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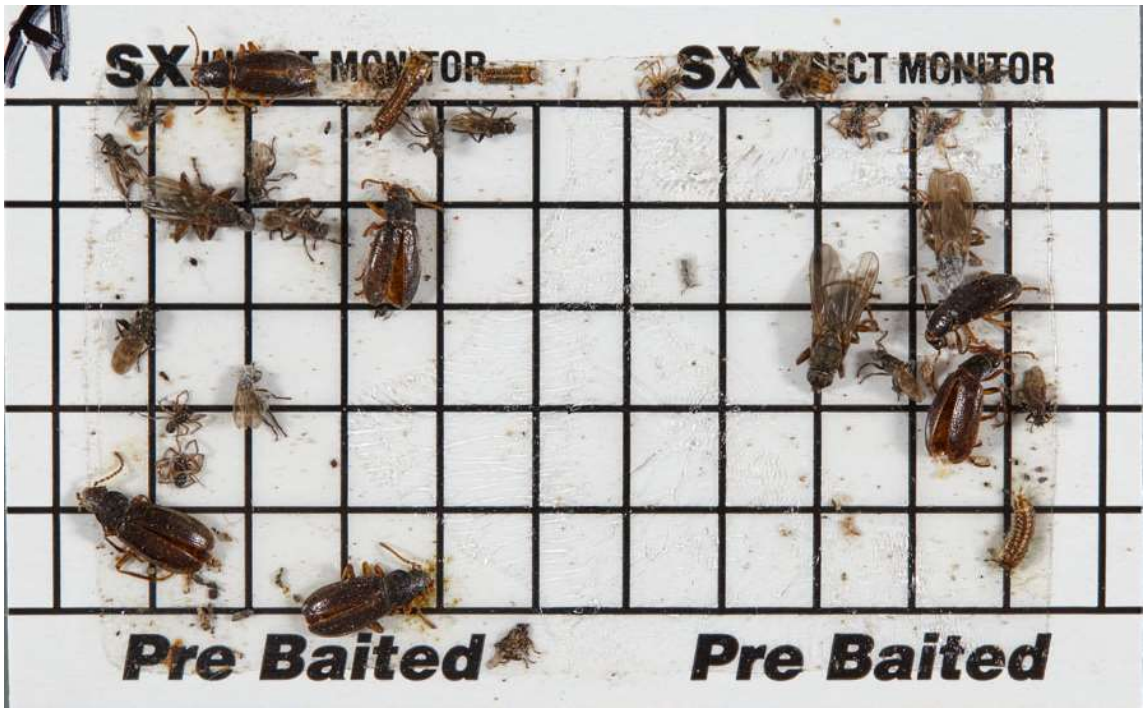
EARLY DETECTION OF POTENTIALLY INVASIVE NON-NATIVE INVERTEBRATES IN SOUTH GEORGIA



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Early detection of potentially invasive non-native invertebrates in South Georgia

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First Edition December 2019

Cover picture: A sticky trap from King Edward Point, South Georgia. Trapped invertebrates shown include a beetle *Hydromedion sparsutum* (Müller, 1884) (Family: Promecheilidae); lesser dung fly *Antrops* sp., probably *A. quadrinotus* (Family: Phaeroceridae); a dark-winged fungus gnat *Bradysia* sp. (Family: Sciaridae); a helcomyzid fly *Paractora* sp. (Family: Helcomyzidae) and six unidentified spiders (Family: Linyphiidae).

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1. PURPOSE AND SCOPE

The introduction of invasive non-native species (INNS) are threatening the biodiversity, human health and the economy in UK Overseas Territories (OT's). Despite stringent biosecurity measure in the Southern Ocean Islands, researchers continue to record new introductions associated with human activity. With increasing numbers of visitors to South Georgia and the South Sandwich Islands, the risk of introduction of INNS is increased. A Horizon Scanning exercise held in 2018, led by the Centre for Ecology and Hydrology, part of the GB Non-Native Secretariat project 'Tackling invasive non-native species in the UK Overseas Territories, funded by the UK Government Conflict, Stability and Security fund identified a list of priority species if INNS that pose the greatest threat for South Georgia. Two terrestrial invertebrates were included in this list.

This guide is intended to be used by those working in biosecurity, with the aim of empowering the Biosecurity Officer and other government officers in South Georgia to rapidly detect non-native species of terrestrial invertebrates caught on sticky traps. It is not intended to enable government staff to identify terrestrial invertebrates to species level, for this further assistance will be required from a relevant specialist, but it will help staff to detect and prioritise potential invasive species.

2. INTRODUCTION

Ensuring South Georgia's biodiversity is protected from invasive species is a strategic priority for the Government of South Georgia and the South Sandwich Islands (GSGSSI). The threat posed by escalating numbers of invasive non-native species (INNS) to biodiversity, human health and the economy is a major concern for all of the UKOTs. It is estimated that there are at least 2,261 occurring across the OT's, although there are currently none recorded in the South Sandwich Islands (Roy *et al.,* 2019). Early detection and identification of INNS can enable effective and appropriate measures to be taken in a timely manner to eradicate, contain and/or manage the pests (Roy *et al.,* 2019). Due to extensive survey work over the past 50 years or more, and the relatively low diversity, the indigenous invertebrate fauna of the major islands in the Antarctic region are reasonably well known. Gressitt (1970) coordinated a series of surveys on the invertebrate fauna of South Georgia and recorded 148 species, with 37% apparent endemism.

Key and Key (2009) produced a list of the 21 known alien invertebrates from South Georgia based on data from Varnham (2006) and Frenot *et al*. (2005). They recorded whether these species had established (if known) and helpfully noted that a few of the records were based on single specimens. Key and Key (2009) conducted an extensive survey of the invertebrate fauna in 2008-2009 and collected a further eight new species, all insects.

The insect fauna of South Georgia is predominantly made up of beetles and flies. Chown and Convey (2016) produced a list of some insect orders in the Antarctic by geographical region, listing eighteen native and eleven introduced species for South Georgia. Convey *et al*. (1999) and Greenslade and Convey (2012) have studied the collembolan fauna and listed Twenty-three species, of which five are introduced. Five native species of spider are recorded from South Georgia, a previously introduced European species (*Tegenaria domestica* – house spider) is now believed to have become extinct (Forster, 1970; Lavery, 2017). An updated checklist of the arthropod species recorded from South Georgia, based on published records, can be found in Appendix E.

South Georgia has a very small non-permanent population of scientists, government personnel, HM armed forces and expedition staff who reside at King Edward Point. There are no permanent native populations living on South Georgia or the South Sandwich Islands. Although there are no scheduled passenger ferries to or from the territory, GSGSSI, British Antarctic Survey (BAS) and Royal Navy vessels routinely dock, transporting staff, equipment, food and other cargo to the station at King Edward Point. Visits to the Island by cruise liners and sailing yachts have become incredibly popular, with several thousand visitors each summer. There is an increasing risk of INNS arriving accidentally as stowaways in association with shipping freight (i.e. plants and produce, building material, equipment and vehicles), cruise liners and yachts (i.e. passenger baggage). One example of a species that arrived in South Georgia via this route is *Trechisibus antarcticus* (Carabidae), a predatory beetle endemic to the Falkland Islands. *Trechisibus antarcticus* has invaded the coastal lowland areas and is building up local high densities in the dominant tussock-forming grass *Parodiochloa flabellate* (Ernsting *et al*. 1999). It is a voracious predator, feeding on beetle larvae and other soil arthropods, such as mites and springtails. The larvae of the endemic detritivorous beetle known as *Hydromedion sparsutum* (Perimylopidae) are a favoured prey for *T. antarcticus* and on sites colonised by the carabid, total abundances of larval and adult *H. sparsutum* are far lower (Ernsting *et al.* 1999).

The GSGSSI has stringent biosecurity measures in place to safeguard South Georgia and the South Sandwich Islands against the introduction and spread of invasive non-native species. The GSGSSI Biosecurity Handbook (Policy No: 18, revised June 2019 by R. James) is a detailed statement of current biosecurity policy and specifically refers to the risk of alien invertebrates that might arrive on vessels and stipulates actions that must be taken to avoid them reaching land and potentially establishing. As well as details of pre and post border biosecurity checks, the biosecurity policy gives details of the regulations regarding personal baggage, cargo packing requirements, measures regarding the import of fresh produce, the use of wood packaging, and standards that should be met for shipping containers transported to the territory.

Occasionally invertebrates arrive in cargo, personal baggage or mail, and due to their cryptic nature may go undetected during biosecurity inspections and escape into the station facilities. There is the potential for multiple individuals of a species to arrive that can colonise the natural environment. According to the Biosecurity Handbook, measures for invertebrate detection include the extensive use of crawling and flying insect traps in high risk areas such as the biosecurity facility, storage sheds, shipping vessels, shipping containers but also in all habited buildings. Particular attention is paid to rooms that receive large amounts of luggage, cargo or mail including the museum storerooms and workshops where building supplies are stored.

The GSGSSI Biosecurity Policy states that traps should be monitored each month and catches recorded by Government Officers, therefore it is essential that they have the knowledge and available resources to be able to recognise potential INNS.

3. PRIORITY INVASIVE ALIEN INVERTEBRATE THREATS TO SOUTH GEORGIA

In 2019 Fera produced a '*Field Guide to invasive alien species in the South Atlantic UK Overseas Territories*'. The invertebrates included in this guide were selected from lists of major economic, human and biodiversity threats identified for each UKOT in the South Atlantic during Horizon Scanning workshops held in Saint Helena and Cambridge (UK) during 2018. Preliminary lists of potential Invasive Non-Native Species that they considered to constitute the highest risk with respect to the likelihood of arrival, establishment and the magnitude of their potential negative impact on biodiversity and ecosystems or human health or economies over the next ten years were compiled. Thirty-two detailed factsheets were produced covering each of the species listed. Invertebrate species that present a priority biodiversity threat for South Georgia and South Sandwich Islands were listed as:

Hypogastrura manubrialis – A springtail

Invasive springtails are transported globally by numerous human activities, particularly trade in plants and produce, movement of soil contaminated vehicles or equipment and tourism. In South Georgia, alien invasive collembolan species numbers increased significantly after the introduction of exotic weeds around dwellings (Convey *et al*., 1999). Greenslade and Convey (2012) suggested that the importation of root and other vegetables was the route by which these species arrived and that that increased visitation by tourists, research and maintenance personnel seems an obvious cause despite strict quarantine controls imposed on all visitors. In 1994, Pugh highlighted the ineffective control on the import of contaminated equipment or vegetation by the military garrison at King Edward Point, or by the trawlers, yachts and cruise ships that dock.

The most effective way of monitoring for the presence of Collembola is by using a Berlese or Tüllgren funnel to extract them from of soil, leaf litter or bark. They may also be collected by hand using a mouth operated aspirator, or hand operated aspirator. Overturning rocks and other objects frequently will expose them, and pitfall traps can be used to capture collembola (Bellinger et al., 2019). Springtails can be carried by the wind and have been recorded at heights of more than 3000 metres, therefore it is possible that they will be collected on sticky traps suspended at a height around the dock at King Edward Point.

Forficula auricularia – European earwig

Forficula auricularia, has become a considerable domestic and public nuisance in the Falkland Islands, due to large numbers of earwigs entering homes and causing significant problems for local horticulture by eating garden vegetable crops. *Forficula auricularia* are not likely to disperse over long distances naturally as although they can fly, they rarely do, and they do not move far by crawling either (Crumb *et al*., 1941). Accidental introduction within building material, bulk goods, flowers, vegetables and hitchhiking on vehicles etc. is the most likely means of dispersal (Capinera, 2016; CABI, 2019). Earwigs are nocturnal and tend to hide in small crevices and can withstand a wide range of temperatures/humidity levels and long periods without food (Crumb *et al*., 1941), so long-distance transport via ship, trucks, containers can easily facilitate their spread. In addition, females can deposit fertile eggs several months after mating (Crumb *et al.,* 1941) and it is therefore feasible that new colonies can be founded by single females. Detection of earwigs within shipments is difficult due to their cryptic nature, therefore sticky blunder traps are an ideal method of collecting them.

4. TRAPS SUBMITTED TO FERA FOR SCREENING

4.1. Background

In November 2019 the Biosecurity Officer in South Georgia submitted ten sticky traps to the Fera Science Entomology Team for screening. These sticky traps provide useful baseline data on the range of invertebrate fauna that could be caught on monitoring traps which are used extensively by GSGSSI for biosecurity purposes.

Two of the traps submitted were 'Trapper MC Glue Traps', disposable cardboard glue boards designed to capture mice and insects without bait. The sticky boards are placed within covered re-useable plastic 'Pest Monitor' traps (Figs. 2 & 3), which offer some protection and means they can possibly be used outdoors. The glue used for these traps is a very powerful gel-like adhesive. These two large traps were placed indoors at the old jail building at King Edward Point on the floor at the edges of the room. The traps were both were placed in situ in January 2019.

The remaining eight traps submitted were small 'SX Insect Glue Pads' (Fig. 1), monitoring sticky traps pre-baited with an unspecified volatile compound produced by ripening bananas. Theses traps are designed to attract cockroaches, but in this instance have proven successful at capturing other invertebrates by acting as a simple blunder trap. These traps were all placed in situ in March 2017, on the floor at the edges of the room in bedrooms of GSGSSI staff, apart from one which was placed in the old jail building.

4.2. Trap screening

The traps were all individually screened by the author under a Leica M205C binocular microscope and insects photographed with a Nikon DS Fi2 camera attachment. The invertebrates caught on the sticky traps varied in their physical condition. This is likely to be dependant upon the length of time that had passed since they had been caught on the trap, for instance most traps had been placed in situ 32 months previously. Some individuals had deteriorated considerably and were unidentifiable beyond family level. However, where possible insects caught on the traps were identified to species level. All Diptera (flies) were identified by Rob Deady (Fera). Where needed, insects were removed from traps for further study. This is done by dropping white spirit on and around them to dissolve the glue, and then carefully teasing them off with fine needles or forceps.

4.3. Results Summary

A total of 135 invertebrate organisms were trapped consisting of at least thirteen species. A summary of the trap catches can be found in Table 1. Wherever possible insects were identified to species. Notable non-native species are discussed further.

The trap catches were predominantly made up of Coleoptera (beetles) and Diptera (flies). The following were found: One species of springtail (Collembola); three mites (Acari); at least two spiders (Araneae); at least four flies (Diptera), three beetles (Coleoptera); and at least one booklouse (Psocoptera). The bedroom trap catches demonstrated more diversity of species that the old jail building. There are a number of factors that may have influenced this outcome, most notably the greater number of bedroom traps, the fact that they were pre-baited with an insect attractant and lastly the fact that they were in situ significantly longer than the old jail traps.

The predominant species caught were native to South Georgia. Two species made up 65% of the trap catches: forty-three adult and larval individuals of the endemic tussock beetle *Hydromedion sparsutum* (Müller, 1884) (Family: Promecheilidae) and forty-six adult individuals of a lesser dung fly *Antrops* sp., probably *A. quadrinotus* (Bigot, 1888) (Family: Phaeroceridae) were trapped. Unfortunately, due to the poor condition of the majority of the flies on the traps, it was impossible to confirm any to species level, but most were identified to generic level. Flies degrade quickly on sticky traps, often becoming too brittle to manipulate after a few weeks of capture. None of the flies captured where suspected to be non-indigenous species and it quite possible that all were native species.

4.4. Non-indigenous species

Of the specimens studied in detail thus far there were two species of non-indigenous insect caught on the sticky traps.

Trechisibus antarcticus (Dejean, 1831) (Coleoptera: Carabidae)

There are no Carabidae (predatory ground beetles) native to South Georgia, however in the last 50 years or more there are been two human-assisted introductions of two South American species, *Merizodus soledadinus* (Guerin-Ménéville) and *Trechisibus antarcticus*. A single adult individual of *T. antarcticus* was trapped in a bedroom in South Georgia. This species is thought to have been accidentally transported from the Falkland Islands or southern South America (Convey *et al.* 2011). It is a voracious predator of small insects and other invertebrates, and where it occurs it has significantly modified the local food webs, which contain no other comparable indigenous predators (Convey *et al*. 2011). The presence of *T. antarcticus* on South Georgia has led to significant reductions in populations of the endemic herbivorous tussock beetle *Hydromedion sparsutum* (Müller, 1884) (Family: Promecheilidae). Other endemic species thought to be at risk of predation include two flies which have ground dwelling flightless morphs, *Eretmoptera murphyi* Schaeffer (Chironomidae) and *Antrops truncipennis* Enderlein (Sphaeroceridae).

Table 1. Invertebrates identified from sticky traps from South Georgia.

Number of individuals on traps by trapping area is recorded.

HIGHER TAXONOMY	SPECIES	COMMON NAME	OLD JAIL	BED-ROOMS
ARACHNIDA				
ARANEAE				
Linyphiidae	Undetermined species	spiders	3	8
ORIBATIDA				
?Glycophagidae	Undetermined species	storage mite		3
MESOSTIGMATA	Undetermined species	?phoretic mite		1
TROMBIDIFORMES	Undetermined species	Undetermined mite		1
ENTOGNATHA				
ENTOMOBRYOMORPHA				
Isotomidae	Undetermined species	springtail	1	
INSECTA				
COLEOPTERA				
Carabidae	*Trechisibus antarcticus* (Dejean, 1831)	ground beetle		1
Lathridiidae	*Cartodere malouinensis* (Champion, 1918)	plaster beetle	1	2
Promecheilidae	*Hydromedion sparsutum* (Müller, 1884)	tussock beetle	21	22
DIPTERA				
Helcomyzidae	*Paractora* sp.*	kelp flies		4
Sciaridae	*Bradysia* sp.*	fungus gnat	1	2
Sciaridae	Undetermined sp.*	fungus gnat		2
Sphaeroceridae	*Antrops* sp. ?*quadrinotus**	lesser dung fly	31	15
Sphaeroceridae	?*Antrops* sp.*	lesser dung fly		6
Acalyptrate*				5
PSCOCOPTERA				
Trogiidae	*Lepinotus* or *Trogium* sp.*	booklouse		1
Trogiidae	*Lepinotus patruelis* Pearman, 1931	booklouse		1
Undetermined*		booklouse	1	

* Unable to identify further due to poor condition

Lepinotus patruelis Pearman, 1931 (Psocoptera: Trogiidae)

There are no Psocoptera (booklice or psocids) known to occur naturally in South Georgia, and there are no published records of any incursions or species becoming established. Three individual booklice were trapped, on three individual traps, one in the old jail and the other two in KEP bedrooms. Two individuals were wingless, and one was micropterous (wings dramatically reduced, lacking distinct venation). Unfortunately, due to the condition of the specimens, only one was determined to species. The species determined was confirmed as *Lepinotus patruelis,* is a domestic species of booklouse, native to western Europe. They prefer dark, warm, humid environments such as the folds of packaging in food cupboards and in dust and debris under appliances. They feed on microscopic moulds and mildews that flourish in warm places such as domestic kitchens and bathrooms. *Lepinotus patruelis* has been recorded from the following New Zealand sub-Antarctic Islands: Auckland, Campbell, Snares and Antipodes Islands.

4.5. Further study

There was a single species of Collembolan (springtail) found among the invertebrates caught on traps. It was not possible to identify beyond family level (Isotomidae: Entomobryomorpha), however I plan to carefully remove it from the sticky trap in order to mount and study it further, and will hopefully confirm that it is one of the ten species of Isotomid present on South Georgia and not a non-native species.

The Arachnida (spiders and mites) caught on the traps will be studied further later, as it was not possible for Fera's specialists in these groups to examine them within the time frame.

5. PROTOCOL FOR SCREENING BLUNDER AND STICKY TRAPS

The GSGSSI Biosecurity Policy stipulates that traps used to monitor for invertebrates are examined monthly and any catches recorded. It is essential therefore it is essential that the GSGSSI staff they have the knowledge and available resources to be able to recognise potential INNS on these traps. Arthropods are an incredibly large and diverse group of organisms; therefore, invertebrate biologists tend to specialise in individual orders or family groups. For example, plant quarantine diagnostics teams in government departments throughout Europe are made of several invertebrate diagnosticians, each with specialities in specific taxonomic groups. It would be impossible to produce a single resource that would allow a GSGSSI Biosecurity Officer to identify all organisms caught on traps to species level. However, given the limited invertebrate diversity recorded on South Georgia, it would be possible to provide baseline data for indigenous and known established species, which could be used as a comparison tool. A checklist of the arthropod fauna of South Georgia (based on published accounts) is provided in Annex E.

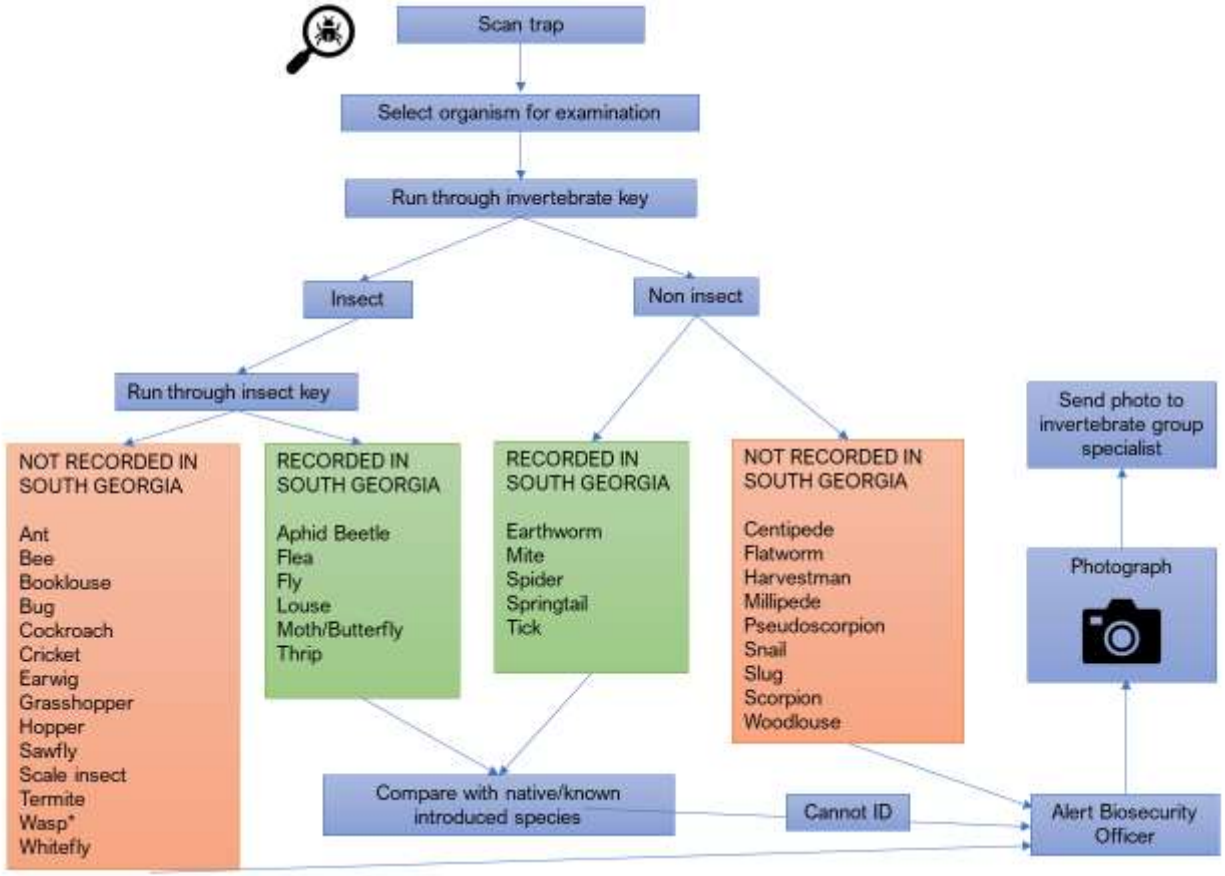
5. 1. *Examining sticky traps*

Sticky traps are best studied in an area of good lighting, with magnification from a hand lens or microscope. USB microscopes are used by several the UKOT government departments to study and photograph invertebrates. It is sometimes possible for specialists to identify invertebrates from photographs, therefore capturing images of suspected INNS is advised. The guide '*Taking digital photos of suspect invasive alien invertebrates in the UK Overseas Territories for identification purposes'* by Chris Malumphy is available to download from the *Biosecurity tool kit* (www.nonnativespecies.org). A database of regularly trapped invertebrates can be created to aid with trap monitoring and staff training.

Invertebrate specimens caught on sticky traps are very vulnerable to damage, particularly winged specimens or those with. Do not attempt to re-orientate an invertebrate specimen or remove it from a sticky trap without dissolving the surrounding glue with white spirit first.

5.2. Flow diagram to assist triaging trap catches

The following flow diagram is designed to support the GSGSSI staff responsible for monitoring sticky traps, by supporting them with decisions on triaging trap catches and deciding on the most appropriate action once trapped organisms have been identified.



* There is only one wasp species recorded from South Georgia, a fairy wasp *Notomymar aptenosoma* Doutt & Yoshimot (Mymaridae: Chalcidoidea). It is wingless, less than 0.8mm long and would key out as an ant if using the insect key.

5.3. Simplified Keys

Simply keys have been produced to the main groups of terrestrial invertebrates. The first is a key to the main invertebrate groups (Annex A), the second is a key to the most common insect groups (Annex B). The purpose of this these is to enable non-specialists to identify commonly encountered terrestrial invertebrates to a higher taxonomic rank (Phyla, Class or Order); and insects to Order (in some cases lower rank). Although some invertebrate groups within the key are unlikely to be trapped on sticky traps, they may be intercepted during biosecurity inspections of cargo. The keys will not always work for immature specimens or brachypterous morphs (forms with reduced wings) of adult specimens. Most of the morphological characters selected can be seen when looking at the invertebrate from above although some characters, such as insect mouthparts, may only be visible from the side or below. It is useful to have a x10 hand lens or microscope to examine the smaller specimens.

6. RECOMMENDATIONS

The Biosecurity Officers in South Georgia have over time submitted a small number of photos and samples of suspected biosecurity threats to Fera as part of the OT Biosecurity Project ID project funded by Defra. In 2011 we identified several insects caught on sticky traps in a food store. We were able to identify two species of fly and two beetles to species. One of the species identified, *Ptinus tectus* Boieldieu (Coleoptera, Anobiidae), the Australian Spider Beetle, is not native to South Georgia, and had not been previously recorded. Australian spider beetle is a cosmopolitan pest of stored products, both adults and larvae feed on dried stored food and museum specimens, it is established in the Falkland Islands.

During 2019 we have received photo samples of INNS such as the European hoverflly *Eristalis croceimaculata* Jacobs (Diptera, Syrphidae). It is not always possible to identify invertebrates from photos however, therefore a recommendation would be for the Biosecurity Officer to continue to submit samples of suspected INNS. The UK Overseas Territories Sample Submission Form gives details of how to submit sticky traps, this can be found in the *Field Guide to Invasive Alien Invertebrates in the South Atlantic UK Overseaes Territories* (Malumphy *et al*. 2019) available to download from the OT *Biosecurity tool kit* (www.nonnativespecies.org).

A further recommendation would be the introduction of yellow and blue sticky traps to capture flying insects. These could be placed indoors and sheltered areas out of doors. A number of insect pests are attracted by the colours yellow (aphids, whitefly and some moths) and blue (leafminer flies and thrips) and can be caught on coloured sticky traps. They are efficient at monitoring population densities of flying insects in the field and under protection and can also be used as a control measure to some degree.

As mentioned in section 3., the most effective way of monitoring for the presence of Collembola (springtails) is by using a Berlese or Tüllgren funnel to extract them from of soil, leaf litter or bark. Springtails can be carried by the wind and have been recorded at heights of more than 3000 metres, therefore it is possible that they will be collected on sticky traps suspended at a height around the dock at King Edward Point.

7. ACKNOWLEDGMENTS

I wish to thank Defra for funding of this project, an element of the OT Biosecurity Project, which is coordinated by a team led by the GB Non-native Species Secretariat. Ross James, Emma Jones and Paula O'Sullivan from GSGSSI who submitted samples. I would also like to thank my Fera colleagues Rob Deady for identifying the fly samples and Chris Malumphy who gave advice and support.

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9. ANNEX A: PHOTOGRAPHS

Fig. 1 A pre-baited insect monitor trap which has caught a range of invertebrates © Fera

Fig. 2 Endemic tussock beetles, *Hydromedion sparsutum* (Promecheilidae) © Fera

Fig. 3 Pest monitor trap for mice and invertebrates © Bell Labs

Fig. 4 *Paractora* sp. (Helcomyzidae)

Fig. 5 *Hydromedion sparsutum* (Promecheilidae) adult beetle © Fera

Fig. 6 *Hydromedion sparsutum* (Promecheilidae) beetle larva © Fera

Fig. 7 *Bradysia* sp. (Sciaridae), fungus gnat © Fera

Fig. 8 *Antrops* sp. ?*quadrinotus* (Sphaeroceridae) © Fera

Fig. 9 *Cartodere malouinensis* (Lathridiidae) © Fera

Fig. 10 *Trechisibus antarcticus* (Carabidae) © Fera

Fig. 11 *Lepinotus patruelis* (Trogiidae), a non-native booklouse © Fera

Fig. 12 Undetermined spider (Linyphiidae) © Fera

Fig. 13 Trombidiformes. A unidentified mite © Fera

Fig. 14 Mesostigmata. An unidentifed mite © Fera

Fig. 15 Blunder traps from the Falkland Islands Conservation herbarium opened to show a variety of crawling insects and some flying insects © C. Malumphy

Fig. 16 Sticky trap from Stanley Growers, Falkland Islands, showing a variety of flying insects, including an invasive European earwig © C. Malumphy