Some recent observations of woodlice (Isopoda: Oniscidea), millipedes (Diplopoda) and centipedes (Chilopoda) from artificially heated glasshouses

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Abstract

Heated glasshouses provide stable environmental conditions that allow introduced non-native species to exist well beyond their natural (outdoor) range. The woodlice, millipedes and centipedes of heated glasshouses are relatively well known in Britain with many species discovered in recent decades. Here we collate our recent observations, including six species of woodlice, four of millipede and two of centipede, that are characteristic inhabitants of heated glasshouses, including the first Welsh and Scottish records for the millipede *Poratia digitata*. Further surveys may reveal additional species.

Introduction

Heated glasshouses, such as those of botanic gardens and butterfly houses, provide stable environmental conditions, characterised by artificially maintained temperatures and irrigation, which typically provide relatively higher temperatures and higher humidity than observed in semi-natural or synanthropic habitats that occur outside in Britain. Woodlice (Isopoda: Oniscidea), millipedes (Diplopoda) and centipedes (Chilopoda), either as eggs, juveniles or adults, can be readily and unintentionally introduced along with soil and other substrates associated with imported plant material (Cochard, *et al.*, 2010; Stoev, *et al.*, 2010). Thus, introduced non-native ('exotic') species are able to thrive within heated glasshouses well beyond their natural (outdoor) range; species which otherwise would be unable to survive outdoors in our mild British climate.

The woodlice, millipedes and centipedes of heated glasshouses have been relatively well studied in Britain since at least the start of the 20th Century (Gregory, 2009; Lee, 2006; Barber, 2009). In recent decades collecting from heated glasshouses has become more popular, and several woodlice, millipedes and centipedes have been discovered new for Britain (e.g. Read, *et al.*, 2002; Lewis, 2007; Read, 2008; Gregory, 2014; Telfer & Gregory, 2018). Currently, eighteen species of woodlouse, eleven of millipede and seven of centipede have been recorded in Britain only from artificially maintained climates such as those found inside heated glasshouses (Lee, 2015; Telfer & Gregory, 2018). Many of these species are typically known from very few sites.

This paper collates recent observations made by the authors during a series of visits targeting a number of heated glasshouses across Britain between 2015 and 2017.

Localities surveyed

A total of seven sites were visited by the authors between 2015 and 2017 (Table 1). One site, Royal Botanic Gardens Edinburgh (RBGE), Midlothian, is in Scotland and was visited during the BMIG spring field meeting to Linlithgow. One site is in Wales: National Botanic Garden of Wales (NBGW), Carmarthenshire. The remaining five sites are in southern England: Living Rainforest (LRF), Berkshire; Cambridge Botanic Garden (CBG), Cambridgeshire; Birmingham Botanical Gardens (BBG), Warwickshire; Whipsnade Zoo (WZ), Bedfordshire; and Stratford Butterfly Farm (SBF), Warwickshire.

Where possible live specimens were collected and photographed by KL (e.g. see Figs. 1 and 2) and uploaded to the relevant species accounts on the BMIG website (www.bmig.org.uk).

Table 1: List of sites visited and glasshouses surveyed

Locality (Site)	Glasshouse	Code	Date	Grid Ref.	VC	Recorders
Royal Botanic Garden Edinburgh ~ RBGE	Arid House Fern House House 19 Tropical Orchids Montane Tropics Orchid & Cycad Temperate House Tropical Palm Wet Tropics	1a 1b 1c 1d 1e 1f 1g 1h 1i	10.iv.2015	NT 247 755	83	S.J. Gregory & K. Lugg NB: other BMIG members are also present, but their records are not available to the authors.
Living Rainforest ~ LR	Lowland Amazonica	2a 2b	12.i.2017	SU 537 764	22	S.J. Gregory & K. Lugg
Cambridge Botanic Garden ~ CBG	Tropical Forest Continents Apart Mountains	3a 3b 3c	19.i.2017	TL 454 572	29	S.J. Gregory & K. Lugg
Birmingham Botanical Gardens ~ BBG	Tropical House Subtropical House Mediterranean Arid House	4a 4b 4c 4d	24.i.2017	SP 048 854	38	S.J. Gregory & K. Lugg
Whipsnade Zoo ~ WZ	Butterfly House Discovery Centre	5a 5b	07.ii.2017	c. TL 00 17	30	S.J. Gregory, K. Lugg, A.R. Outen & M.G. Telfer
National Botanic Garden of Wales	Tropical Dome	6a 6b	06.vi.2016 27.ii.2017	SN 522 181 SN 522 181	46	S.J. Gregory K. Lugg
Stratford Butterfly Farm ~ SBF	Flight Area Insect City	7a 7b	10.xi.2017	SP 206 546	38	S.J. Gregory & K. Lugg

Table 2: Species of Woodlice recorded, and the glasshouses in which they were found.
For key to localities (maximum 7) and glasshouses (maximum 23) see Table 1. * = non-native species characteristic of heated glasshouses.

Locality & Glasshouse:	RBGE			LR	CBG			BBG				WZ		NB GW	SBF		No. locali-	No. glass-
Woodlice	**1d**	**1e**	**1f**	**2b**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**4d**	**5a**	**5b**	**6b**	**7a**	**7b**	**ties**	**houses**
Androniscus dentiger	#									#			#				**3**	**3**
Haplophthalmus danicus													#				**1**	**1**
*Styloniscid female indet.				#													**1**	**1**
**Styloniscus mauritiensis*[1]		#		#				#						#			**4**	**4**
**Anchiphiloscia pilosa*[2]												#					**1**	**1**
Philoscia muscorum							#										**1**	**1**
Oniscus aesllus asellus							#	#	#						#	#	**3**	**5**
**Trichorhina tomentosa*				#	#										#		**3**	**3**
Porcellio dilatatus											#			#	#		**3**	**3**
Porcellio scaber			#	#		#			#	#		#					**5**	**6**
Porcellionides pruinosus								#									**1**	**1**
**Nagurus cristatus*								#									**1**	**1**
Armadillidium nasatum				#	#		#								#		**3**	**4**
Armadillidium vulgare						#	#								#	#	**2**	**4**
**Reductoniscus costulatus*				#	#								#				**3**	**3**

[1]Previously reported by Gregory & Lugg (2018); [2]Previously reported by Telfer & Gregory (2018).

Woodlice Recorded

Fifteen species of woodlouse (Isopoda: Oniscidea) are recorded (Table 2), including six non-native species only found inside heated glasshouses in Britain: *Styloniscus mauritiensis* (Barnard) (Styloniscidae), an unidentified Styonliscid, *Trichorhina tomentosa* (Budde-Lund) (Platyarthridae), *Anchiphiloscia pilosa* (Budde-Lund) (Philosciidae), *Nagurus cristatus* (Dollfus) (Trachelipodidae) and *Reductoniscus costulatus* Kesselyák (Armadillidae). These six represent a third (33%) of Britain's 18 species of non-native woodlice characteristic of heated glasshouses (Lee, 2015; Telfer & Gregory, 2018) and are discussed below. Of the remaining 12 species that are not recorded by this survey, these have either not been seen in Britain since their initial discovery in the early- to mid-20th Century (Gregory, 2009) or are recent additions to the British list discovered at the Eden Project (Gregory, 2014).

Styloniscus mauritiensis (Fig. 1A) was previously only known from RBG Edinburgh where it was discovered in the mid-1980s. It was found to be still present in 2015, and three additional localities are added by this survey (as previously reported by Gregory & Lugg, 2018): the Living Rainforest, where it was found among rotting wood, the tropical glasshouse at Birmingham Botanical Gardens and the National Botanic Garden of Wales.

Females of an unidentified small (3mm in length) well pigmented styloniscid (Fig. 1B) were found at the Living Rainforest under leaf sheaths at the base of a banana plant (associated with *R. costulatus*). It is hoped to make a return trip to collect male specimens for positive identification.

Trichorhina tomentosa (Fig. 1C) is a well-known inhabitant of heated 'glasshouses' with six post 1980 localities given in Gregory (2009), varying from a confines of a heated cockroach cage to the vast expanse of the Eden Project Tropical Biome. Here we add three additional localities. At the Living Rainforest it was found within a rotting palm stump; at Cambridge Botanic Garden among chipped bark and under logs (associated with *R. costulatus*) in the tropical forest glasshouse and at Strafford Butterfly Farm it was collected from beneath low growing sprawling vegetation.

Anchiphiloscia pilosa (Fig. 1D) was first collected new for Britain by Mark Telfer from Whipsnade Zoo Butterfly House (Telfer & Gregory, 2018), where subsequent visits have found it to be well established among leaf-litter.

The only modern record for *Nagurus cristatus* (Fig. 1E) is from the Eden Project where it was collected between 2004 to 2010 (Gregory, 2014). Here we add an observation from the tropical glasshouse at Birmingham Botanical Gardens where it was collected from among accumulated leaf-litter at the base of a shallow depression.

Reductoniscus costulatus (Fig. 1F) is well known at Kew Gardens, where it has been recorded on several occasions (Gregory, 2009) and it has been recently recorded from Eden Project (Gregory, 2014). Here we report three additional locations. At the Living Rainforest it was found under a leaf sheath at the base of banana plant and among peaty 'soil' nearby. At Cambridge Botanic Garden it was found (associated with *T. tomentosa*) among chipped bark and under logs in the tropical forest glasshouse. It was also found, among detritus, at the (now closed) Whipsnade Zoo Discovery Centre.

Five additional woodlouse species, *Androniscus dentiger* Verhoeff (3 localities), *Haplophthalmus danicus* Budde-Lund (1 locality), *Armadillidium nasatum* Budde-Lund (3 localities), *Porcellio dilatatus* Brandt (3 localities) and *Porcellionides pruinosus* (Brandt) (1 locality) are frequently reported from inside glasshouses, although by no means confined to them (Gregory, 2009). The remaining four species, *Philoscia muscorum* (Scopoli) (1 locality), *Oniscus asellus* Linnaeus (3 localities), *Porcellio scaber* Latreille (5 localities) and *Armadillidium vulgare* (Latreille) (2 localities), are common and ubiquitous across much of Britain (Gregory, 2009). However, it is of note that these 'common' species were recorded in just a few of the surveyed sites, and typically in low numbers.

Figure 1: Some characteristic woodlice of heated glasshouses recorded during this survey. A) *Styloniscus mauritiensis* (from BBG); B) Unidentified Styloniscid female (LRF); C) *Trichorhina tomentosa* (SBF); D) *Anchiphiloscia pilosa*, (WBH); E) *Nagurus cristatus* (BBG); F) *Reductoniscus costulata* (LRF). For key to localities see Table 1 (images © Keith Lugg).

Millipedes Recorded

Eleven species of millipede (Diplopoda) are recorded (Table 3) of which four non-native species are found only inside heated glasshouses in Britain: *Oxidus gracilis* (C.L.Koch) (Paradoxosomatidae), *Cylindrodesmus hirsutus* Pocock (Haplodesmidae), *Poratia digitata* Porat (Pyrgodesmidae) and *Cylindroiulus salicivorus* Verhoeff (Julidae). These four represent about a third (36%) of Britain's eleven species of non-native millipede characteristic of heated glasshouses (Lee, 2015) and are discussed below. Of the additional seven heated glasshouse species that are not recorded by this survey *Prosopodesmus panporus* Blower & Rundle was recorded from Kew Gardens in 1975, and the remainder are recent discoveries in the UK, mainly from the Eden Project (Lee, 2015).

Oxidus gracilis is a well-known inhabitant of plant nurseries and botanic gardens across Britain (Lee, 2006). Thus, it is no surprise that this millipede was recorded from 13 glasshouses (of a total of 23; 56%) at all seven of the localities surveyed, often in good numbers.

Currently, *Cylindrodesmus hirsutus* (Fig. 2A) is known from 'tropical' glasshouses at Kew Gardens, Wisley Gardens and Eden Project (Lee, 2006; Lee, Barber & Gregory, 2019). Here we add Whipsnade Zoo, where it was recorded from both the Butterfly House and the (now closed) Discovery Centre.

Poratia digitata (Fig. 2B) has been reported from four localities in England, including repeated observations at Kew Gardens (Lee, 2006). Here we report the first Welsh and Scottish records from NBG of Wales and the Tropical Palm House at RBG Edinburgh, respectively.

Cylindroiulus salicivorus (Fig. 2C) was first reported from RBG Edinburgh in 1987 (Read, *et al*. 2002), who also note a second Scottish site, St Andrews Botanic Gardens. Here we confirm it continued occurrence at RBG Edinburgh in the Montane Tropics and Temperate glasshouses.

Choneiulus palmatus (Němec) (recorded from 12 glasshouses at 6 localities) and *Cylindroiulus truncorum* (Silvestri) (Fig. 2D) (from 5 glasshouses at 4 localities) are heavily synanthropic in the UK and are often found inside glasshouses (Lee, 2006).

Of the remaining five millipedes, *Polydesmus coriaceus* Porat*, Blaniulus guttulatus* (Fabricius) and *Cylindroiulus britannicus* (Verhoeff) (Fig. 2D) are common and widespread species occurring in a wide variety of habitats in Britain and Ireland (Lee, 2006). *Allaiulus nitidus* (Verhoeff) and *Cylindroiulus londinensis* (Leach) are widespread but uncommon in Britain. Although the former is known to have synanthropic tendencies, the latter (recorded from the RBGE Temperate House) favours woodland and is rare in Scotland (Lee, 2006).

Centipedes Recorded

Nine species of centipede (Chilopoda) are recorded (Table 4), of which two non-native species only occur inside heated glasshouses in Britain: *Tygarrup javanicus* (Attems) (Mecistocephalidae) and *Lamyctes caeculus* (Brolemann) (Henicopidae). These two represent a third (33%) of Britain's six non-native centipedes characteristic of heated glasshouses (Lee, 2015). Of the additional four heated glasshouse species not recorded by this survey *Dicellophilus carniolensis* has not been reported since early in the 20th Century and the remainder are relatively recent discoveries in the UK (Lee, 2015).

Tygarrup javanicus is currently known from four localities, including tropical glasshouses at Kew Gardens, Wisley Gardens and Eden Project (Barber, 2009; Lee, Barber & Gregory, 2019). Here we add an additional locality; the Living Rainforest (Lowland glasshouse) in Berkshire, where it was found among sparse leaf-litter.

Barber (2009) reports *Lamyctes caeculus* (Fig. 2E) from two sites (Eden Project and NBG of Wales). Here we add two additional localities; Cambridge Botanical Gardens and Whipsnade Butterfly House, where it was recorded among sparse leaf-litter.

Table 3: Species of Millipede recorded, and the glasshouses from which they were found.

For key to localities (maximum 7) and glasshouses (maximum 23) see Table 1. * = non-native species characteristic of heated glasshouses.

Locality & Glasshouse: / Millipedes	RBGE									LR		CBG		BBG			WZ		NBGW		SBF		No. localities	No. glasshouses
	1a	1b	1c	1d	1e	1f	1g	1h	1i	2a	2b	3a	3c	4a	4b	4c	5a	5b	6a	6b	7a	7b		
Blaniulus guttulatus						#	#	#	#														**1**	**4**
Choneiulus palmatus	#	#	#		#							#	#	#	#	#	#		#		#		**6**	**12**
Allaiulus nitidus			#																				**1**	**1**
Cylindroiulus britannicus	#	#					#			#	#	#			#				#			#	**6**	**9**
Cylindroiulus londinensis							#																**1**	**1**
**Cylindroiulus salicivorus*					#		#																**1**	**2**
Cylindroiulus truncorum										#	#	#			#		#						**4**	**5**
**Cylindrodesmus hirsutus*																	#	#					**1**	**2**
**Oxidus gracilis*	#	#		#					#	#	#	#		#	#		#	#	#		#	#	**7**	**14**
**Poratia digitata*								#												#			**2**	**2**
Polydesmus coriaceus						#	#					#					#						**3**	**4**

Table 4: Species of Centipede recorded, and the glasshouses from which they were found.

For key to localities (maximum 7) and glasshouses (maximum 23) see Table 1. * = non-native species characteristic of heated glasshouses.

Locality & Glasshouse: / Centipedes	RBGE							LR		CBG			BBG				WZ	NBGW		SBF		No. localities	No. glasshouses
	1a	1b	1c	1d	1f	1g	1i	2a	2b	3a	3b	3c	4a	4b	4c	4d	5a	6a	6b	7a	7b		
**Tygarrup javanicus*								#														**1**	**1**
Haplophilus subterraneus					#	#															#	**2**	**3**
Stenotaenia lineata						#																**1**	**1**
Cryptops hortensis			#	#			#					#	#		#			#		#		**5**	**8**
**Lamyctes caeculus*											#						#					**2**	**2**
Lithobius forficatus		#	#					#	#	#										#		**4**	**6**
Lithobius lapidicola	#	#												#			#					**3**	**4**
Lithobius melanops											#	#			#	#						**2**	**4**
Lithobius pilicornis																			#			**1**	**1**

Figure 2: Some characteristic millipedes and centipedes of heated glasshouses recorded. A) *Cylindrodesmus hirsutus* (WBH); B) *Poratia digitata* (RBGE); C) *Cylindroiulus salicivorus* (RBGE); D) *Cylindroiulus truncorum* (darker specimen) and *C. britannicus* (paler specimen) (LR); E) *Lithobius lapidicola* (note last pair of legs missing) (BBG); E) *Lamyctes caeculus* (WZ). For key to localities see Table 1 (images © Keith Lugg, except D, by Steve Gregory).

Lithobius lapidicola Meinert (Lithobiiidae) (Fig. 2D) has an interesting distribution in Britain. It is recorded from a handful of outdoor coastal sites in Kent and Suffolk, but also reported from glasshouses at RBG Edinburgh and in Dorset (Barber, 2009). Here we confirm its continued occurrence at RBG Edinburgh and report the collection of specimens from two additional sites; Birmingham Botanical Gardens and Whipsnade Butterfly House.

Stenotaenia lineata (C.L.Koch) is mainly known from a few outdoor synanthropic sites in south-east England (Barber, 2009), but has been recorded elsewhere. This includes RBG Edinburgh (A.D. Barber, pers. comm. to SJG) where we also found the species in 2015. *Lithobius pilicornis* Newport can be locally frequent in south-west England and south Wales. Here we record it from the NBG of Wales. The remaining four centipedes, *Cryptops hortensis* (Donovan) (recorded from 5 localities), *Haplophilus subterraneus* (2 localities), *Lithobius forficatus* Linnaeus (4 localities) and *L. melanops* Newport (2 localities), are common and widespread species occurring in a wide variety of habitats in Britain and Ireland (Barber, 2009).

Discussion

The distribution of species associated with heated glasshouses is not restricted by outdoor climatic factors, such as temperature or rainfall (as with native and naturalised species), but by their ability to disperse through human activity to new sites (i.e. as accidental imports). Thus, species associated with heated glasshouses may be recorded anywhere within Britain and Ireland, wherever appropriately heated and irrigated glasshouses, and opportunities for accidental introduction, exist.

During this survey about a third of the non-native 'exotic' woodlice, millipedes and centipedes that are found only inside heated glasshouses in Britain were recorded; i.e. six of 18 woodlouse species, four of 11 millipedes and two of six centipedes. A relatively large proportion of those species that were not recorded by this survey have either not been seen in Britain since their initial discovery in the early- to mid-20th Century (Lee, 2015) or are recent additions to the British list, such as those discovered at the Eden Project (Lewis, 2007; Read, 2008; Gregory, 2014).

A few of the non-native species characteristic of heated glasshouses, notably the millipede *Oxidus gracilis,* but also the woodlouse *Trichorhina tomentosa*, are widely recorded and are well documented within such artificially maintained envirnments (Lee, 2006; Gregory, 2009). However, many of these characteristic heated glasshouse species are typically known from very few sites and seem to be sporadically encountered, perhaps being less readily dispersed by human activity. Other species seem to have been under-recorded in the past, with a relatively high proportion of records made during these recent targeted surveys. This includes the woodlice *Styloniscus mauritiensis* and *Reductoniscus costulatus*: the millipedes *Cylindrodesmus hirsutus* and *Poratia digitata*; and the centipedes *Tygarrup javanicus* and *Lamyctes caeculus*. However, this may be a reflection of recent renewed interest in the fauna of heated glasshouses. Some species recorded appear (at the moment) to be one-off introductions, such as Mark Telfer's discovery of *Anchiphiloscia pilosa* at Whipsnade Zoo (Telfer & Gregory, 2018). Of course, it is possible that in time this, and other species, may be unintentionally spread to other sites in Britain.

Surveys of other heated glasshouses (botanic gardens, butterfly houses, etc.) throughout the British Isles are likely to prove interesting. Indeed, one is never sure which species may be found inside a given glasshouse, and additional species of woodlouse, millipede and centipede new for Britain undoubtedly await discovery. We hope that this article will encourage others to have a closer look at the Isopod and Myriapod fauna of heated glasshouses.

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