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Collembola fauna of the South Shetland Islands revisited

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Abstract: A review of the collembolan fauna of the South Shetland Islands is presented. *Cryptopygus nanjiensis* Yue & Tamura is synonymized with *C. antarcticus* Willem. A record of *Tullbergia mediantarctica* Wise from King George Island is considered a misidentification of *Tullbergia mixta* Wahlgren and *Tillieria penai* Weiner & Najt, described from the same island, is synonymized with *T. mixta*. The current fauna stands at eleven species, of which at least three are introduced. A checklist of Collembola currently considered to occur in the South Shetland Islands is supplied with distributional data.

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Key words: *Cryptopygus*, *Folsomotoma*, *Friesea*, *Hypogastrura*, invasive species, *Protaphorura*, quarantine controls, *Tillieria*, *Tullbergia*

Introduction

The South Shetland Island archipelago is located *c.* 120 km north of the Antarctic Peninsula in the Southern Ocean at 62°0'S, 58°0'W and has a total area of nearly 4000 km^2 being 80% glaciated (Fig. 1a). The group consists of a chain of several islands and includes many rocky stacks and small islets. The eleven major islands from north to south are: Elephant Island, Clarence Island, King George Island, Nelson Island, Robert Island, Greenwich Island, Livingston Island, Snow Island, Smith Island, Deception Island and Low Island (Fig. 1b). The outlying Hoseason Island, Trinity Island, Brabant Island and Anvers Island to the south, are not included in the group. Some of the islands are of volcanic origin and there is an active volcano on Deception Island. More than a dozen nations operate stations in the group and most of them are situated on King George Island. Chile owns the largest number of stations of which one has been permanently occupied since 1944. A whaling station was operating on Deception Island between the years 1912 and 1931.

The vegetation consists of bryophytes, such as mosses and lichens, as well as algae and has been described in detail for King George Island by Lewis Smith (1988). The horseshoe-shaped flooded caldera of Deception Island is subject to periodic volcanic eruptions which have been known to cover nearly all the island in ash; the last eruption was in 1971. The island still has many active fumaroles in the Central Bay which is warmer than other parts of the South Shetland Islands and the surrounding land carries a slightly different flora to the rest of the island (Izagguirre *et al*. 2006).

The South Shetland Islands are more easily accessed than other parts of the Antarctic Peninsula and continent because of their less severe weather and proximity to a temperate continent, South America, so it is not surprising that Collembola were collected from these islands by the earliest Antarctic scientific expeditions. The main islands from which Collembola have been collected are: Deception Island, Livingston Island and King George Island. Because taxonomists from a variety of nationalities (Australian, Belgian, British, Chinese, French, German, Polish, Russian, Swedish) have described species from this region, some of whom did not have access to the older literature, a few anomalies have emerged in the species names described and recorded. This paper attempts to remove the anomalies by synonymising one species, correcting misidentifications and providing a list of those species currently considered to comprise the fauna of the South Shetland Islands.

Historical background

The following publications have included records of Collembola from the South Shetland Islands: Wahlgren (1906), Gressitt & Weber (1959), Gressitt (1967), Tilbrook (1967), Wise (1967, 1971), Weiner (1980), Greenslade & Wise (1984), Bulavintsev (1990), Weiner & Najt (1994), Greenslade (1995), Ohyama & Shimada (1998), Downie *et al*. (2000) and Yue & Tamura (2001). Ohyama & Shimada's (1998) species records are not reliable as the authors state that their study was not 'taxonomically stressed' and congeneric species were not distinguished. The list of species from maritime Antarctica given by Hogg & Stevens (2002) should be disregarded as it contains numerous errors. The species recorded by each author are listed below and their total distributions given in Table I. Only relevant synonyms are provided.

Systematics

HYPOGASTRURIDAE

Hypogastrura viatica (Tullberg, 1872)
=*Hypogastrura antarctica* Salmon, 1962

The first record of this species in the South Shetland Islands was by Hack (1949) who collected specimens between

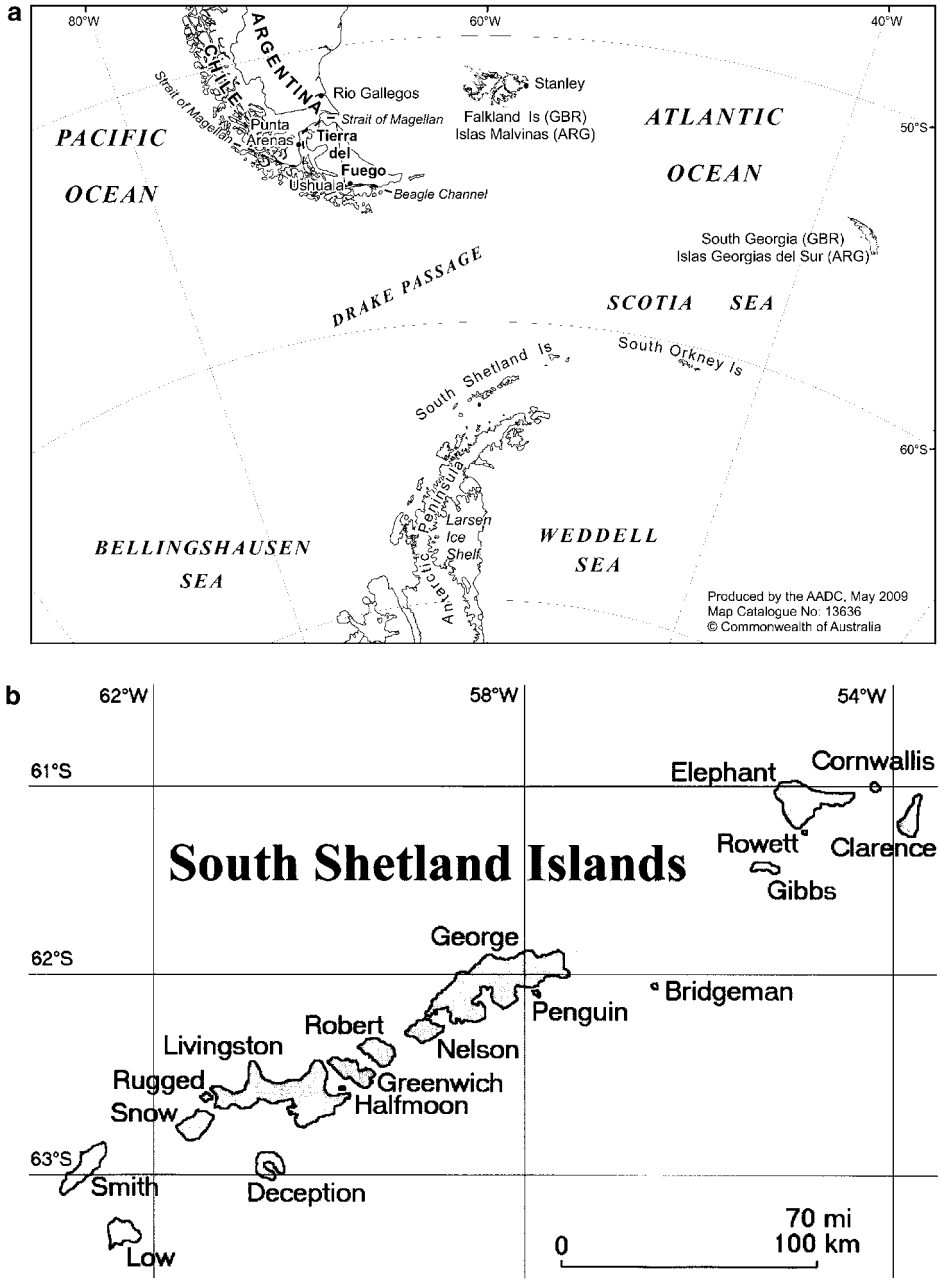

Fig. 1. a. Location of South Shetland Islands. (©Australian Antarctic Division). **b**. South Shetland Island chain. (Anon. http://upload.wikimedia.org/wikipedia/commons/7/7c/South_Shetland_Islands_Map.pn).

December 1948 and January 1949 from a whale carcass lying on soil warmed by fumaroles on Deception Island. Tilbrook (1967), Wise (1967) and Greenslade & Wise (1984) confirmed the record. Wise (1971) recorded the species from Tower Island, Palmer Archipelago (collected in 1966) and Greenslade (1995) recorded *H. viatica* from Leonie Island near Adelaide Island extending its distribution further south.

Salmon (1962) described *H. antarctica* from Deception Island based on leg morphology. Wise (1971) synonymized *H. antarctica* with *H. viatica* showing that leg morphology did not differ between the two species.

Hypogastrura viatica is a cosmopolitan species mainly found in saline or polluted habitats (Greenslade 2006). Where it occurs, this species tends to be very abundant, particularly supralittorally. It is surprising then that the earlier collecting expeditions of the late 19th and early 20th century did not collect it from the South Shetland Islands or Palmer Archipelago and its first record was only in 1949 from the heavily visited Deception Island some 50 years later. Wise (1967) suggested that the species was introduced and only invaded the region in the mid 20th century. *Hypogastrura viatica* was first recorded much earlier on Macquarie Island in collections made in 1901

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Table I. Checklist of species currently considered to be present in the South Shetland Islands with distributions.

Family	Species	Distribution	Status in South Shetland Islands
Tullbergiidae	*Tullbergia mixta* Wahlgren, 1906	South Shetland Islands only	endemic
Hypogastruridae	*Hypogastrura viatica* (Tullberg, 1872)	Cosmopolitan but not yet found on the Antarctic Continent or on some sub-Antarctic islands	exotic
Onychiuridae	*Protophorura fimata* (Gisin, 1952)	Deception Island, Macquarie Island, otherwise cosmopolitan except for Antarctic and other sub-Antarctic islands	exotic
Neanuridae	*Friesea grisea* (Schäffer, 1891)	South Georgia otherwise currently considered widespread in maritime and continental Antarctica	native
Neanuridae	*Friesea woyciechowskii* Weiner, 1980	King George Island, South Orkney Islands	native
Isotomidae	*Cryptopygus antarcticus antarcticus* Willem, 1901	Maritime Antarctica, South Orkney Islands and unconfirmed records from sub-Antarctic islands, Australia, New Zealand	native
Isotomidae	*Cryptopygus badasa* Greenslade, 1985	Livingston Island, Alexander Island, Adelaide Island, South Georgia	native
Isotomidae	*Crytopygus caecus* Wahlgren, 1906	Deception Island and sub-Antarctic, South Africa, Australia, New Zealand, South America (except for Antarctic continent)	native
Isotomidae	*Archisotoma brucei* (Carpenter, 1907)	Maritime Antarctica, South Orkney Islands and sub-Antarctic islands, New Zealand	native
Isotomidae	*Folsomotoma octooculata* (Willem, 1901)	Maritime Antarctica, South Orkney Islands	native
Isotomidae	*Folsomia candida* Willem, 1902a	Deception Island only, otherwise cosmopolitan except for Antarctic and sub-Antarctic regions	exotic

(Greenslade & Wise 1986) but there had been almost continuous sealing activity on that island from the early part of the 18th century with many vessels visiting (Greenslade 2006). The species can survive for long periods and even reproduce floating on or in seawater and also freshwater and it is thought that this ability has contributed to its wide distribution (Mertens *et al*. 1983, Witteveen & Joose 1988). The species can almost certainly also be carried on debris on ships hulls and on floating debris such as algae and may be still extending its geographical range in a southerly direction with climate warming and increasing shipping activity.

TULLBERGIIDAE

Tullbergia mixta Wahlgren, 1906
= *Tillieria penai* Weiner & Najt, 1994 syn. nov.

Wahlgren (1906) described *T. mixta* from Nelson Island. Later records from the South Shetland Islands were made by Gressitt & Weber (1959), Gressitt (1967), Tilbrook (1967), Wise (1967, 1971). More recently, Greenslade (1995) recorded the species from Livingston Island and Ohyama & Shimada (1998) also recorded it from the Fildes Peninsula, King George Island. The species appears to be endemic to the South Shetland Islands. Bulavintsev (1990) recorded an unidentified *Tullbergia* sp. from the Fildes Peninsula, King George Island that was probably *T. mixta*.

Weiner & Najt (1994) described a new species, *Tillieria penai,* from King George Island but did not state how it differed from *T. mixta* or even mention this species. The genus *Tillieria* Weiner & Najt, 1991, is closely related to *Tullbergia* Lubbock and was erected for two species from New Caledonia. It was originally characterized by the possession of a small, simple, apical bulb on antenna IV, small anal spines on abdomen VI and pseudocelli of type I (Weiner & Najt 1991) with 8–10 branches and a border of 4–6 rows of compact, primary cuticular granules as well as on its pseudocellar formula. These characters may not have validity at generic level. Deharveng (1981), in a detailed description of the type of the genus, *Tullbergia antarctica* Lubbock and related sub-Antarctic species, *Tullbergia bisetosa* Lubbock, *Tullbergia maxima* Deharveng and *Tullbergia crozetensis* Deharveng, stated that there is intraspecific variation in the length of the anal spines and papillae from which they arise. Furthermore, Deharveng's figures indicate that all the four species have apical bulbs on antenna IV which could be considered small being only a tenth of the width of antennal segment IV, the same ratio as for *Tillieria* species. Moreover, the pseudocellar formula can be variable as shown by Greenslade & Wise (1986) where 30% of specimens of *T. templei* Wise, were asymmetric in this character. Although, from the figures, the pseudocelli of the genus type, *Tillieria insularis* Weiner and Najt, 1991 are drawn with two (not 4–6) rings of slightly enlarged cuticular granules, it is not clear from Deharveng's figure that *Tullbergia* species do not have a similar structure. *Tullbergia* sp. cf. *templei*, which is similar to *T. penai* in form of claw, pseudocelli formula and postantennal organ tubercle number, was recorded by Deharveng (1981) from Heard and Kerguelen but this author did not consider erecting a new genus for this form. Deharveng noted only that his specimens were well characterized within the genus *Tullbergia* Lubbock. The validity therefore of *Tillieria* is questionable based on these characters alone.

Greenslade (1995) recorded and redescribed *T. mixta* from Livingston Island, *c.* 50 km from the type locality. Comparing the figures of *T. penai* with the redescription of *T. mixta* from

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Table II. Differentiating characters for the genera *Tullbergia* and *Tillieria* according to Weiner & Najt (1991) with comments.

Character	*Tullbergia* a/c Deharveng (1981)	*Tillieria* a/c Weiner & Najt (1991)	*T. penai* a/c Weiner	*T. mixta* a/c Greenslade (1995)	Comment
Ant IV apical bulb type	trilobed	trilobed, bilobed or simple	trilobed	tendency to be trilobed	variable character
Ratio apical bulb width: ant IV width	1:10 from figures	small, 1:10 from figures	unknown	1:10	not discriminating
Ant III organ	with cuticular fold	without cuticular fold	without cuticular fold	with slight cuticular fold	character not distinct
Pseudocelli type (Weiner & Najt 1991)	I	I but surrounded by 4–6 rows primary granules very close together	I	I	character not clear
Pseudocelli formula	variable	11/001/01011	11/001/01011	11/001/01011	variable character
Postantennal organ vesicles	50–100	48–64	30–50	22–58	considerable variation
Ratio anal spines:claw	0.85–1.35	0.29–0.38	0.48	0.43	possible distinguishing character

Livingston Island (Greenslade 1995), no differences in any feature can be found except for p3 on abdomen I being apparently absent from *T. mixta* but this is likely to be a variable character. Following Deharveng (1981), and taking into consideration the intraspecific variation in the characters that are stated to define the genus *Tillieria*, its morphology and its distribution, I reassign *T. penai* to the genus *Tullbergia*. I hereby further synonymize *T. penai* with *T. mixta* because of the lack of characters to separate them (Table II) and their identical distributions.

Wise (1971) noted that *T. mediantarctica* Wise, 1967, *T. mixta* and what is now *T. templei* formed a closely related group because of a similar number of tubercles on the postantennal organ and the arrangement and form of pseudocelli. The short spine laterally on the thorax, originally noted by Wise for this group, is not a group specific character. Although Greenslade (1995) noted that *T. mixta* from Livingston Island did conform to Weiner & Najt's (1991) diagnosis for *Tillieria*, she did not reassign the species at that time to that genus as it was doubtful that the genus had validity based on a morphological phylogeny (Greenslade & Rusek 1996). Greenslade (1995) further noted that it was not clear whether species assigned to *Tillieria* represented a genus, subgenus or species group within *Tullbergia* and that the decision as to its status must await further morphological as well as molecular analyses.

The most recent taxonomic work on the South Shetland Islands fauna was based on a collection made in 1967 from Fildes Peninsula, King George Island (Yue & Tamura 2001), where *T. mediantarctica* was recorded and briefly described from this locality. The species had only previously been recorded from Shackleton Glacier at 84°30'S some 3000 km south. Although Lugg *et al.* (1978) recorded *T.* cf. *mediantarctica* from Bishop Island, off Macquarie Island, these specimens were later shown to be *T. templei* (Greenslade & Wise 1986). Yue & Tamura (2001) noted that the number of tubercles in the postantennal organ was 25–27 in their specimens compared to 40–50 for *mediantarctica* but this character is variable (Greenslade 1995). They also note that the setae on the genital aperture differed but they do not make a study or comparison of the chaetotaxy of their specimens with *T. mixta* nor with *T. penai* or mention Greenslade's redescription of the species from nearby Livingston Island. It is not possible from Wise's and Yue & Tamura's figures to be clear about any differences in chaetotaxy of the genital aperture. Wise (1967), in his original description of *T. mediantarctica,* states that the species possesses a setose unguiculus (empodial appendage) that is absent from *T. mixta.* (Wise may be confused here as he says 'on each side' and he does not have a figure of the structure. His types should be examined). The claw of the Yue & Tamura specimens is figured lacking a setose unguiculus. It is considered here that the Yue & Tamura (2001) record is a misidentification for *T. mixta* taking into consideration its distribution and the lack of characters to

separate them as suggested earlier (P. Greenslade, personal communication in Stevens & Hogg (2006)).

ONYCHIURIDAE

Protaphorura fimata (Gisin, 1952)

Greenslade & Wise (1984) examined collections made by Temple from Deception Island and published a new record of an *Onychiurus* species from the island. Specimens have been re-examined and found to have simple vesicles in the postantennal organ, a furcal remnant present as a small flap, a pseudocelli formula of 3,3/0,2,2/3,3,3,3,3, pseudocelli on precoxa of legs II and III, no s setae on abdomen V and divergent m and a (prespinal) setae on abdomen VI. Specimens conform to *P. fimata* following Fjellberg (1998). This species has a cosmopolitan distribution and occurs in moist, disturbed habitats where organic matter is high. On Deception Island it was collected under whale bones on Whalers' Beach which is geothermally warmed.

NEANURIDAE

Friesea grisea (Schäffer, 1891)
Tullbergia grisea Schäffer, 1891
=*Achorutoides antarcticus* Willem, 1901

Records from the South Shetland Islands of this species include Wahlgren (1906), Gressitt & Weber (1959), Gressitt (1967), Tilbrook (1967), Wise (1967, 1971), Bulavintsev (1990), Ohyama & Shimada (1998) and Downie *et al*. (2000) (the latter authors spelling the genus incorrectly as *Freisia*).

Friesea grisea was first described from South Georgia, however the description was brief and many subsequent records and redescriptions have been made from locations distant from South Georgia. For instance, a redescription of the species by Salmon (1949) was based on material from the American "East Base". Denis (1946) recorded *Friesea grisea* from August Island, Gerlache Strait and illustrated the mouthparts and Greenslade (1995) figured specimens from Livingston Island. The species has not been recollected from South Georgia recently despite several surveys. The true identity of this species therefore remains in doubt.

An examination of type specimens borrowed from Hamburg indicates that three specimens of two different species were present in Schäffer's type series, one appeared to be a *Tullbergia* species and the other two possibly belong to the genus *Friesea*. All three were sealed in alcohol in a small tube and labelled "*Pseudotullbergia grisea* Schäffer, (*Tullbergia grisea*, *Friesea grisea*) - 1 Röhrchen, Typenmaterial (2 Expl.) Collembola", and it was not possible to mount them. Slides of *F. grisea* from South Georgia collected by M. Clagg in 1964 deposited in the Auckland Institute and Museum, showed some morphological differences from specimens from the Antarctic Peninsula, in that they were larger and the chaetotaxy of abdomen VI differed. However other details of chaetotaxy could not be determined from the uncleared specimens and fresh material is needed to resolve this issue. A full understanding of the true identity of this species awaits detailed examination of specimens from type locality especially as there is now doubt that only single species has been included in its records.

Willem (1901) described *Achorutoides antarcticus* from Harry Island, Gerlache Strait which was synonymized with *F. grisea* by Wahlgren (1906) after examining the mouthparts and furca. At the same time Wahlgren recorded the species from Nelson Island. As the true identity of *F. grisea* has not been established, it is possible that the South Georgian specimens and the South Shetland Islands specimens represent different species.

Friesea woyciechowskii Weiner, 1980

Weiner, 1980 described *Friesea woyciechowskii* from King George Island and Yue & Tamura (2001) also recorded this species from the same island noting that their specimens were different in some aspects of morphology. The species has also been recorded from South Orkney Islands (Usher & Edwards 1984).

ISOTOMIDAE

CRYPTOPYGUS WILLEM

Type species: *Cryptopygus antarcticus* Willem, 1902b
Rusek (2002) redefined *Cryptopygus* basing his description on specimens he identified as *C. antarcticus*, seemingly collected on King George Island but the precise locality was not given. He stated that his 'narrower than Deharveng's (1981) conception of the genus' meant that there were no European representatives. One problem was that one of the diagnostic characters Rusek uses is ambiguous (mucro long). Rusek (2002) did not document the material he examined nor give a list of species which he considered belonged in the genus using his new diagnosis. In spite of Rusek's (2002) paper, Bellinger *et al*. (2009) lists nearly 86 species names in the genus from all continents (some are known synonyms).

Cryptopygus antarcticus antarcticus Willem, 1901
=*Cryptopygus crassus* Carpenter, 1907
=*Cryptopygus nanjiensis* Yue & Tamura, 2001 nov. syn.

Willem described *Cryptopygus antarcticus* from a range of localities in the Gerlache Strait, all *c.* 200 km south of the South Shetland Islands (Augustus Island, Harry Island, Danco Territory, Brabant Island, Cap van Beneden, Ile de Cavelier de Cuverville, Wiencke Island and Bob Island). No type locality was designated. Records from the South Shetland Islands were later made by Wahlgren (1906), Gressitt & Weber (1959), Gressitt (1967), Tilbrook (1967), Wise (1967), Greenslade & Wise 1984, Bulavintsev (1990), Ohyama & Shimada (1998) and Downie *et al*. (2000). Salmon (1949) added to the description as did Greenslade

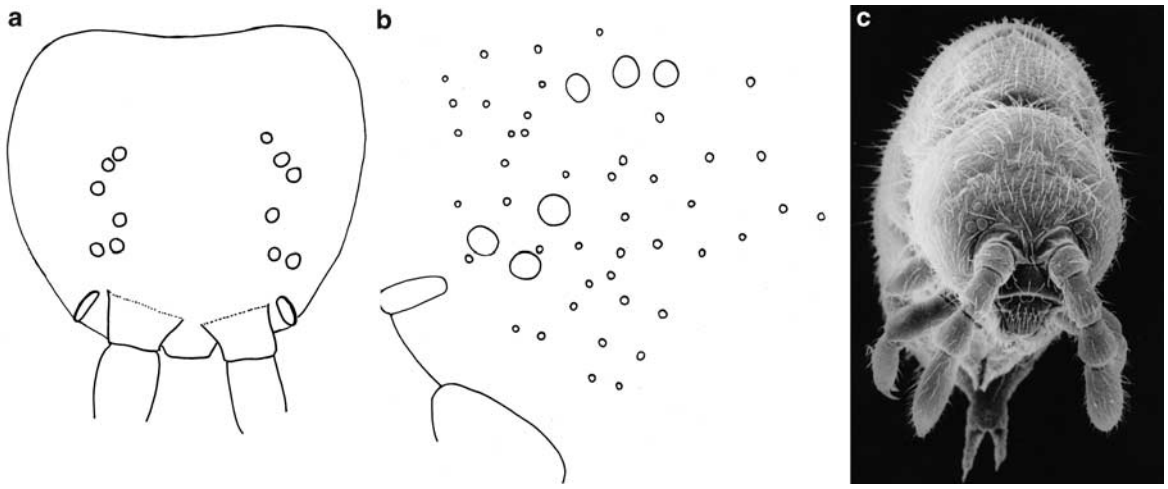

Fig. 2. a. Head of paratype of *C. nanjiensis* showing position of ocelli. **b.** Head of paratype of *C. nanjiensis* showing setal insertions, postantennal organ and ocelli. **c.** Scanning electron micrograph of *C. antarcticus,* head width 0.2 mm.

(1995), the latter based on material from some of the same localities as used in the original description.

Cryptopygus crassus was described from the South Orkney Islands where it was abundant. Carpenter (1907) distinguished it from *C. antarcticus* on having 6 + 6 ocelli but it was synonymized with *C. antarcticus* by Folsom in Ewing (1922). Ivanoff (1913) first showed that *C. antarcticus* (spelling it incorrectly as *Cryptopigus*) had 6 + 6 ocelli and not the 7 + 7 as given in the original description. As *C. crassus* was described from the South Orkney Islands, molecular studies may indicate that the species does differ from *C. antarcticus* as has been found for other southern oceanic islands (Stevens *et al*. 2006).

Deharveng (1981) published the latest morphological study of the species, dividing it into four subspecies. On molecular data, Stevens *et al*. (2006) showed that two of the subspecies, *reagens* Enderlein, 1909 and *travei* Deharveng, 1981 are not closely related to *C. a. antarcticus* from the type locality and are given full species status here as *Cryptopygus travei* Deharveng, 1981 and *Cryptopygus reagens* Enderlein, 1909, as suggested in Stevens *et al*. (2006). The status of the fourth subspecies, *C. a. maximus* Deharveng, 1981, is not clear and so it is maintained as a subspecies of *C. antarcticus* Stevens *et al*. (2006). It should be noted from the same paper that Macquarie Island is shown to have three species/subspecies in the group, one is *maximus*, one the same as a distinct species on Heard Island and one apparently endemic to the island. The three species appear have different distributions and ecological requirements and should be individually determined in any ecological study.

Based on a collection made in 1967 from Fildes Peninsula, King George Island, Yue & Tamura (2001) described *Cryptopygus nanjiensis* as new. The authors distinguished *C. nanjiensis* from *C. antarcticus* on the basis of three characters only: lacking ocelli, ventral tube (they mistakenly say retinaculum) with 3 distal setae (they figure 3 + 3) and 4 + 4 basal setae (they figure 3 + 4) and with 1,2,2 clavate tenent hairs respectively on legs I, II and III. It was also pigmented black. Deharveng (1981) redescribed *C. antarcticus antarcticus* with 3 + 3 laterodistal and 6 (5-8) posteriobasal setae on the ventral tube and clavate hairs on legs I, II and III as 1,2,2 respectively exactly as for *C. nanjiensis* although this author based his description on material of *C. antarcticus* from Îles Kerguelen.

There are 26 slides carrying *c.* 100 specimens of *C. nanjiensis* in the Shanghai Institute of Plant Physiology & Ecology. Six ocelli on each side of the head in the typical arrangement of 3 anterior and 3 posterior have been observed all those specimens that were cleared sufficiently for observation yet not over cleared (Fig. 2a & b). The ocelli size and position and head chaetotaxy have been compared with *C. antarcticus* from the Antarctic Peninsula from close to the type locality and no differences can be detected (Fig. 2c). No other Collembola are known that lack ocelli but which are pigmented black as it is physiologically improbable. I therefore consider that, due to the very dark pigment normally found in these Antarctic organisms, the authors were unable to detect the ocelli. Numerous specimens of *C. nanjiensis* were found and it is known that *C. antarcticus* occurs on the Fildes Peninsula of King George Island in great abundance (Bulavintsev 1990, Ohyama & Shimada 1998). This is also strong evidence pointing to *C. nanjiensis* being synonymous with *C. antarcticus*. Ohyama & Shimada (1998) collected from sites on the Fildes Peninsula adjacent to the Chinese permanent Great Wall Station from where the Yue & Tamura (2001) material was obtained. Based on its morphology and distribution, *C. nanjiensis* is synonymized with *C. antarcticus* here as suggested earlier (P. Greenslade, personal communication quoted in Stevens & Hogg (2006)).

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This species is probably the most abundant and widespread species on in the maritime Antarctic region and consequently the most studied and numerous papers have been published on its habitat, reproduction and feeding behaviours and cold temperature adaptation (Haward *et al*. 2004, Bokhorst *et al*. 2007, 2008, Schulte *et al*. 2008, Elnitsky *et al*. 2008, Benoit *et al*. 2009, Day *et al*. 2009) and its complete mitochondrial genome has been described (Carapelli *et al*. 2008). Although Shao *et al*. (2000) stated that they sequenced mitochondrial DNA cytochrome oxidase II of this species (the use of the name *C. nanjiensis* in their paper was invalid), on reanalysis of the sequence, we found the data appeared anomalous. Molecular analyses of populations of *C. a. antarcticus* on the Peninsula and South Shetland Islands indicate that only one species is involved and that there has been stochastic dispersal and colonization events, some over long distances, but generally in a southerly direction from an ancestral source area in the South Shetland Islands (McGaughran *et al*. 2009). However, the relatively rapid and long distance dispersal events have largely obscured ancestral patterns. In contrast, populations of *Gomphiocephalus hodgsoni* Carpenter, a much-studied eastern Antarctic species, still retain ancestral links indicating a slower, less random expansion from isolated relictual populations. It was suggested that the differences between the two species was caused by different habitat preferences (McGaughran *et al*. 2009) but it is known that C. *a. antarcticus* is readily distributed both aerially on wind currents, as shown by catches in wind traps, and by rafting on water surfaces (Hawes *et al*. 2007a, 2007b). It is more likely that the difference is a result of differing mobilities, *C. a. antarcticus* is likely to be more vagile than *G. hodgsoni* based on their morphologies.

Cryptopygus badasa Greenslade, 1995

Greenslade (1995) recorded *C. badasa* from Livingston Island. Ohyama & Shimada (1998) also recorded Collembola from King George Island referring to Greenslade (1995) but not following the published taxonomic revision, misspelling the name as *badasu*. It is also found on Alexander Island, Adelaide Island and South Georgia (Convey & Lewis Smith 1997, Convey *et al*. 1999).

Cryptopygus caecus Wahlgren, 1906

Originally described from South Georgia, Wise (1967) recorded *C. caecus* from the South Shetland Islands for the first time (Deception Island) and Tilbrook (1967), Wise (1971) and Greenslade & Wise (1984) confirmed the record. Wise (1967) suggested it was introduced but it is may be native.

This species is the currently considered the most widespread *Cryptopygus* species with records from southern South America, southern Australia and New Zealand as well as several sub-Antarctic islands. A molecular analysis has not been carried out on the different populations which might reveal that cryptic species, or even subspecies, are present.

Archisotoma brucei (Carpenter, 1907)
Isotoma brucei Carpenter, 1907

This species was described from Laurie Island, South Orkney Islands where it was abundant on a penguin carcass. Gressitt (1967) and Wise (1967) first recorded *A. brucei* from Deception Island and the latter author described the mouthparts and ocelli (Wise 1971). Other records from the South Shetland Islands were Tilbrook (1967), Greenslade & Wise (1984), Greenslade (1995) and Downie *et al*. (2000). The latter authors recorded the habitat of *A. brucei* as in vegetation. Although all species in the genus are strictly marine-littoral, individuals have been recorded in large numbers in traps set supralittorally on Heard Island and in Tasmania presumably blown in sea spray (Greenslade 1998 and unpublished data). Marine littoral species generally have more widespread distributions than terrestrial species because of habitat requirements and dispersal abilities.

Folsomotoma octooculata (Willem, 1901) *stat. nov.*

Isotoma octooculata Willem, 1901
Parisotoma octooculata (Willem, 1901): Salmon 1949
Isotoma (Folsomotoma) octooculata. Willem, 1901: Greenslade 1995

Willem (1901) described *Isotoma octooculata* from Harry Island, Cape van Benenden in Danco Land and Cavelier de Cuverville Island, all in the Gerlache Strait. No type locality was designated. Records from the South Shetland Islands were made by Enderlein, (1909), Gressitt & Weber (1959), Gressitt (1967), Wise, (1967, 1971) and Tilbrook (1967), Bulavintsev (1990), Greenslade (1995), Ohyama & Shimada (1998), and Downie *et al*. (2000).

Greenslade (1986) reassigned *I.* (*P.*) *octooculata* to the subgenus, *Folsomotoma* Bagnall. Following Potapov (2001), who raised several Palaearctic subgenera of *Isotoma* to generic status, the subgenus *Folsomotoma* is also given full generic status here.

Gressitt & Weber (1959) recorded *Isotoma octooculata kerguelensis* Enderlein from the South Shetland Islands but this record and that from Graham Land are certainly incorrect. The error is likely to have resulted from a misunderstanding of earlier records (Wise 1967). Deharveng (1981) showed that *I. octooculata octooculata* and *I.* (*P.*) *kerguelensis* are both good species, the latter endemic to Iles Kerguelen. *Isotoma octooculata gracilis* Carpenter, from the South Orkney Islands was considered by Denis (1947) to be unrecognizable.

Folsomia candida Willem, 1902b

The single record is from a moist site under whale bones warmed by fumaroles on Deception Island that was rich in organic matter (Greenslade & Wise 1984). This species was

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first described from a cave in Belgium and is now known to have a cosmopolitan distribution but is confined to moist sites where competition from other species is low or absent.

Discussion

The fauna of the South Shetland Islands is mainly composed of species belonging to the families Isotomidae and Tullbergiidae and the genus *Friesea*, as is typical for Antarctic and sub-Antarctic regions (Greenslade 2007). The numerically dominant genus overall is *Cryptopygus* although densities of *F. grisea* and *F. octooculata* have been shown to be over 40 000 and 16 000 m^{-2} respectively in some habitats compared to 4000 m^{-2} for *C. antarcticus* (Richard *et al*. 1994). Convey *et al*. (1996) described the ecological characteristics of the species found on the Livingston Peninsula noting that *Tullbergia* individuals are most abundant below the ground surface. As is also found on sub-Antarctic islands (Greenslade 2006), there is an exotic element, probably introduced by human visitations, consisting of three species, two of which are confined to a single site on Deception Island that has been heavily visited by scientists and tourists over many years (Table I). The native fauna comprises seven species but there may be more *Friesea* species yet to be discovered. The records of an unidentified *Cryptopygus* sp. and *Friesea* sp. by Bulavintsev (1990) from the Fildes Peninsula, King George Island probably refer to species described since 1990. The genus *Cryptopygus*, although shown to have radiated on sub-Antarctic islands and in southern Australia (Stevens *et al*. 2006), may only comprise three species in the South Shetlands Islands, one of which is widespread and abundant both in the South Shetland Islands and on the Antarctic Peninsula. One other species, being small, is likely to have been overlooked so may be more widespread than current records suggests.

The relatively large number of introduced species only on Deception Island is worth noting and it seems likely that the warm conditions there due to subterranean thermal activity has allowed colonisation by exotics on this heavily visited island (Downie *et al*. 2000). The island may act as a source site for further invasions of exotics under climate amelioration and increased tourism. On Macquarie Island, source populations have expanded from a greenhouse. Three exotic species, *Mesaphorura macrochaeta* Rusek, *Protaphoura fimata* and *Proisotoma minuta* Axelson, both earlier only known from the greenhouse to where they were introduced in peat moss imported for growing vegetables (Greenslade 1987), have recently been found in soil outside but near station structures in samples taken in 2007/08 (P. Greenslade unpublished results). A further exotic, *Isotomurus palustris* (Müller), was first collected in the summer of 2004 from near an original sealers settlement at Waterfall Gully, Lusitania Bay but is likely to been on the island some years in localized populations (P. Greenslade unpublished results). A different but congeneric species, *Isotomurus maculatus* (Schäffer), another exotic, has now been identified as an alien on Marion Island (P. Greenslade unpublished results) and also seems to have been on that island many years but is more widespread there. As an example of rapid spread of an exotic, *Lepidocyrtus violaceus* (Geoffroy), the species identity confirmed here for Macquarie, was first collected in 1967 only at Nuggets Point, near another sealers settlement, but thirty years later was widespread on the island (Greenslade 2006). All the five aliens on Macquarie mentioned above, are common in Tasmania and southeast Australia, appear to have been introduced to Macquarie Island from between 50 to 150 years ago and have spread from the original site since then to varying extents.

An improbable exotic Antarctic Peninsula record is that of *Isotoma* sp. by Carl (1907) from Hovgaard Island, Wilhelm Archipelago, as he compares his specimens to *Isotoma viridis* Bourlet and *Isotoma georgiana* Schäffer, but the specimens were probably *F. octooculata.*

A risk assessment for potential alien introductions of Collembola to Heard Island determined that species of Hypogastruridae were the most likely future immigrants there (Greenslade 2002). She suggested measures to reduce the likelihood of accidental introductions. The same risk assessment should be carried out both to and from the South Shetland Islands as it is important to maintain, and in fact increase, quarantine controls in the region to prevent further introductions because of the potential of these species to displace native species (Convey *et al*. 1999).

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