation Science Team at RBG Kew for

assistance with the diagnosis of suspected alien plant diseases on threatened endemic plant species.

Due to the remoteness and accessibility of some of the islands and the practicalities of transporting plant material, submission of samples for disease testing from the territories has it's difficulties. Despite this, we have received a number of enquiries and photographs of suspected biosecurity threats, which demonstrates that there continues to be a clear demand for an identification service for invasive plant pathogens to improve biosecurity and support the preservation and conservation of biodiversity in the UKOTs.

In conclusion there is a continued demand for the identification of invasive and the project continues to fulfil its aims.

WP4: Gut content analysis of invasive predatory invertebrates in Saint Helena

In September 2022 we met with two members of the St Helena National Trust invertebrate recovery team to develop a protocol for optimal sample preservation of the target organisms. We held training sessions in the dissection of praying mantis and wasp guts and provided a methodology. St Helena's team was unable to catch enough adult mantids during the season to deliver the samples to Fera in December 2022. We anticipate receiving samples at the end of April 2023, so we will begin processing them in May. It is expected that a full report will be submitted by March 2024.

Acknowledgements

The authors wish to thank Defra for funding of the project, [redacted] the Non-Native Species Secretariat for supporting the project, and everyone within the UKOTs who submitted samples. We would particularly like to thank [redacted] (Ascension) and [redacted] (St Helena) for collecting ants for study. [redacted] for carrying Winkler traps and transporting samples. Thanks are also due to those people who gave advice and support in compiling a list of contacts in the Overseas UKOTs, in particular [redacted] (RBG Kew). We would also like to thank our colleagues [redacted] for all their hard work with processing and identifying the samples and providing technical advice.

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Appendices

1. WP1: Summary of invertebrate identifications made during 2022-2023
2. WP1: Annotated list of invertebrates collected by Jill Key in Tristan da Cunha 2022
3. WP2: Summary of ant identifications made during 2022-2023
4. WP2: Ant survey, training, and management in St. Helena
5. WP2: Protocol for collection, preservation, and submission of ant samples
6. WP2: Draft Keys to Ants of South Atlantic Ocean