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1 SHORT NOTE

2
3 **The fate of the non-native Collembolon, *Hypogastrura viatica*, at the southern extent of**
4 **its introduced range in Antarctica**

5
6 Kevin A. Hughes¹, Penelope Greenslade² and Peter Convey¹

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8 ¹ British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United
9 Kingdom

10 ² Federation University Australia, Mt Helen, Ballarat, Victoria, Australia

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12 **Abstract**

13 Invasive species present a risk to Antarctic ecosystems by altering community structure and
14 function. Reports of non-native invertebrates are increasing at Antarctic sites subject to
15 tourism industry and national operator activity. Furthermore, dispersal of existing non-native
16 species to other Antarctic sites may greatly expand their distributions and increase the spatial
17 scale of potential impacts. Consequently, non-native species occurring near logistical hubs
18 present an enhanced risk. The non-native Collembolon, *Hypogastrura viatica*, was
19 introduced to Léonie Island, Ryder Bay, near the logistical hub of Rothera Research Station,
20 Rothera Point, Adelaide Island, at some point before 1993, but no attempt has been made to
21 assess the extent of its distribution in the local area. In this study, we surveyed the regularly
22 frequented islands of Ryder Bay and Rothera Point in order to attempt to assess the continued
23 presence and distribution of this species. *Hypogastrura viatica* was not identified amongst
24 the 36,796 Collembola specimens extracted from 138 samples taken from the islands and
25 Rothera Point. With no evidence of the continued presence of this non-native Collembolon

in the local area, either *H. viatica* has become extinct or, has such a restricted spatial distribution that our monitoring programme failed to detect it. In light of these results, existing local biosecurity measures will be maintained as a precautionary measure to reduce the risk of further anthropogenic dispersal of this potentially invasive Collembolon as well as of any other species imported unintentionally in future.

Keywords: biosecurity; invasive; transient; alien; springtail;

Introduction

The Protocol on Environmental Protection to the Antarctic Treaty contains some of the strictest legislation in force worldwide with regard to non-native species (Frenot et al., 2005; Hughes and Convey 2010; Hughes and Pertierra 2016). The deliberate introduction of non-native species to the Antarctic Treaty area is prohibited without a permit, and any introduced plant or animal must be removed or appropriately disposed of at the end of the permitted period (Annex II, Article 4). Building on this legislation, the Committee for Environmental Protection's Non-native Species Manual recommends a non-native species management framework with monitoring as one major component so that appropriate management action can follow (CEP 2016).

The Collembolon *Hypogastrura viatica* (Tullberg 1872) is often described as 'cosmopolitan', but is more accurately widely but sporadically distributed at mid to high latitudes in both Hemispheres (Convey et al. 1999; Greenslade 2010; Sørensen and Holmstrup 2011). It is not recorded from the tropics, or at lower latitude than 30°S in Australia (Greenslade et al. 2014). When found at introduced locations in the Southern Hemisphere *Hypogastrura viatica* is often only located close to the coast and in saline influenced habitats (Witteveen and Joosse 1987). *Hypogastrura viatica* has been recorded

from sub-Antarctic Marion Island, the Crozet Islands and Kerguelen archipelago, as well as being invasive on Macquarie Island and South Georgia (Deharveng, 1981; Greenslade and Convey 2012). However, impacts of invasive Collembola upon indigenous species remain poorly understood, although they are likely to be complex. *Hypogastrura viatica* has not been recorded from Heard Island; however, a risk assessment for Collembola invading sub-Antarctic Heard Island found *H. viatica* to be the highest risk species of the 20 assessed (Greenslade 2002; Greenslade et al. 2012). Collections made in the South Shetland Islands and Palmer Archipelago in the late 19th and early 20th Centuries did not detect *H. viatica* (Greenslade 2010). However, it was first recorded from Deception Island in 1949 (Hack, 1949), which is an area subject to considerable historic and current human activity, leading to the suggestion that the species was introduced to the region around this time (Wise, 1967). Within the Antarctic Treaty area, *H. viatica* has been reported from five popular visitor sites on the Antarctic Peninsula and its offshore islands (Wise 1971; Greenslade, 1995; Russell et al. 2013; Hughes et al. 2015). The most southerly report of the species was from collections made on Léonie Island, Ryder Bay, Marguerite Bay (c. 68°S), by W. Block in 1993, where *H. viatica* was found in vegetation and soil samples collected from a coastal terrace with moss and the grass *Deschampsia antarctica* (Greenslade 1995). There is no information on the possible source of the species on Léonie Island. Since then, other non-native invertebrates, such as the fly *Lycoriella* sp. living synanthropically within Rothera research station and several species including the springtail *Setocerura georgiana* and chironomid *Eretmoptera murphyi* from and native to South Georgia, have been accidentally introduced to Rothera Point, but have either not established or have been removed (Hughes et al. 2005, 2010).

Léonie Island is located 9 km from Rothera Research Station, which was first constructed in 1974 and, since a major redevelopment in the mid-1990s, has included a crushed rock airstrip and wharf. It acts as logistic hub for movement of personnel and cargo

by aircraft and ship both inter-continentially and within the broader Antarctic region (see <https://www.bas.ac.uk/polar-operations/sites-and-facilities/>). Should *H. viatica* have extended its distribution to the environs of Rothera Research Station, there is clearly a risk of further anthropogenically-assisted intra-regional dispersal being possible from this logistic hub, potentially resulting in wider establishment and invasion. The aim of this study was to determine the continued presence of *H. viatica* on Léonie Island, and also whether the species has become distributed more widely in ice-free areas around Ryder Bay that are commonly visited by station personnel, thereby allowing an assessment to be made of the risk of further dispersal so that appropriate management action could be implemented (Convey and Smith 1997).

Material and methods

Between 13 and 23 January 2015, 138 soil and vegetation samples (including lichens, bryophytes (e.g. *Sanionia uncinata*, *Andreaea* spp., *Brachythecium austrosalebrosus* and *Polytrichastrum alpinum*) and vascular plants (*Deschampsia antarctica* and *Colobanthus quitensis*)) were collected across representative terrestrial and supralittoral locations on Rothera Point (36 samples), Anchorage Island (30 samples), Lagoon Island (18 samples) and Léonie Island (54 samples) (Figure 1) (see Convey and Smith (1997) for comprehensive site descriptions). These were rapidly (< 2 h) returned to the Bonner Laboratory (Rothera Research Station) for immediate extraction of invertebrate fauna using Tullgren funnel extractors (Burkhard Manufacturing Co. Ltd, Rickmansworth, UK). Although spatially explicit location data accurate to metre scale were not recorded for the original collections in which *H. viatica* were found, the described moss and grass habitat has very limited spatial distribution on Léonie Island, and we ensured that this habitat was sampled in the current

study. Specimens were preserved in 95% ethanol, returned to the UK by ship and then sent to co-author Dr. P. Greenslade (Federation University, Australia) for identification.

Results

A total of 36,796 specimens of Collembola were collected and the 34,490 adult specimens were identified. *Hypogastrura viatica* was not identified in any samples collected from the four locations. Three species were identified: *Cryptopygus antarcticus* (Willem 1901) (58.6%), *C. badasa* (Greenslade 1995) (25.7%) and *Friesea* sp. cf. *grisea* (9.4%).

Unidentified immature specimens comprised the remaining 6.3% of extracted specimens (see Table 1).

Discussion

Our targeted monitoring for *H. viatica* on the main islands in Ryder Bay and on Rothera Point, where Rothera Research Station is located, revealed no evidence of the presence of this non-native Collembolon. These data suggested that either *H. viatica* has become extinct in the area (i.e. was a transient non-native species) or that if still present in the area, it occurs either in sufficiently low numbers, or with a sufficiently spatially restricted distribution, for our monitoring programme to fail to detect it (c.f. the introduced enchytraeid worm *Christensenidrilus blocki* which is known to continue to occur at Signy Island, South Orkney Islands (Dózsa-Farkas and Convey 1997), but despite the large number of specific samples obtained in the most recent surveys carried out there, was only detected in low numbers close to the introduction site (Hughes and Worland 2010)).

Prior to this study, Marguerite Bay was thought to represent the southern extent of *H. viatica*'s confirmed range. Natural variability in local climatic conditions may have prevented *H. viatica* surviving more than a few years; however, it is capable of survival in

extreme Arctic environments and may be able to adapt to changing conditions including tolerance of low temperatures and humidities (Hodkinson and Bird 2004; Sørensen and Holmstrup 2011). An ecophysiological and modelling study of the non-native South Georgian flightless midge *Eretmoptera murphyi*, introduced to Signy Island, South Orkney Islands, suggests that microhabitat conditions may be appropriate for establishment of it and other non-native invertebrates originating from the sub-Antarctic islands across much of the Scotia Arc, Antarctic Peninsula and its offshore islands, including as far south as the ice-free areas in and surrounding Marguerite Bay (Hughes et al. 2013). As *H. viatica* is well-established and invasive on South Georgia (Convey et al. 1999) it seems unlikely that its continued presence in the Rothera area would be limited by local climatic conditions.

Our study confirmed the presence of the three common Collembola species known from the region; however, *Isotoma (Folsomotoma) octooculata* recorded in a single sample from Léonie Island during a study undertaken during the 1994/95 summer season (Convey and Smith 1997) was not detected. The 1994/5 study also found no specimens of *H. viatica*.

Given the difficulty in ‘proving a negative’, i.e. that *H. viatica* is no longer present in the area, the precautionary principle has been adopted by the British Antarctic Survey, and the strict biosecurity precautions that were in place for those travelling between Rothera Point and locations in Ryder Bay will continue to be implemented. Should *H. viatica* still persist in this area, these precautions will reduce the risk of this non-native species being transported to Rothera Point and then potentially on to other locations by either ship or aircraft. The biosecurity precautions will also reduce the risk of any other non-native species that may arrive at Rothera following either inter-continental or within-Antarctic transport being translocated to the local islands, which are of substantial scientific interest. Based on this example, we would recommend further monitoring of the status of non-native invertebrates at

other known introduction sites on the Antarctica Peninsula and Scotia Arc, particularly those that receive high levels of tourist and national operator visitation (Hughes et al. 2015).

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Figure 1. Map of sample locations (white circles) on Rothera Point and the Ryder Bay

Islands

249 Table 1. Percentage of Collembolon species found on the Ryder Bay islands and Rothera
 250 Point

	<i>Cryptopygus</i> <i>antarcticus</i>	<i>Friesea</i> sp. cf. <i>grisea</i>	<i>Cryptopygus</i> <i>badasa</i>	Unidentified immature Collembola
Léonie Island	61.6%	8.6%	28.0%	1.8%
Lagoon Island	77.4%	1.7%	3.5%	17.4%
Anchorage Island	52.6%	11.5%	29.2%	6.7%
Rothera Point	72.0%	5.7%	16.9%	5.5%

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