Improving Bio-security in the United Kingdom Overseas Territories

Identification service for invasive invertebrate plant pests

2018-19

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Figure 1 Invertebrate plant pests observed in the Cayman Islands © C. Malumphy

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POTENTIAL THREATS TO BIODIVERSITY AND AGRICULTURE IN THE UKOTS IDENTIFIED DURING 2018-19

Figure 2 *Phylica arborea* trees in Tristan da Cunha are being smothered with sooty mould growing on honeydew egested by a scale insect. This threatens the endemic *Nesospiza* finches which rely on *Phylica* fruits © Andy Schofield

Figure 3 *Coccus hesperidum,* brown soft scale adult female, suspected to be damaging the *Phylica arborea* trees in Tristan da Cunha © C. Malumphy

Figure 4 *Technomyrmex albipes,* white-footed ant, a highly invasive species recorded from BIOT for the first time ©AntWeb.org

Figure 5 *Paratrechina longicornis,* long-horned crazy ant, a second highly invasive ant species new for BIOT ©AntWeb.org

Figure 6 *Gymnaspis aechmeae* causing chlorosis to the critically endangered old George *Wittmackia* (= *Hohenbergia*) *caymanensis*, new for the Cayman Islands © C. Malumphy

Figure 7 *Philephedra tuberculosa* on *Hibiscus rosa-sinensis*, first record for the Cayman Islands, a polyphagous pest © C. Malumphy

Figure 8 Adult lace bug *Phymacysta tumida*, new for the Cayman Islands, a pest of West Indian cherry *Malpighia emarginata* © C. Malumphy

Figure 9 *Planchonia stentae*, South African pit scale, first record for the Cayman Islands, a polyphagous pest © Fera

Figure 10 *Bemisia tabaci,* tobacco whitefly, new for Gibraltar. This is a major agricultural and horticultural pest, and vector of 100+ plant pathogenic viruses © Fera

Figure 11 *Singhiella simplex*, Fig whitefly, new for Gibraltar. This Asian whitefly is an important pest of *Ficus* © C. Malumphy

Figure 12 *Aulacaspis yasumatsui*, Cycad Aulacaspis scale, new for Gibraltar. This Asian scale is causing chlorosis and dieback to cycads in Gibraltar. The base of the fronds is white due to the scales © C. Malumphy

Figure 13 *Macrohomotoma gladiata*, a plant jumping-louse or psyllid, new for Gibraltar. This Asian pysllid is a pest of *Ficus* © C. Malumphy

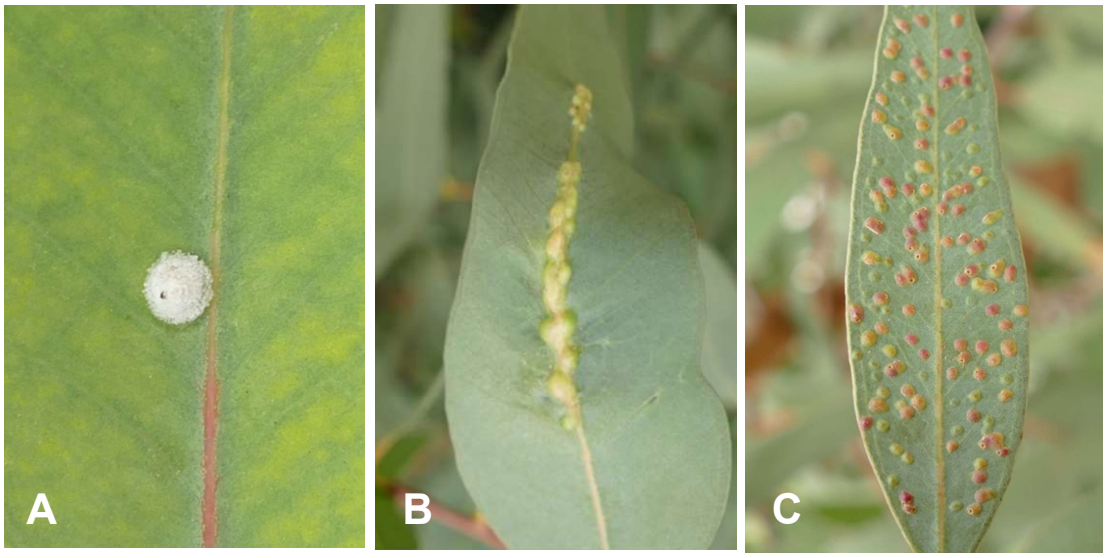

Figure 14 Ecalypt-feeding insects new for Gibraltar: A, red gum psyllid *Glycaspis brimblecombei* protective was cover for the nymph (lerp); B, blue gum chalcid*, Leptocybe invasa* galls along the mid-vein on a leaf; C, Eucalyptus leaf gall wasp, *Ophelimus maskelli*, button-galls on the leaf lamina; all found on the same tree

Figure 15 *Josephiella microcarpae,* a gall-forming wasp, new for Gibraltar. This Asian wasp is a pest of *Ficus* © C. Malumphy

Figure 16 An undescribed *Aleuroplatus* sp. puparia on *Petrobium arboretum* from Saint Helena © C. Malumphy

Figure 17 Colony of *Vryburgia amaryllidis*, Jamestown, first record for Saint Helena © C. Malumphy

Figure 18 Amaryllidaceae plants dying due to huge infestation of *Vryburgia amaryllidis*, Jamestown © C. Malumphy

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1.0 Executive summary

Biodiversity in the UK Overseas Territories (UKOTs) is globally significant and is recognised as being under threat from invasive alien species. Preventing the establishment of invasive alien species in the UKOTs is a strategic priority for the UK Government. Rapid and accurate identification of potential invasive alien species is the essential first step. The Plant Protection Programme (PPP) 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 within the PPP has led a Defra-funded project to provide an identification service for invasive invertebrate plant pests for the UKOTs since November 2009. During 2018/19, eight territories (Bermuda, British Indian Ocean Territory, Cayman Islands, Falkland Islands, Gibraltar, Saint Helena, South Georgia and Tristan da Cunha) used the service for biosecurity advice or identifications. Five territories (British Indian Ocean Territory, Cayman Islands, Falkland Islands, Saint Helena and South Georgia) submitted samples and photos for identification. The first author also collected samples during Horizon Scanning Workshops for the UKOTs held in the Cayman Islands, Gibraltar and Saint Helena. A total of 167 samples (including some 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 2018/2019 project include:

- 167 samples were received during 2018/19 from six territories (British Indian Ocean Territory, Cayman Islands, Falkland Islands, Gibraltar, Saint Helena and South Georgia).
- At least 160 invertebrate taxa were identified.
- Approximately 400 individual specimens were examined; found in association with 65 plant species.
- The fly-speck scale *Gymnaspis aechmeae* was found causing chlorosis to the critically endangered old George *Wittmackia caymanensis*, in the Cayman Islands

- An undescribed species of whitefly (Aleyrodidae) was recorded from Saint Helena.
- Fifty-nine species are recorded from Gibraltar for the first time, five species are recorded new for British Indian Ocean Territory and three species are recorded new for the Cayman Islands.
- A field guide to aid the identification of an invasive scale insect on Tristan da Cunha was produced.
- An annotated list of plant pests observed in Grand Cayman, Cayman Islands, was submitted to the Cayman Islands Department of Agriculture.

2.0 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).

Together with the Foreign and Commonwealth Office, the Department for International Development and the Joint Nature Conservation Committee (JNCC), Defra has agreed a Strategy for the Conservation and Sustainable Use of Biodiversity in the UK Overseas Territories. Effective conservation of biodiversity in the UKOTs is essential if the UK is to meet the 2020 Biodiversity Targets, as well as commitments under other relevant Multilateral Environmental Agreements (MEAs).

Preventing the establishment of invasive alien species in the UKOTs is a strategic priority, therefore accurate and rapid species identification for suspect alien species is fundamental to the enforcement of eradication and quarantine measures.

The PPP 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.

This Defra-funded project was conducted to provide an identification service for invasive invertebrate plant pests that may threaten biodiversity and agriculture in all of the UKOTs.

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).

The aims of the project were to:

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

3.0 Methods

3.1 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 2018/2019. The identification service is promoted on the JNCC website, the GB non-native species secretariat website, and the Caribbean Invasive Alien Species Network website.

3.2 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. Due to time constraints we were unable to deal with all the left-over samples from last reporting year, many are still being studied.

4.0 Results

4.1 The number of samples received, and identifications made

A total of 166 samples and photos were received from six territories between April 2018 and March 2019: British Indian Ocean Territory (32), Cayman Islands (37), Falkland Islands (32), Gibraltar (43), Saint Helena (20) and South Georgia (2).

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

4.2 Summary of findings

Approximately 160 distinct taxa of invertebrates were identified at Fera during 2018-19, of which 110 were identified to at least generic level.

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

ARANEAE (8 spp.).
ACARINA: Trombidiformes (2 spp.); Mesostigmata (1 sp.); Sarcoptiformes (2 spp.)
CHILOPODA: Lithobiomorpha (1 sp.)
DIPLOPODA: Spirostreptida (1 sp.); Spirolobida (1 sp.)

GASTROPODA: Stylomatophora (2 spp.)
ENTOGNATHA: Poduromorpha (1 sp.)
INSECTA: Blattodea (2 spp.); Coleoptera (20 spp.); Diptera (7 spp.); Embioptera (1 sp.); Hemiptera (70 spp.); Hymenoptera (17 spp.); Isoptera (1 sp.); Lepidoptera (8 spp.); Odonata (1 sp.); Orthoptera (5 spp.); Psocoptera (2 spp.); Siphonaptera (1 sp.); Thysanoptera (6 spp.)
MALACOSTRACA: Isopoda (1 sp.)

In terms of the number of species identified, the dominant group was the Hemiptera, in particular the scale insects (Coccoidea). 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).

In total more than 400 individual organisms were examined, collected from more than 65 host plant species.

A full list of the taxa identified during the reporting period can be found in Appendix 1 'Summary of invertebrate identifications 2018-2019'. Many taxa are still being studied 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.

4.3 New geographical and host records, and potential plant health 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.

4.3.1. British Indian Ocean Territory

Thirty-two samples were received from British Indian Ocean Territory. The samples were all collected on Diego Garcia, apparently from numerous habitats.

There was a total of 177 individual organisms within the sample batch from a wide range of invertebrate groups. Some of the organisms within these samples are still being studied, thus far we have identified a few significant invasive ant pests. Among those were two highly invasive tramp ants, 'white-footed ant' (*Technomyrmex albipes*) (Fig. 4) and 'long-horned crazy ant' (*Paratrechina longicornis*) (Fig. 5). Both are known to promote the establishment of mealybugs, scales, whitefly and aphids by deterring the natural enemies of these hemipteran pests. This in turn can lead to the increased incidence of various diseases. The former species has also been implicated in the spread of fungal diseases. Another significant ant found is *Solenopsis germinata*, the

'tropical fire ant, an economically important pest of seeds in agricultural crops such as tomato, corn and sorghum. Because of the ability for *S. geminata* to bite and sting, this species is considered a pest of humans and animals.

4.3.2 Cayman Islands

Thirty-seven samples were received from the Cayman Islands.

A number of pest whitefly and scale insects were identified within the samples. Significant finds include *Planchonia stentae* (Hemiptera: Asterolecaniidae, Fig. 9), 'South African Pit Scale' feeding on *Bryophyllum pinatum*. This is a new country and host record. Native to South Africa, *P. stentae* was introduced to the USA (California and Florida), and several countries in the Caribbean. It is polyphagous, feeding on plants belonging to at least 16 families, with a preference for Apocynaceae, Asteraceae, Euphorbiaceae and Fabaceae.

One species of spider mite, *Mononychellus caribbeanae*, was recorded for the first time from the Cayman Islands.

The first author visited the Cayman Islands twice in 2018 to attend a UKOT Horizon Scanning workshop and for a family holiday. He worked with Joan Steer and her colleagues from the Cayman Islands Department of Agriculture, and produced a report on the plant pests they observed which was written at home in his own time (see Appendix 8.2). A further nine species of insect plant pest were detected for the first time from the Cayman Islands: Aleyrodidae – *Minutaleyrodes minuta*; Coccidae – *Philephedra tuberculosa* (Fig. 7); Diaspididae – *Diaspis boisduvalii*, *Gymnaspis aechmeae* (Fig. 6), *Melanaspis coccolobae* and *Melanaspis* sp.; Pseudococcidae – *Pseudococcus elisae*; Tingidae – *Phymacysta tumida* (Fig. 8). The most destructive of these pests is the croton scale (*Philephedra tuberculosa*) (Fig. 7) which feeds on a range of tree fruit crops and some ornamentals, especially croton (*Codiaeum variegatum*). Potentially the most significant finding was the fly-speck scale *G. aechmeae* (Fig. 6) causing chlorosis to the critically endangered old George *Wittmackia* (= *Hohenbergia*) *caymanensis* (Burton et al., 2017). There are only about 350 mature individuals remaining which are threatened by habitat loss.

4.3.3. Falkland Islands

Thirty-two samples and photographs were received from the Falkland Islands.

Among them were a few significant plant pests, including a fruitfly (Tephritidae) larva found in a consignment of imported peaches, and cutworm larvae (*Spodoptera* sp.) attacking a potato crop. There were also several samples and photos of fleas that were of concern to the biosecurity officer as they were found in association with a cat. Cat flea (*Ctenocephalides felis*) and dog flea (*Ctenocephalides canis*) are of biosecurity significance as they are not recorded from the Falkland Islands. We were able to confirm that the fleas were not of the genus *Ctenocephalides*, but were likely to be a species of *Frontopsylla*, which are parasites of birds predominantly. The flea specimens have been sent to an expert for further study.

4.3.4 Gibraltar

Forty-three samples were taken during the first author's technical visit to Gibraltar. Remarkably 59 species of insect are recorded from Gibraltar for the first time. This reflects that some groups of insects are under-recorded from the territory and that Gibraltar is a major shipping/tourist centre, located at the gateway to Europe and Africa, and where the Atlantic and Mediterranean meet. Therefore, there are numerous potential pathways of introduction.

Significant new records include *Bemisia tabaci* (Fig. 10) (major agricultural and horticultural pest, vector of 100+ plant pathogenic viruses), *Singhiella simplex* (Fig. 11) (pest of *Ficus*), *Parasaissetia nigra* (polyphagous pest), *Cacopsylla fulguralis* (major pest of Elaeagnus), *Aulacaspis yasumatsui* (Fig. 12) (major pest of cycads), *Uhleria araucariae* (pest of Cupressaceae), *Phenacoccus peruvianus* (major pest of *Bougainvillea*), *Glycaspis brimblecombei* (Fig. 14) (pest of *Eucalyptus*), *Macrohomotoma gladiata* (Fig. 13) (pest of *Ficus*), *Josephiella microcarpae* (Fig. 15) (pest of *Ficus*), *Leptocybe invasa* (Fig. 14) (pest of *Eucalyptus*) and *Ophelimus maskelli* (Fig. 14) (pest of *Eucalyptus*).

4.3.5 Saint Helena

Twenty samples were received from Saint Helena during 2018/2019. There are further samples awaiting processing.

Most of these were samples of spiders caught in monitoring traps and are awaiting study. An undescribed species of *Aleuroplatus* whitefly (Fig. 16) was found on whitewood (*Petrobium arboretum*) and is to be studied further. The lily bulb mealybug *Vryburgia amaryllidis* (Figs 17-18) was found causing serious damage and mortality to Amaryllidaceae plants in Jamestown.

4.3.6 South Georgia

Two photos of insects were submitted to Fera for identification. Among them were a number of flies and a wood-boring beetle. We hope to be able to identify these further when the physical samples arrive.

4.4 Bio-security 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.

4.4.1 Bermuda

Technical advice was provided to Bermuda Biosecurity at the request of Jill Key, Overseas Territories Project Manager at NNSS by reviewing a 'Rapid Response Plan' that they had produced for Giant African Snail a highly invasive pest.

Achatina fulica (Stylommatophora: Achatinidae), is a major plant pest, native to East Africa, that has been introduced accidentally to many parts of the world with trade and/or intentionally as a food source, for scientific research and education, and as a novelty pet (CABI, 2019; Global Invasive Species Database, 2013). It is readily transportable over considerable distances as it can go into a state of aestivation in cooler or unfavourable conditions. It has established in many tropical regions where it has had a major negative impact due to its broad polyphagy and prodigious reproductive capacity. As a result, *A. fulica* has been classified as one of the world's top 100 invasive species by The World Conservation Union, IUCN (Global Invasive Species Database, 2013).

4.4.2 Tristan da Cunha

We provided technical advice to RSPB when they contacted us about an invertebrate pest problem on Tristan da Cunha

Three cosmopolitan scale insect pests have been introduced to the Tristan da Cunha archipelago, where their main host species is the island tree *Phylica arborea*, the only tree native to the islands. Infestations of one species, *Coccus* ?*hesperidum* (Fig. 3), are having a significant impact on *Phylica* fruit production (Fig. 2). This can affect the populations of large-billed forms of *Nesospiza* finches because they rely on *Phylica* fruits and are endemic to Tristan (Ryan *et. al*., 2014.)

We produced a field guide to scale insects (Hemiptera: Coccoidea) recorded on *Phylica arborea* on Tristan da Cunha, gave advice on sampling and use of biological control agents. The field guide can be found in Appendix 8.2.

4.5 Scientific publications

One scientific paper relevant to the UKOTs in the Caribbean was published and one is in press. A submission of a manuscript on the whiteflies and scale insects of the Cayman Islands which includes 43 species recorded as new for the territory has been delayed due to further new records found during 2018.

Malumphy, C. 2018. Two species of whitefly and seven species of scale insect (Hemiptera: Aleyrodidae and Coccoidea), new for Antigua, Lesser Antilles. Entomologists Monthly Magazine, 154: 53-59.

4.6 Building diagnostic capacity in the UKOTs

A range of approaches for developing diagnostic capacity and up-skilling in the UKOTs were considered but these were restrained by the limited diagnostic resources of many of the territories (e.g., laboratories, microscopes, trained staff, information centres and reference collections) and the limited budget available to Fera.

An illustrated report has been produced on the whiteflies and scale insects of the Cayman Islands. This includes pictures of many of the invasive species found in the Caribbean region and will aid field recognition of these pests.

In addition to the identification service and as a separate Defra funded project we created a field guide to invasive invertebrate pests that threaten the South Atlantic UKOTS. This will enable those involved with plant health to recognise the main groups of invertebrate plant pests and the plant damage they cause, an it also provided detailed factsheets on key invasive alien invertebrate pests that currently threaten plant health, human health and biodiversity in the region.

4.7 Feedback on the diagnostic service

Our contacts in the territories have always been very complimentary of our assistance with identifications and for providing technical advice. All UKOTS that submitted samples were sent a 'Service Satisfaction Survey' in March 2019 (see Appendix 5).

Naomi Baxter, Biosecurity Officer at the Falkland Islands Department of Agriculture fed back to us that she was delighted with every aspect of the identification service, namely the speed with which the identification or advice was delivered, the quality of information or advice received, the ease of contacting us, and the clarity of communication received from Fera.

She included an additional note: " *Chris and Sharon are fantastic and provide an invaluable service to us, I don't know what we'd do without them!"*

Shariffa Chantilope-Zelaya, Scientific Assistant in Plant Protection & Agronomy at Cayman Islands Department of Agriculture fed back to us that she was delighted or very satisfied overall with the identification service

She included an additional note: "*On behalf of the Cayman Islands Department of Agriculture, I would like to say that we are very pleased with the assistance FERA has provided us through this program. The staff competency level and the detailed and well organized reports are highly regarded. We have been able to build our pest list and identify species of economic importance with the FERA UKOT identification service."*

5.0 Conclusions

Preventing the establishment of invasive alien species in the UKOTs is a strategic priority of the UK Government's Overseas Territories Biodiversity Strategy. Accurate and rapid species identification for suspect alien species is fundamental to the enforcement of eradication and quarantine measures to protect biodiversity and agriculture.

There continues to be a clear demand for an identification service for invasive invertebrate plant pests to improve bio-security and support the preservation and conservation of biodiversity in the UKOTs and the service has produced a wealth of new and useful data. 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 2018/19 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. An undescribed species of whitefly was found in association with whitewood in Saint Helena and a mealybug pest of lilies recorded for the territory for the first time.
4. Fifty-nine species were recorded from Gibraltar for the first time, five species were recorded new for British Indian Ocean Territory and three species are recorded new for the Cayman Islands. These include a number of highly invasive polyphagous pests that continue to spread in the UKOTs.
5. 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.
6. 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.
7. 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 1250 samples. More than 100 of the invertebrate species examined to date have never before been reported from the UKOTs. A total of nineteen 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).

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

6.0 Acknowledgements

The authors wish to thank the Conflict, Stability and Security Fund (CSSF), Tackling Invasive Non-Native Species in the UK Overseas Territories for funding of the project, Niall Moore and Jill Key of the Non-Native Species Secretariat for supporting the project, and everyone within the UKOTs who submitted 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 Martin Hamilton (RBG Kew). We would also like to thank our colleagues Mark Delaney, Duncan Allen, Rob Deady and Joe Ostoja-Starzewski for all their hard work with processing and identifying the samples, and Prof. Janice Edgerley-Rooks, Helen Roy and Gavin Broad for their specialist advice and identifications.

7.0 References

Burton, F.J., Clubbe, C.P. & Bárrios, S. 2017. *Wittmackia caymanensis* (amended version of 2014 assessment). *The IUCN Red List of Threatened Species* 2017: e.T56499801A118321942. http://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T56499801A118321942.en.

Cheesman, O.D., Clubbe, C., Glasspool, A.F. & Varnham, K. 2003. Dealing with invasive species: sharing knowledge and experience. In: M. Pienkowski ed. A Sense of Direction: a conference on conservation in the UK Overseas Territories and other small island communities. Over Norton: UK Overseas Territories Conservation Forum, 257-272. Available from: http://www.ukotcf.org.

Collins, D W. & Evans, G. B. 2013. *Scirtothrips coccolobae* sp. nov. (Thysanoptera: Thripidae), a Leaf-Feeding Thrips on Sea Grape Known from Florida and the Cayman Islands. *Florida Entomologist* **96** (4): 1359-1364.

BAS. 2018. British Arachnological Society (BAS) websiteFalse Widow Spiders http://britishspiders.org.uk/wiki2015/index.php?title=False_Widow_Spiders. Accessed on 03 April 2018.

CABI (2019) Invasive species Compendium. Datasheet downloaded from http://www.cabi.org/isc. CAB International, Wallingford, UK

GISD (2013) Global Invasive Species Database. 100 of the World's worst invasive alien species. http://www.iucngisd.org/gisd/100_worst.php. Accessed 21st February 2019.

Gray, A., Stroud, S., Lambdon, P.W., Niissalo, M. & Renshaw, O. 2016. *Euphorbia origanoides*. The IUCN Red List of Threatened Species 2016: http://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T43921A88582641.en. Accessed on 03 April 2018.

Miller, G.L. & Miller, D.R. 2003. Invasive soft scales (Hemiptera: Coccidae) and their threat to US Agriculture. *Proceedings of the Entomological Society of Washington*, 105, 832-846.

Pellizzari, G. & Dalla Montá, L. 1997. 1945-1995: Fifty years of incidental insect pest introductions to Italy. *Acta Phytopathologica et Entomologica Hungarica*, 32, 171-183.

Ryan, P.G., Heinz, E.O., & Herian, K. 2014. Cascading effects of introduced scale insects on *Nesospiza* finches at the Tristan da Cunha archipelago. *Biol. Conserv.,* 176 (2014), pp. 48-53

Smith, R.M., Baker, R.H.A., Malumphy, C.P., Hockland, S., Hammon, R.P., Ostojá-Starzewski, J.C. & Collins, D.W. 2007. Recent non-native invertebrate plant pests establishments in Great Britain: origins, pathways, and trends. *Agricultural and Forest Entomology*, 9, 307–326.

Thomas, M.C. 2006. The exotic invasion of Florida. A report on arthropod immigration into the sunshine state. Available from: http://www.freshfromflorida.com/Divisions-Offices/Plant-Industry/Science/The-Exotic-Invasion-of-Florida

Varnham, K. 2006. Non-native species in UK Overseas Territories: a review. *JNCC Report 372*. Peterborough: United Kingdom.

Wilson, E.O. (2002) *The Diversity of Life*. Harvard University Press. Pages 16-23.

8.0 Appendices

8.1 Summary of invertebrate identifications made during 2018-2019

8.2 Annotated list of plant pests observed in Grand Cayman, Cayman Islands, in May and June 2018

8.3 Field guide to scale insects (Hemiptera: Coccoidea recorded on *Phylica arborea* on Tristan da Cunha

8.4 Malumphy, C. 2018. Two species of whitefly and seven species of scale insect (Hemiptera: Aleyrodidae and Coccoidea), new for Antigua, Lesser Antilles. Entomologists Monthly Magazine, 154: 53-59.

8.5 Service Satisfaction Survey