WOODLICE (ISOPODA: ONISCIDEA) FROM THE EDEN PROJECT, CORNWALL, WITH DESCRIPTIONS OF SPECIES NEW TO BRITAIN AND POORLY KNOWN BRITISH SPECIES

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ABSTRACT

The Eden Project, an extensive glasshouse complex covering 2.2 ha, has been stocked with thousands of introduced plant species and was opened in 2001. Woodlice samples collected from the Eden Project by various researchers between 2003 until 2010 have been identified and records collated. Fourteen species are recorded from the Rainforest Biome, four from the Mediterranean Biome and seven from the Outdoor Biome. Five species are recorded new to Britain: *Pseudotyphloscia alba* (Philosciidae), *Nagurus nanus* (Trachelipodidae) and *Gabunillo* n. sp. (Armadillidae) from the Rainforest Biome; and *Chaetophiloscia sicula* (Philosciidae) and *Lucasius pallidus* (Porcellionidae) from the Mediterranean Biome. Descriptions and figures based on specimens collected from the Eden Project are given for eleven species that are either new to Britain or have not been adequately described in the modern British literature.

INTRODUCTION

The woodlice (Isopoda: Oniscidea) of heated glasshouses have been relatively well studied in Britain, but much of the available information dates from the early to mid 20th Century (e.g. Edney, 1953). In later decades collecting from glasshouses, such as those of botanical gardens, has not been popular. Gregory (2009) reported twelve species of woodlice that can only survive in artificial climates in Britain, such as those maintained inside heated glasshouses.

In 2001 a new extensive glasshouse complex, the Eden Project, near the town of St Austell, Cornwall (SX 04-55-), was opened to the public. The site, constructed within a disused china-clay quarry, includes the world's largest 'greenhouse' (Smit, 2001) which comprises two artificial biomes which have been stocked with thousands of introduced plant species. The Rainforest Biome (formerly known as the Humid Tropical Biome) covers 1.5 ha (3.9 acres) and the Mediterranean Biome (formerly known as the Warm Temperate Biome) about 0.66 ha (1.6 acres). Invertebrate sampling within the Rainforest Biome was undertaken by the Entomology Department of the Natural History Museum, London, between 2003 and 2007. This resulted in the discovery of the armadillid woodlouse *Venezillo parvus* new to Britain (Gregory, 2009). In addition several millipedes new to Britain were collected (Read, 2008). However, other species, including a small pallid philosciid and a small trachelipodid remained unidentified. Surveys were also undertaken in the Mediterranean Biome by Tony Barber in 2005, which produced female specimens of an *Armadillidium* species and a *Chaetophiloscia* species, neither referable to known British species.

Further recording within the Eden project biomes was undertaking in April 2009 during the BMIG field meeting to Cornwall. Provisional results reported by Barber, Gregory & Lee (2010), only included millipedes collected from the outdoor gardens (the Outdoor Biome). No woodlice (or centipede) records were presented. However, Mark Telfer, who undertook extensive surveys within the Rainforest Biome on that date, found many species of woodlice that could not be readily identified using standard British identification keys (Hopkin, 1991 or Oliver & Meechan, 1993).

There remained many unanswered questions about the identity of the woodlice fauna occurring at the Eden Project. In April 2010 Mark Telfer, Darren Mann, and the author returned to the Eden Project to undertake two days of intensive field work within all three biomes: Rainforest Biome, Mediterranean Biome and Outdoor Biome (gardens). In addition, all available material collected from surveys undertaken between 2003 and 2010 (as described above) has been examined by the author. This report collates, and lists, records for all woodlice (Isopoda: Oniscidea) found at the Eden Project. Descriptions and figures are given, based on specimens collected from the Eden Project, of five species that are new to Britain. A further six species, that have not been adequately described in British literature (i.e. by Hopkin, 1991 or Oliver & Meechan, 1993), are also described.

WOODLICE RECORDED FROM THE EDEN PROJECT

To date 22 species of woodlice (Isopoda: Oniscidea) and one waterlouse (Isopoda: Asellota) have been recorded from the Eden Project Biomes. The species records are summarised in Tables 1, 2 & 3, which list the collector, year of collection and the number of specimens within the samples. Additional details of species records are given in the taxonomic listing presented below.

Outdoor biome

Despite the BMIG field trip to the Eden Project in 2009, no woodlice or waterlice records are reported by Barber, Gregory & Lee, (2010) from the Outdoor Biome (gardens). In 2010 a brief survey by the author recorded seven familiar British species from the gardens (Table 1).

TABLE 1: Woodlice and Waterlice recorded from the Outdoor Biome, Eden Project.
Collected by Steve Gregory (SG) in 2010. m = male, f = female

Family	Species Name	Status in UK	SG 2010
Asellidae	*Asellus aquaticus*	Native	mf
Trichoniscidae	*Androniscus dentiger*	Native	mf
Trichoniscidae	*Trichoniscus pusillus* agg.	Native	ff
Philosciidae	*Philoscia muscorum*	Native	mf
Oniscidae	*Oniscus asellus* ssp. o*ccidentalis*	Native	mf
Porcellionidae	*Porcellio scaber*	Native	mf
Armadillidiidae	*Armadillidium vulgare*	Native	mf

Mediterranean biome

Four species of woodlice have been identified from the Mediterranean Biome (Table 2). Despite the survey effort it is surprising (even disappointing) that more species were not found. However, this biome is rather dry and additional species, if present, may prove elusive. The most frequently encountered woodlouse in this biome was the ubiquitous *Porcellio scaber*. Surprisingly, considering the relatively favourable climate in this biome, no other known British species were found. However, two widespread 'Mediterranean' species have been discovered: *Chaetophiloscia sicula* (Philosciidae) and *Lucasius pallidus* (Porcellionidae). An as yet unidentified species of *Armadillidium* (Armadillidiidae) was also collected. *L. pallidus* was not discovered until 2010 and may have been overlooked during the 2005 survey. These three are new species records for Britain and Ireland.

TABLE 2: Woodlice recorded from the Mediterranean Biome, Eden Project, 2005 & 2010
Recorders: TB – Tony Barber; T-M-G -, Mark Telfer, Darren Mann & Steve Gregory.
m = male, f = female

Family	Species Name	Status in UK	TB 2005	T-M-G 2010
Philosciidae	*Chaetophiloscia sicula*	Non-native New to UK	1f	1m 5f
Porcellionidae	*Lucasius pallidus*	Non-native New to UK		1m 4f
Porcellionidae	*Porcellio scaber*	Native	4mf	40mf
Armadillidiidae	*Armadillidium* sp.	Non-native New to UK	5f	1m 4f

TABLE 3: Woodlice recorded from the Rainforest Biome, Eden Project, 2003 to 2010
Recorders: NHM – Natural History Museum, London; MT – Mark Telfer;
T-M-G -, Mark Telfer, Darren Mann & Steve Gregory. (HR) – collected Helen Read.
m = male, f = female, j - juvenile

Family	Species Name	Status in UK	NHM 2003	NHM 2004	NHM 2005	NHM 2007	MT 2009	T-M-G 2010
Styloniscidae	Styloniscidae sp.1	Non-native		1f				
Styloniscidae	Styloniscidae sp.2	Non-native					1f (HR)	
Trichoniscidae	*Haplophthalmus danicus*	Native					20mf	
Platyarthridae	*Trichorhina tomentosa*	Non-native		19f	~250f	8f	~50f	~100f
Philosciidae	Philosciidae sp.	Non-native	1f					
Philosciidae	*Pseudotyphloscia alba*	Non-native New to UK		1m	2m 2j			50mf
Porcellionidae	*Agabiformius lentus*	Non-native					3mf	
Porcellionidae	*Porcellio scaber*	Native						1f
Trachelipodidae	*Nagurus cristatus*	Non-native		1j	1j		3f	9f
Trachelipodidae	*Nagurus nanus*	Non-native New to GB		~50mf	1m			
Armadillidiidae	*Armadillidium nasatum*	Native	12mf	18mf				
Armadillidae	*Gabunillo* n. sp.	Non-native New to UK	5f	1f	11f	1f	13f	22f
Armadillidae	*Reductoniscus costulatus*	Non-native	1f		5f	12mf	4mf	54mf
Armadillidae	*Venezillo parvus*	Non-native New to UK		12mf	250mf	24mf	~20mf	30mf

Rainforest biome

Of the 14 species of woodlice collected from the Rainforest Biome only 11 can be reliably identified (Table 3). Two female styloniscids (collected in 2004 & 2009) and a single female philosciid (collected in 2003) cannot be identified and have only been allocated to family. Three species collected are familiar British woodlice able to thrive outdoors in our climate: *Haplophthalmus*

danicus, *Porcellio scaber* and *Armadillidium nasatum*. The remainder include several cosmopolitan inhabitants of heated glass-houses, such as *Trichorhina tomentosa* (Platyarthridae), *Nagurus cristatus* (Trachelipodidae) and *Reductoniscus costulatus* (Armadillidae). In 2010 *T. tomentosa* and *Venezillo parvus* (Armadillidae) were locally common throughout this biome, while other species were patchily distributed and were typically only encountered in small numbers. *Pseudotyphloscia alba* ((Philosciidae), first collected in 2004, and *Gabunillo* n. sp. (Armadillidae), first collected in 2003, both represent new species records for Britain and Ireland.

DESCRIPTIONS OF NEW AND POORLY KNOWN BRITISH WOODLICE

Family PHILOSCIIDAE

Chaetophiloscia sicula Verhoeff, 1908

Chaetophiloscia massoncellensis Verhoeff, 1931

Material examined

A single female was collected from the Mediterranean Biome in 2005 by Tony Barber. It was not possible to confirm the species until 2010 when a male and five additional females were collected by Mark Telfer and the author.

Appearance

Figures 1a-c. This is a relatively slender species. The four gravid females ranged in size from 5.5 mm to 7.0 mm in length by 2.0 mm to 2.6 mm wide. The male specimen was 4.5 mm x 1.5mm. The cephalon, pereionites and pleon are pale brown, with a smooth dorsal surface. The pigmentation pattern of the epimera of the pereionites is distinct (see Noël, Séchet, Mouquet & Bécheau, 2014), allowing separation of females from its European congeners *C. elongata* and *C. cellaria*.

Cephalon with small median lobe and very feeble lateral lobes. Eyes are composed of numerous ommatidia and antennal flagellum is composed of three segments. Posterior margins of the anterior pereionites are rounded, without backward projections. Pleon much narrower than pereion, producing a strongly stepped body outline. Each pleonite bears a feeble, barely discernible, backward projecting ‘tooth’ at its lateral-posterior corner. Telson triangular, with straight edges. Uropods relatively long and slender.

Male sexual characters

Figures 1d-e. First pleopod with distinctive endopod, very broad at base and tapering towards the tip, which bears a distinctive notch. First exopod simple, triangular, with rounded corners. Second pleopod with its endopod narrow and parallel sided for two thirds of its length, before tapering to a fine point. Its exopod simple; an elongated triangle with a rounded posterior margin.

Distribution

This is the first British record for this species. The Eden Project specimens were found clinging to the damp underside of large embedded rocks in the 'Mediterranean Cyprus' area. Specimens of the porcellionid *Lucasius pallidus* were also present (pg.12).

Chaetophiloscia sicula is common in Mediterranean regions of southern France and Italy, including off-shore islands of Corsica and Sicily, central Greece and the Canary Islands (Vandel, 1962, Schmalfuss, 2003). It has been introduced into the USA, where an apparently isolated population has

been discovered in Baltimore, Maryland (Hornung & Szlavecz, 2003). Noël, Séchet, Mouquet & Bécheau (2014) report its occurrence in north-west France and suggest that *C. sicula* may be expanding its range into north-western Europe. In France, Vandel (1962) considered *C. sicula* to be frequently found with its more widespread congener *C. elongata*, which favours damp open habitats (and avoids woodlands).

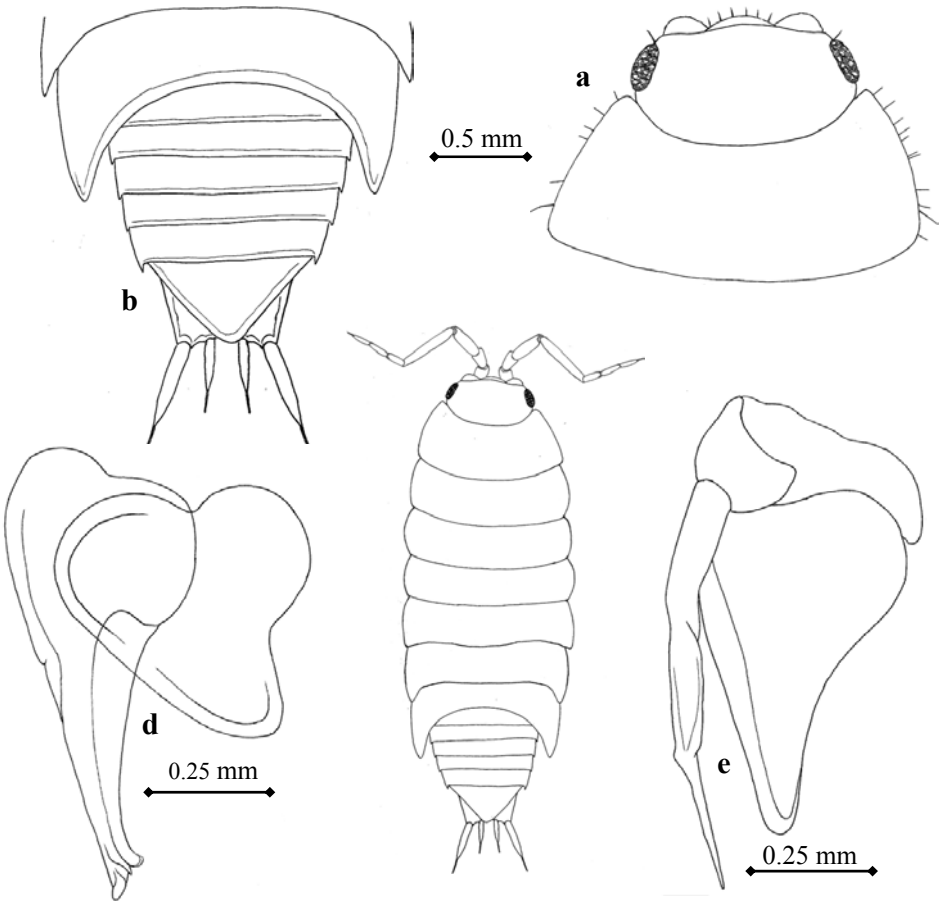

FIGURE 1: *Chaetophiloscia sicula* Verhoeff, male, from Mediterranean Biome
a) head and first pereionite, dorsal view; b) seventh pereionite, pleon, telson and uropods, dorsal view; c) entire animal, dorsal view; d) first pleopod; e) second pleopod.

Family PHILOSCIIDAE

Pseudotyphloscia alba (Dollfus, 1898)

Material examined

Three male specimens (and two juveniles) were collected by Tullgren funnel extraction from litter samples in the Rainforest Biome by the Natural History Museum, London in 2004 and 2005. Intensive searching in 2010 collected an addition 50 specimens, including mature males, females and immatures.

Appearance

Figures 2a-d. This is a very slender species. Gravid females were typically between 3.5 and 4 mm in length, and up to 1.8 mm in width. Male specimens were relatively more slender, reaching about 3.75 mm in length by 1.25 mm in width. In life specimens are a translucent off-white colour, infused with a pale orange pigment, especially along the lateral margins. This pigment rapidly disappears upon preservation in alcohol. Cephalon, pereionites and pleon with a smooth dorsal surface.

Cephalon bears a small median lobe and very feeble lateral lobes. Eyes are reddish in colour and composed of between four or five ommatidia (some specimens had up to ten ommatidia – see *Other remarks* below). Antennae are strikingly long, about half total body length. In the male fifth article of peduncle is distinctly swollen, first article of flagella slightly longer than second or third. Entire antennae, most noticeably the flagella segments, are clothed with conspicuous setae and spines on all sides. Posterior margins of anterior pereionites are rounded, without backward projections. Pleon much narrower than pereion, producing a strongly stepped body outline. Each pleonite without a backward projecting 'tooth' at its lateral-posterior corner. Telson triangular, with straight edges. Uropods relatively long and slender.

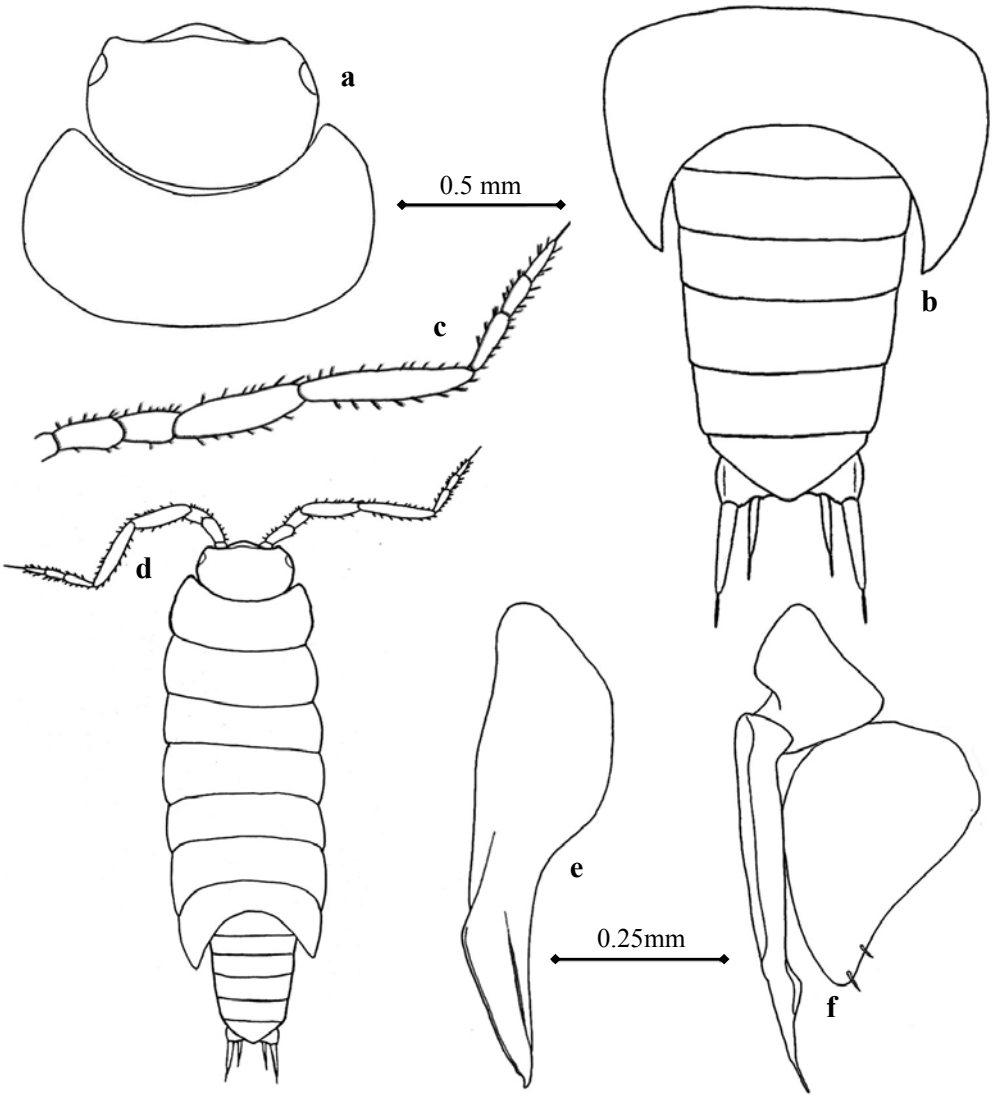

FIGURE 2: ***Pseudotyphloscia alba*** **(Dollfus), male, from Rainforest Biome**
a) head and first perionite, dorsal view; b) seventh pereionite, pleon and telson, dorsal view; c) antenna; d) entire animal, dorsal view; e) first endopod; f) second pleopod

Male sexual characters

Figures 2e-f. First pleopod with endopod with broad base tapering gradually to a pointed tip. There is distinct angular bend at about two-thirds along its length. Second pleopod with endopod narrow and parallel sided for two thirds of its length, before bulging slightly and then tapering to a fine point.

Distribution

This is the first British (and European) record for this species. The Eden Project specimens were found mainly in damp areas, such as under dead wood beside a small stream, and among accumulated leaf litter (where sieving proved productive). Specimens moved fast and were difficult to capture by hand.

Pseudotyphloscia alba has a wide Oriental distribution, being recorded from Southern China, Taiwan, Philippines and Indonesia (Schmalfuss, 2003).

Other Remarks

The genus *Pseudotyphloscia* was erected by Verhoeff (1928) to incorporate *P. pallida* (which has subsequently been synonymised by Green *et al* (1990) with *Philoscia alba*, Dollfus, 1898). This genus is close to *Burmoniscus* (Collinge, 1914) and differs only in the structure of the maxillular teeth. Currently, this is a monotypic genus.

Many specimens collected from the Eden Project conform to the 'typical' *P. pallida*, as described and figured by Verhoeff (1928) and Green *et al* (1990). However, some specimens have larger eyes comprising eight to ten ommatidia (instead of four to five), and there also appear to be subtle differences in the shape of the endopod of the first male pleopod. These 'large-eyed' specimens need to be carefully re-examined in case there is a second species is present in the samples collected from Eden Project. This could be an un-described species or it may belong to *"Philoscia" pallida* (Dollfus, 1898) described from Java (S. Taiti, pers. comm.). Dollfus' (1898) description of this species is very brief and examination of the type-material may be required to clarify the situation.

Family PLATYARTHRIDAE

***Trichorhina tomentosa* (Budde-Lund, 1893)**

Alloniscus tomentosus Budde-Lund, 1893
Bathytropa thermophila Dollfus, 1896
Trichorhina monocellata Meinertz, 1934
Trichorhina thermophila (Dollfus, 1896)
Trichorhina vannamei Verhoeff, 1937

Material examined

Between 2004 and 2010 more than 400 specimens were collected in the Rainforest Biome.

Appearance

Figures 3a-d. This is a small woodlouse with a distinctive elongated oval outline. Gravid females collected from the Eden Project were between 3 to 3.5 mm in length by 1.5 mm to 2 mm wide. Those examined from elsewhere Britain reach 5mm (personal observation). It is off-white to pale buff in colour, with the entire body clothed in blunt tipped scale-spines giving a characteristic sheen to live and preserved specimens.

Lateral lobes of cephalon weakly developed, medial lobe very feeble. Eyes typically composed of a single black ommatidium, but some specimens with a single reddish ommatidium, sometimes apparently absent. Antennae rather stout, and entirely covered with setae. Flagellum comprising two distinct segments, first much shorter than second.

Posterior margins of anterior pereionites rounded, without backward projections. Posterior pereionites and pleon with well developed backward projections. The telson triangular, translucent, with rounded tip. Uropods are conical and terminated in conspicuous bristles.

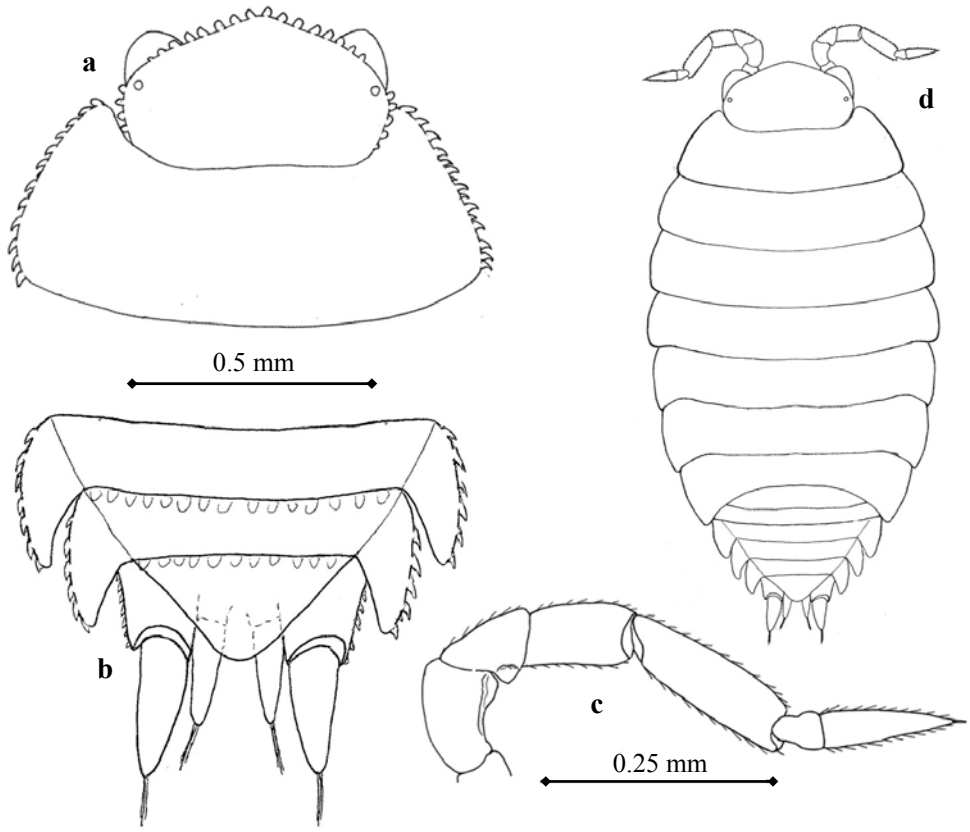

FIGURE 3: ***Trichorhina tomentosa*** **(Budde-Lund), female, from Rainforest Biome**
a) head and first perionite, dorsal view; b) fourth & fifth pleonites, telson and uropods, dorsal view; c) antenna; d) entire animal, dorsal view.

Male sexual characters

This species reproduces parthenogenetically and males are unknown.

Distribution

Trichorhina tomentosa is probably the most frequently encountered woodlouse in the Rainforest Biome being readily collected from among damp litter, beneath dead wood, etc. In addition to the Eden Project, this species is widely distributed in heated glass-houses in Britain and Ireland. More recent records include Glasgow Botanic Gardens, Belfast Botanic Gardens, Oxford University Museum of Natural History (where it occurs in a heated Cockroach cage) and a heated reptile house in Somerset (Gregory, 2009).

In the wild it is known from tropical Central and South America, but has been introduced throughout the tropics (Schmalfuss, 2003) and into heated glasshouses across most of Europe (Cochard, Vilisics & Séchet, 2010). This species is sold commercially as 'dwarf tropical woodlice', primarily as food for pet spiders and amphibians.

Family PORCELLIONIDAE

***Agabiformius lentus* (Budde-Lund, 1885)**

Numerous synonyms are listed in Schmalfuss (2003) within the genera *Angara, Leptotrichus, Lucasius, Lyprobius, Metoponorthus, Porcellio* and *Porcellionides.*

Material examined

A male and two females were collected in the Rainforest Biome by Mark Telfer in 2009.

Appearance

Figures 4a-c. The male specimen was 5.5 mm in length by 2.3 mm wide. Females were relatively broader, the largest being 5.25 mm long and 2.4 mm wide. Cephalon and pereionites have a yellowish background, with a broad brown stripe running the entire length of the pereion and thin lateral markings which become broader and more prominent on the posterior pereionites. Epimera are brown, separated from the main body by a thin pale line. Pleon darker brown, but telson and uropods much paler, providing a striking contrast.

Lateral lobes of cephalon well developed with rounded anterior margins. Medial lobe feebly developed, but looks larger since cephalon is extended forward between lateral lobes (Fig 4a). Eyes composed of many ommatidia and antennae relatively short, each with two flagellal segments. Cephalon, pereionites and pleon bear feeble tubercles. Posterior margins of anterior pereionites are rounded. Epimera lack backward projections and are poorly developed resulting in a rather arched body. Pereion/pleon outline is continuous. Posterior pleonites bear strongly curved backward projections. Telson triangular, with slightly concave lateral margins and broadly rounded tip. Uropods very short.

Male sexual characters

Figures 4d-e. First pleopod with endopod stout and tapering to rounded tip. First exopod of distinctive triangular shape, with posterior margin sharply truncated to leave a straight, but undulating, edge. Second pleopod with endopod narrow, curved along its entire length, with a constriction near the mid point and then tapered to a very fine point. The exopod triangular, bearing a few spines on the outer margin.

Distribution

First reported by Randell Jackson (1910) from a nursery at Chester, *A. lentus* was cited to be Britain's most widespread heated glasshouse woodlouse (Sutton 1972). However, there appear to be no modern (post-1980) records until the 2009 records for the Eden Project.

This species originates from the eastern Mediterranean (Vandel 1962), but it is an expansive species that has been introduced to many other parts of the world by human activities, including northern Europe, Africa, China and South America (Schmalfuss, 2003). It is adapted to dry conditions and in France it readily colonises synanthropic habitats, such as gardens (Vandel, 1962).

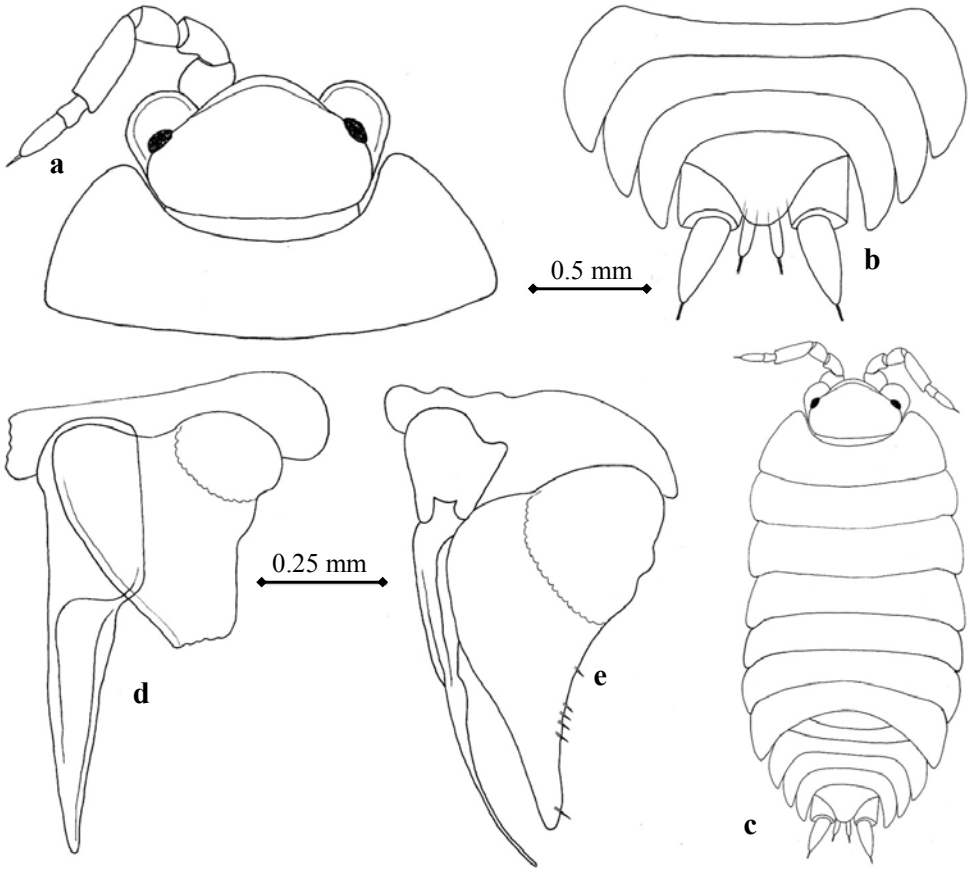

FIGURE 4: ***Agabiformius lentus*** **(Budde-Lund), male, from Rainforest Biome**
a) head and first pereionite, dorsal view; b) pleon, telson and uropods, dorsal view; c) entire animal, dorsal view; d) first pleopod; e) second pleopod.

Other Remarks

This species is morphologically very variable, such as degree of body pigmentation, development of dorsal tubercles, form of head-lobes and form of exopodite of male first pleopod (Vandel, 1962). Consequently, it has been repeatedly re-described from various parts of the world using numerous specific names within a variety of genera.

Family PORCELLIONIDAE

Lucasius pallidus **(Budde-Lund, 1885)**
Porcellio pallidus Budde-Lund, 1885
Lucasius occhialinii Arcangeli, 1924

Material examined

Two males, seven females and two juveniles were collected from the Mediterranean Biome in 2010 by Mark Telfer and the author.

Appearance

Figures 5a-c. Females vary in size from 5.25 mm long by 2.2 mm wide to 6.5 mm by 3.0 mm. The male specimen was 6.0 mm by 2.8 mm. Vandel (1962) gives up to 7 mm for specimens in France

and up to 8 mm in Spain. General appearance akin to a pale, poorly pigmented *Porcellio scaber*, but the body is relatively broader and shorter (as immature *Oniscus asellus*). It is light brown in colour, with noticeably pale antennae and pereiopods. Each pereionite bears a pair of pale patches situated either side of a pale longitudinal central line.

Cephalon covered with prominent tubercles. Its lateral lobes well developed with rounded anterior margins and medial lobe triangular. Eyes composed of many ommatidia. Antennae with two flagella segments, first much shorter than the second. Anterior pereionites bear two rows of broad raised bumps, but these become less distinct on posterior ones and the pleon is more or less smooth. Epimera are slightly translucent, those of anterior pereionites with very prominent backward projections, but these become less developed towards the posterior. Pereion/pleon outline is continuous and each pleonite also bears prominent backward projections. Telson is approximately an equilateral triangular, with almost straight lateral margins, and an acute tip.

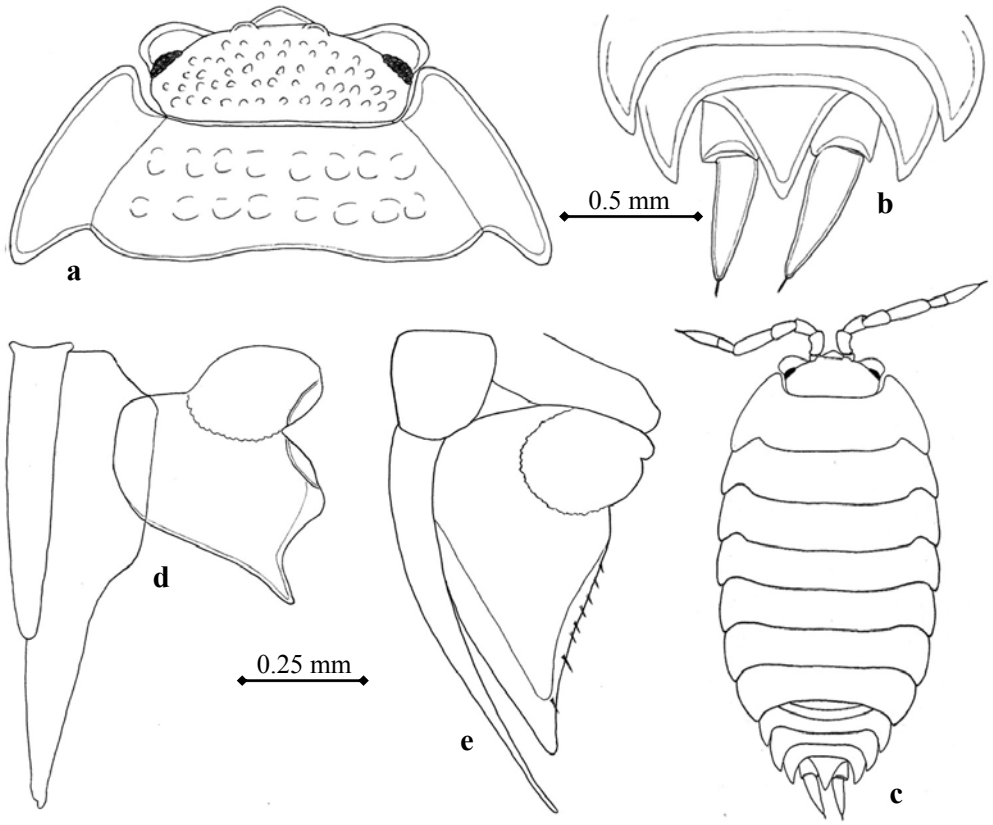

FIGURE 5: ***Lucasius pallidus*** **(Budde-Lund), male, from Mediterranean Biome**
a) head and first pereionite, dorsal view; b) last pleonite, telson and uropods, dorsal view; c) entire animal, dorsal view; d) first pleopod; e) second pleopod.

Male sexual characters

Figures 5d-e. First pleopod with endopod stout and tapering to rounded tip, which bears a small bulge on its inner margin. First exopod very distinctive in shape, with posterior margin elongated into a narrowly triangular point and a prominent bulge on the anterior margin which bears the pseudotracheae. Second pleopod with endopod narrow, curved along its entire length, and tapered to fine point. Exopod triangular, bearing a few spines on the outer margin.

Distribution

This is the first record of this species in Britain. Eden Project specimens were found clinging to the underside of a large embedded stones in the 'Mediterranean Cyprus' area, in association with the philosciid *Chaetophiloscia sicula* (pg.6).

In southern France this species occurs at low altitudes, often in river valleys. Although typically found under stones in association with ants, such as *Lasius* sp., it is not strictly myrmecophilous (Vandel, 1962). It has been recorded from southern Spain, Portugal, Sardinia, Corsica and Tuscany (Vandel, 1946; Taiti & Ferrara, 1989; Taiti & Ferrara, 1996; Schmallfuss, 2003).

Family TRACHELIPODIDAE

***Nagurus cristatus* (Dollfus, 1889)**

Porcellio cristatus Dollfus, 1889
Lyprobius cristatus (Dollfus, 1889)
Leptotrichus emarginatus Pearse, 1917
Nagurus incisus (Verhoeff, 1928)
Bifrontania femina Radu, 1960

Material examined

Single immature specimens were collected in the Rainforest Biome by the Natural History Museum, London, in 2004 and 2005. Adults were not found until 2009 (by Mark Telfer) and 2010 (by Darren Mann), when seven females and five juveniles were hand sorted and sieved from deep accumulations of leaf litter.

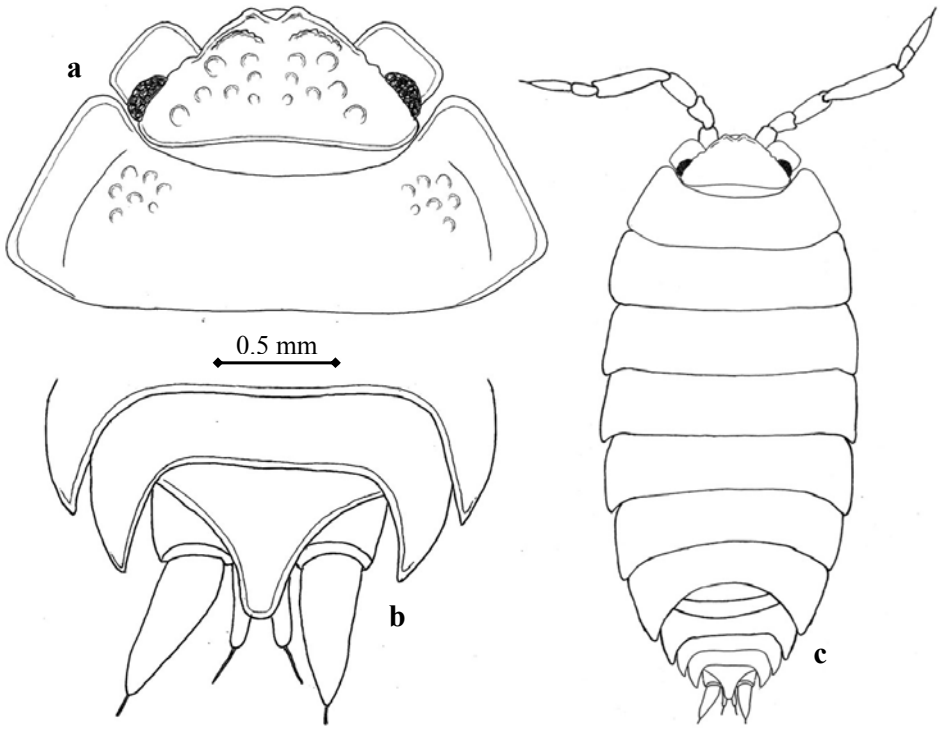

FIGURE 6: *Nagurus cristatus* (Dollfus), female, collected from Rainforest Biome
a) head and first pereionite, dorsal view; b) last pleonite, telson and uropods, dorsal view; c) entire animal, dorsal view.

Appearance

Figures 6a-c. The general appearance is akin to a small, slender *Porcellio scaber*. Gravid females varied in size from 4.5mm long by 1.7 mm wide to 5.5 mm by 2.0 mm. The body has a yellowish background with four irregular brownish longitudinal stripes, of variable width, running the length of the pereion. Cephalon and pleon are darker brown, but the basal two antennal segments and uropods (except the tips) are contrastingly pale.

Cephalon bears broad raised bumps, which are more noticeable towards the lateral margins. Lateral lobes well developed and distinctly rectangular in shape. Medial lobe poorly developed and bears a prominent central cleft (distinct even in small immatures). Laterally the medial lobe extends backwards along the front of the cephalon in the form of a low ridge. Eyes are composed of many ommatidia and antennae have two flagella segments. Pereion and pleon are rather smooth, bearing a few weakly developed tubercles. Posterior margins of anterior pereionites are rounded and their epimera lack backward projections, giving a characteristic rectangular shape to the epimera of the first pereionite. Pereion/pleon outline is continuous and posterior pleonites bear prominent backward projections. Telson triangular, with concave lateral margins and rounded tip.

Male sexual characters

This species reproduces parthenogenetically and males are unknown.

Distribution

In Britain *N. cristatus* has been recorded from Northumberland in 1965 (Gregory, 2009). Until its re-discovery at the Eden Project there had been no additional British records. Elsewhere in Europe it is known from The Netherlands, Germany and Romania (Cochard, Vilisics & Séchet, 2010).

It has a pan-tropical distribution, having been widely dispersed by human activity. In temperate regions it occurs as a synanthrope inside glasshouses (Schmalfuss, 2003).

Family TRACHELIPODIDAE

***Nagurus nanus* (Budde-Lund, 1908)**
Nagurus formosanus Verhoeff, 1928

Material examined

About 50 specimens, including males, were extracted from a litter sample in the Rainforest Biome by the Natural History Museum, London, in 2004. In 2005 a single male was collected. Subsequently, no further specimens have been collected.

Appearance

Figures 7a-c. This is a small, rather ovoid, species, with gravid females between 4.5 mm long by 2.3 mm wide to 5.0 mm by 3.0 mm. Males vary between 4.0 mm long by 2.0 mm wide to 4.5 mm by 2.2 mm. The body is dark brown with two patches of pale yellow mottling situated either side of a broad dark brown central stripe. There is a pale longitudinal line separating the epimera from the main body (rather akin to that seen in *Trachelipus rathkii*).

Cephalon covered in low tubercles (Fig. 7a), but these are indistinct on the pereion and pleon. Lateral lobes well developed, almost semi-circular in shape, and medial lobe rounded. Eyes

composed of many ommatidia and antennae have two flagella segments. Posterior margin of first pereionite straight and its epimera lack backward projections. Pereion/pleon outline continuous and posterior pleonites bear prominent backward projections (Fig. 7c). Telson triangular, longer than broad (Fig. 7b), with deeply concave lateral margins and rounded tip.

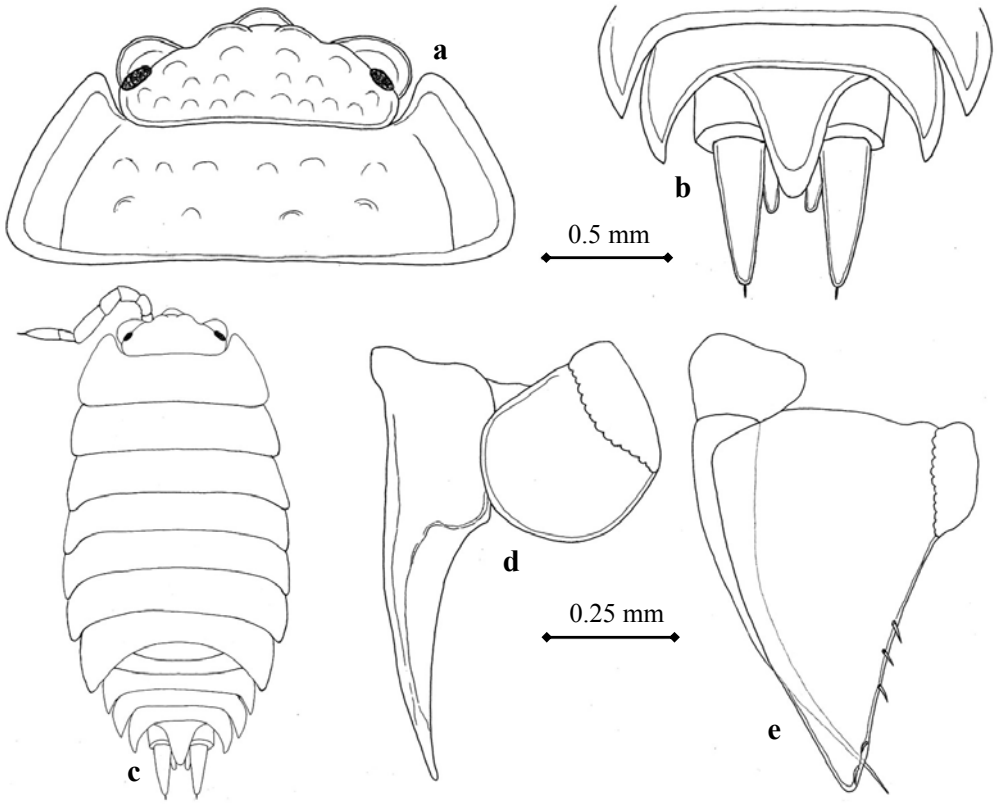

FIGURE 7: *Nagurus nanus* (Budde-Lund), male, from Rainforest Biome
a) head and first pereionite, dorsal view; b) last pleonite, telson and uropods, dorsal view; c) entire animal, dorsal view; d) first pleopod; e) second pleopod.

Distribution

This is the first record for this species in Britain. Previously, a single specimen was collected from a heated glasshouse in Belfast Botanic Gardens (Ireland) in 1911 (Sutton, 1972), but there have been no subsequent records. In fact, no additional European records are given in Cochard, Vilisics & Séche, (2010).

Elsewhere, *N. nanus* has a pan-tropical distribution, where it has been widely introduced, and often inhabits synanthropic habitats (Schmalfuss, 2003).

Family ARMADILLIDIIDAE

***Armadillidium* Brandt *in* Brandt & Ratzeburg, 1831 sp.**

Material examined

Five female specimens were collected from the Mediterranean Biome in 2005 by Tony Barber. In 2010 a male specimen (collected Jo Clark) was found clinging to the underside of a large embedded

rock and four additional females (collected Darren Mann and Mark Telfer) were sieved from litter and debris nearby.

Although quite distinct from known British species of *Armadilllidium*, it has not proved possible to satisfactorily name the species and it is cited here as *Armadilllidium* sp. See '*Remarks'* below.

General appearance

Figures 8a-b. Females are between 5.5 mm and 8.0 mm long by 2.0 to 3.0 mm wide, and up to 4.5 mm in diameter when enrolled. The male specimen is 6.5 mm in length by 2.6 mm wide. The general appearance is of a pale speckled *A. vulgare*. The background colour is uniform brown with cream-yellow mottling developed to a greater or lesser extent (the depth of colour varies from specimen to specimen). The epimera are slightly translucent.

In frontal view the head lobes are similar in shape to *A. vulgare*. Scutellum broad and rises slightly above the outline of the cephalon. Antennae bear two flagellal segments. Eyes are composed of numerous ommatidia. Dorsal surface of the pereionites and pleonites are smooth. Telson triangular with rounded tip.

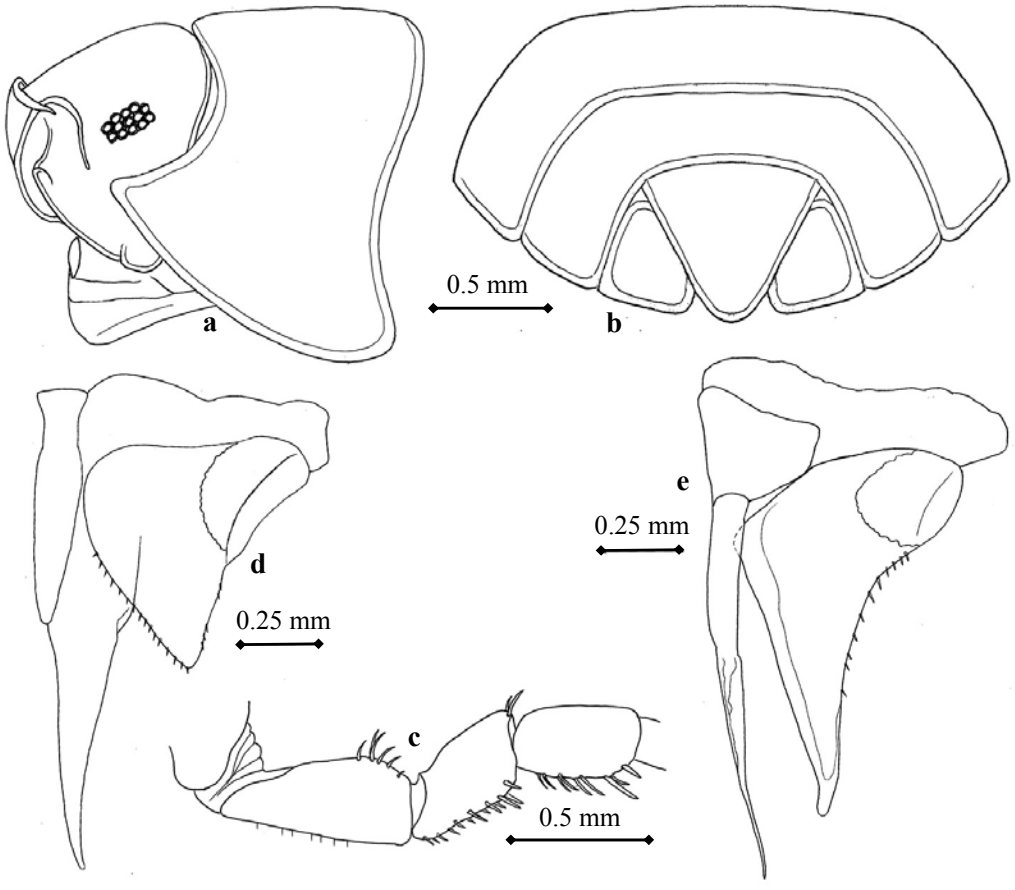

FIGURE 8: *Armadillidium* sp., male, from Mediterranean Biome
a) head and first pereionite, lateral view; b) last two pleonites, telson and uropods, rear view;
c) ischium, merus and carpus of seventh periopod, posterior view;
d) first pleopod; e) second pleopod.

Male sexual characters

Figures 8c-e. Seventh periopod with ischium bearing row of stout spines on dorsal crest and with minute spines on ventral surface. Merus and carpus with stout spines ventrally. First pleopod with endopod straight and tapering to a slightly curved rounded point. Exopod triangular, bearing prominent spines around inner and outer margins. Second pleopod with endopod narrow, tapered to a fine point. Exopod narrowly triangular, with spatulate tip. Inner margin straight and outer margin concave, bearing spines.

Distribution

This is the first record of this species in Britain.

The distribution of species within the genus *Armadillidium* is centred on the Mediterranean region of Europe (Schmidt & Leistikow, 2004).

Remarks

Although provisionally named as *Armadilllidium assimile* Budde-Lund, 1885 (Gregory, 2010), it differs from *A. assimile* in being much smaller in length (5.5-8 mm vs 10-14 mm) and in the shape of the exopod of the first pleopod (e.g. as figured in Taiti & Ferrara (1980) pg. 291) (S. Taiti, pers. comm.). Due to the high number of described species (about 180 listed in Schmalfuss (2003)) and the unknown origin of this introduction, it has not proved possible to satisfactorily name the species.

Family ARMADILLIDAE

***Gabunillo* Schmalfuss & Ferrara, 1983 n. sp.**

Material examined

Specimens were first collected in the Rainforest Biome in 2003 by the Natural History Museum, London, using Tullgren Funnel extraction of leaf-litter. Small numbers were collected each year until 2007. In 2009 and 2010, Mark Telfer collected an additional 35 specimens by intensive hand sorting and sieving of deep accumulations of leaf litter and peaty soil.

Appearance

Figures 9a-d. A very small species capable of conglobating into a perfect sphere. Specimens reach up to 2.5 mm in length by 1.2 mm wide (about 1.3 mm diameter enrolled). The body lacks pigment, being an off-white colour in life, except for a single reddish ommatidium on each side of the cephalon. The entire body surface, including the short stout antennae, is covered in blunt-tipped scale-spines.

First pereionite bears a distinctive grooved margin along its ventral edge (giving the appearance of a double edge) which facilitates conglobation. Epimera are steep (almost vertical). Telson more or less triangular, translucent, with slightly concave sides and rounded tip. The adjacent uropod protopodite are roughly rectangular bearing a very small sub-terminal exopodite.

Male sexual characters

All specimens collected to date (53 in total) have been female and/or immature.

Distribution

This material represents a new species of *Gabunillo* (S. Taiti, pers. comm.) and consequently unknown in the wild.

The two other species described within the genus occur on opposite sides of the Atlantic Ocean: *G. coecus* Schmalfuss & Ferrara, 1983 from caves in Gabon, West Africa and *G. aridicola* Souza, Senna & Kury, 2010 from karst formations in Brazil (Souza, Senna & Kury, 2010).

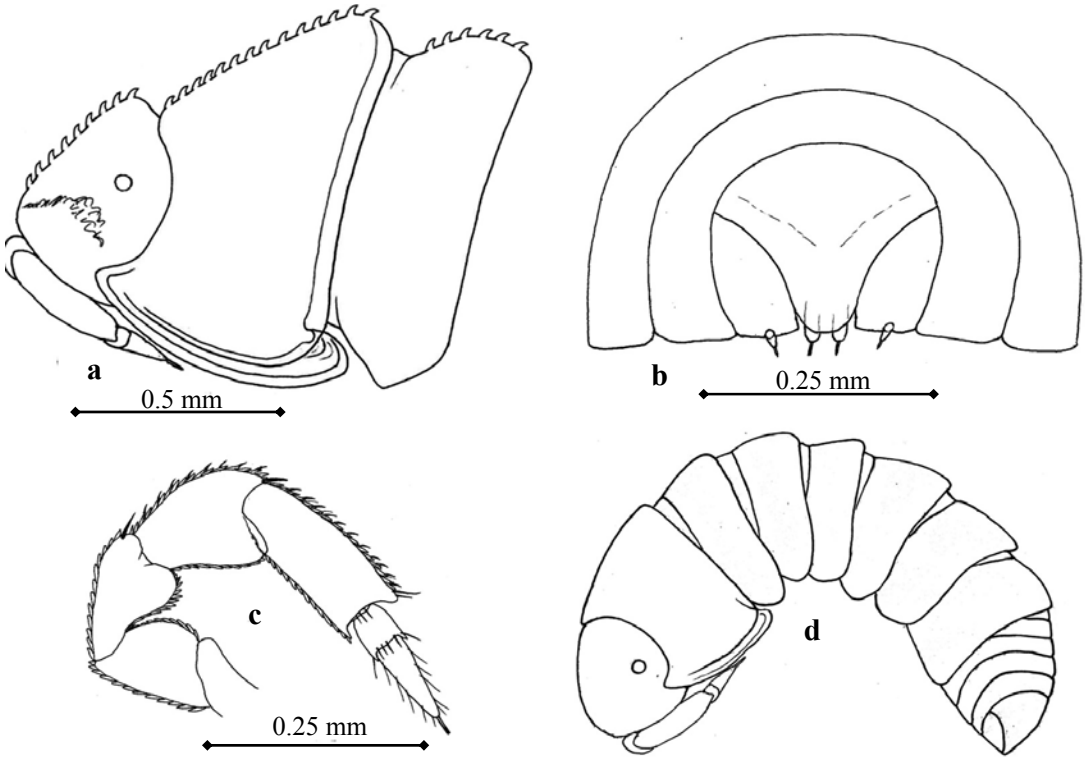

FIGURE 9: *Gabunillo* n. sp., female, from Rainforest Biome
a) head, first and second pereionite, lateral view; b) telson, uropods and last two pleonites, rear view; c) antenna; d) entire animal, legs omitted, lateral view.

Remarks

The genus *Gabunillo* Schmalfuss & Ferrara, 1983, was erected to incorporate *Gabunillo coecus*. The genus is akin to *Synarmadillo* Dollfus, 1892, from which it differs in a number of features (Schmalfuss & Ferrara, 1983).

The specimens collected from the Eden project are close to *G. coecus*, but differ principally by having a single reddish ommatidium on each side of the head (absent in *G. coecus*) and by the shape of the lobes of the schisma on the first pereionite (S. Taiti, pers. comm.). The second described species, *G. aridicola* differs from the Eden specimens principally in being much larger in size (to 6 mm), having better developed body pigmentation and having eyes composed of a cluster of well pigmented ommatidia. Thus, material collected from Eden Project appears to be a new species and it is hoped that a formal description will be published in due course.

All specimens collected have been female, and it may be that this is a genuinely parthenogenetic species. Although parthenogenesis is rare in woodlice, it is well known in species such as *Trichorhina tomentosa* and *Nagurus cristatus*, which are both recorded from the Eden Project.

Family ARMADILLIDAE

Reductoniscus costulatus Kesselyák, 1930
Reductoniscus fritschii Verhoeff, 1937

Material examined

This species was first collected in 2003 by the Natural History Museum, London, when a single female was collected by Tullgren Funnel extraction of leaf-litter in the Rainforest Biome. In 2009 and 2010 intensive searching resulted in the collection of numerous specimens throughout the Rainforest Biome.

Appearance

Figures 10a-c. This very small species is able to conglobate when disturbed. Females reach 2.5 mm in length, about 1.5mm in diameter when enrolled. Males are smaller. Smaller specimens are off-white in colour, but becoming progressively darker brown as they become larger.

Cephalon and pereionites covered in large prominent tubercles of characteristic shape. Epimera steep and telson of distinctive 'hour-glass' shape with broad 'rectangular' tip. Eye composed of cluster of well pigmented ommatidia.

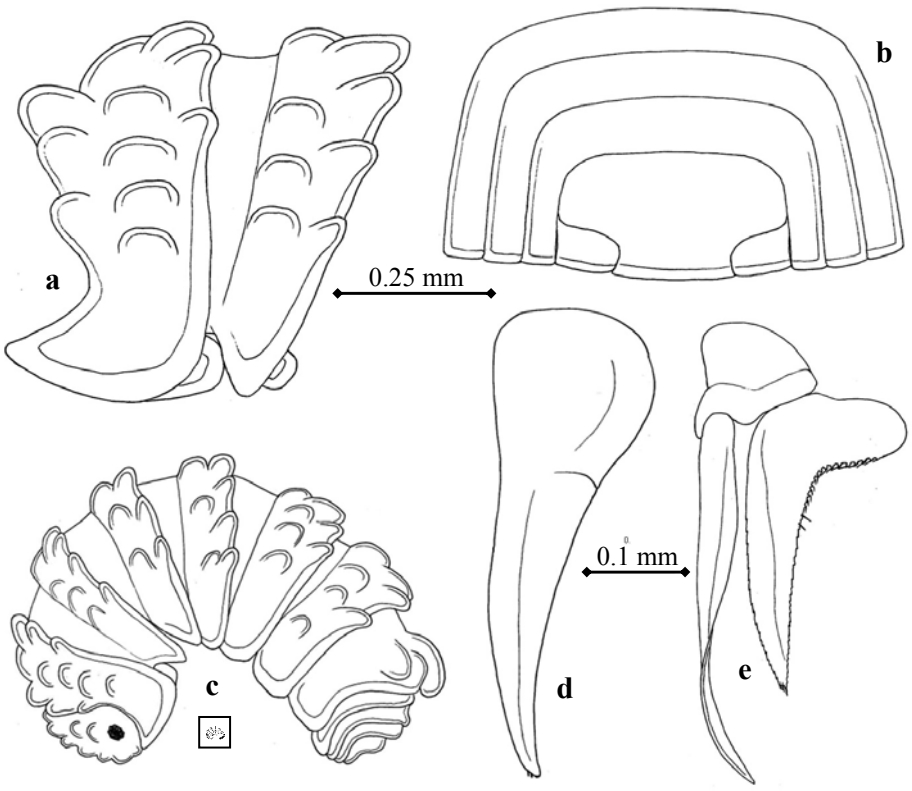

FIGURE 10: *Reductoniscus costulatus* Kesselyák, male, from Rainforest Biome
a) first and second pereionite, lateral view; b) telson, uropods and last three pleonites, rear view; c) entire animal, lateral view (inset life-size); d) first endopod; e) second pleopod.

Male sexual characters

Figures 10d-e. First pleopod with endopod straight, with a broad base tapering to a rounded tip. Second pleopod with endopod narrow, strap-like, tapering gently along its length. Exopod narrowly triangular with dentate edges. These teeth most strongly developed along the deeply concave outer margin, each bearing a bent spine.

Distribution and habitat

This species was first recorded in Britain from Kew Gardens by Holthuis (1947) and it has been rediscovered there in recent years (Gregory, 2009). At Eden Project, intensive hand searching and sieving of leaf-litter in 2009 and 2010 has shown this small and elusive species to be widespread, and locally numerous, throughout the Rainforest Biome; its second British locality.

It has a broad Indo-Pacific distribution, being known outdoors in Seychelles, Mauritius, Malaysia and Hawaiian Islands (Schmalfuss, 2003). It is also well known, as an introduction, inside heated glasshouses across western Europe (Cochard, Vilisics & Séchet, 2010).

Additional Remarks

The genus *Reductoniscus*, as currently defined, includes three species (Ferrara & Taiti, 1990). *R. costulatus* is distinguished by its much smaller size, and characteristically shaped tubercles. The pan tropical genera *Myrmecodillo* and *Pseudodiploexochus* include species of superficially similar appearance and size and it is possible that these may be found at the Eden Project (or other sites in the UK).

Family ARMADILLIDAE

***Venezillo parvus* (Budde-Lund, 1885)**

Armadillo parvus Budde-Lund, 1885
Sphaerillo parvus (Budde-Lund, 1885)
Venezillo evergladensis Schultz, 1963

Material examined

This is one of the most abundant species in the Rainforest Biome and several hundred individuals of all age classes have been collected most years since it was first discovered in 2004.

Appearance

Figures 11a-d. This species is able to conglobate. Males are between 4.0-5.0 mm in length; 2.5-3.0 mm in diameter when enrolled. Females reach 6 mm in length and up to 3.5 mm in diameter. The dorsal surface of the body is smooth.

The background colour is dark brown, with a characteristic pattern of pale yellow on each pereionite, comprising a pale central wedge and a pair of large pale patches with irregular margins (each with a dark centre) on either side. In most specimens a diffuse orange band, of varying intensity, occurs along the posterior margin of each pereionite. The pattern is less clear in juveniles, which are less strongly pigmented.

Cephalon with frontal margin forming a low ridge between the eyes. Eyes composed of cluster of numerous ommatidia. Antennal flagella bearing two segments. First pereionite bears a distinctive

double flange along its ventral edge, which facilitates conglobation. Telson has a distinctive 'hour-glass' shape, with a broad 'rectangular' tip. Adjacent uropod protopodites are roughly rectangular and bear small exopodite on their inner margin.

Male sexual characters

Figures 11e-f. First pleopod with endopod straight, with a broad base tapering to a rounded tip. Exopod tiny, about twice as wide as deep, with at least the outer half occupied by the pseudotracheae. Second pleopod with endopod narrow, parallel sided for much of its length, before curving strongly outwards to a rounded tip. Exopod very narrowly triangular due to deeply concave outer margin, with pseudotrachae occupying much of the anterior portion.

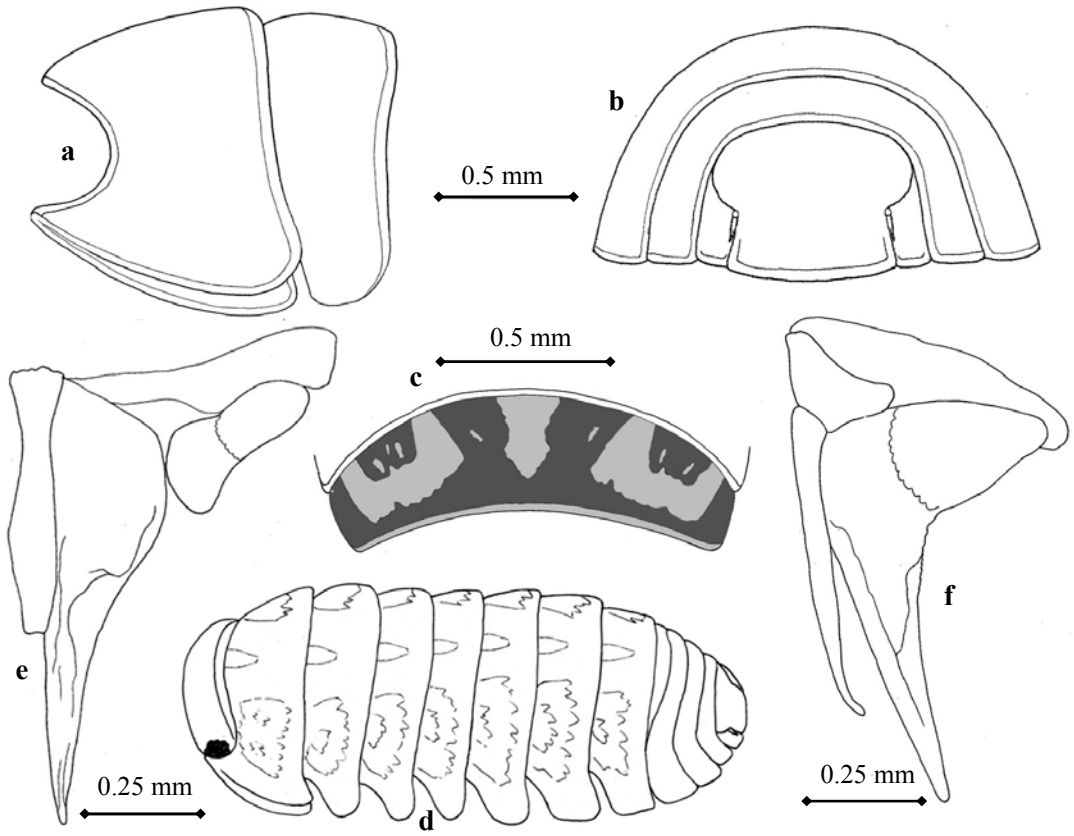

FIGURE 11: ***Venezillo parvus*** **(Budde-Lund), male, from Rainforest Biome**
a) first and second pereionite, lateral view; b) telson, uropods and last two pleonites, rear view;
c) first pereionite indicating typical pigmentation pattern, dorsal view;
d) entire animal, dorso-lateral view; e) first pleopod; f) second pleopod.

Distribution

This species is first reported in Britain by Gregory (2009), based on specimens collected from Eden Project in 2005. Subsequently, it has proved to be one of the most abundant species in the Rainforest Biome.

It has a pan-tropical distribution, being widespread across tropical and sub-tropical regions of America and Africa (Schmalfuss, 2003). Within Europe, it has been introduced into heated glasshouses in the Netherlands (Soesbergen, 2003).

DISCUSSION

Six species of woodlouse (Oniscidea) and the waterlouse *Asellus aquaticus* (Asellota) are recorded from the Outdoor Biome (Eden Project gardens). All are all common eurytopic species in Britain. Considering the overall oniscid species diversity in Cornwall (Gregory, 2009), it is perhaps surprising that additional species have not been recorded. However, collecting effort has been targeted mainly to the indoor biomes. Further fieldwork is likely to yield additional species of woodlice from the outdoor biome, possibly even an introduced species previously unknown in Britain (as is the case with the millipede *Brachyiulus lusitanus* (Barber, Gregory & Lee, 2010). Unidentified female specimens of styloniscidae and philosciidae collected from the Rainforest Biome also hint that additional species may be awaiting discovery.

Examination of the global distributions of species recorded from the indoor biomes indicates that most are well known to be associated with human activity. Four species, *Haplophthalmus danicus, Porcellio scaber, Armadillidium nasatum* and *Agabiformius lentus*, are 'Cosmopolitan' species that have been widely introduced to many parts of the world. Although the first three are native, or at least ancient long-established introductions, to Britain, they can be characteristic inhabitants of synanthropic habitats elsewhere.

Lucasius pallidus and *Chaetophiloscia sicula* collected from the Mediterranean Biome, and *A. lentus* from the Rainforest Biome, have native distributions centred on Mediterranean Europe. These have been spread considerably further afield by human activity (Vandel, 1962; Hornung & Szlavecz, 2003; Schmalfuss, 2003; Noël, Séchet, Mouquet & Bécheau, 2014). It is probable that the unidentified *Armadillidium* species also falls into this category. These are European natives that have been introduced into a European region (in this case Britain) beyond their native range. Cochard, Vilisics & Séchet (2010) consider these species to be more likely to successfully disperse into adjacent habitats from their initial point of introduction, especially in light of climate change. It will be interesting to see if these species begin to colonise the Outdoor Biome (gardens) of the Eden Project.

Four 'Pan Tropical' species, *Trichorhina tomentosa*, *Nagurus cristatus*, *Nagurus nanus* and *Venezillo parvus*, that have been recorded from the Rainforest Biome have been widely spread throughout the tropics by human activity (Schmalfuss, 2003). They frequently turn up in heated 'topical houses' in Europe (Cochard, Vilisics & Séchet, 2010). A fifth species *Reductoniscus costulatus* has an Indo-Pacific distribution, but is also widely reported from heated glasshouses across Europe. Two remaining species are more localised in their known distributions; *Pseudotyphloscia alba* is Oriental Tropical, while the genus *Gabunillo* is Atlantic Tropical. Previously, neither has been reported as an introduction in Europe. Within Britain these tropical species are dependent upon the artificially heated conditions, such as those found inside the Rainforest Biome. It is unlikely that they will survive outdoors in Britain.

It is not possible to comment on changes in populations of each species over time (i.e. from 2003 to 2010) since different sampling methodologies and sampling efforts have been used. However, it appears that those species that were introduced in the early years were able to become successfully established. Within both the Mediterranean and Rainforest Biomes, almost all of the species recorded between 2003 and 2005 were still present in 2010, including *Pseudotyphloscia alba* and *Gabunillo* n. sp. Only two species recorded before 2005, *Nagurus nanus* and *Armadillidium nasatum*, were not refound in 2009 or 2010. It is also of note that the intensive surveys in 2009 and

2010 add just three species to the Eden Project list. These are *Agabiformius lentus* and *Haplophthalmus danicus* (a familiar British species) in the Rainforest Biome and *Lucasius pallidus* in the Mediterranean Biome. It is possible that these three had been overlooked by earlier field work. In the long term it is probable that a few highly competitive species, such as *T. tomentosa, V. parvus* and *R. costulatus*, will continue to dominate the fauna. Other less competitive species may persist, or may be entirely out-competed. It will be interesting to see if populations of species such as *Gabunillo* n. sp. and *Pseudotyphloscia alba* remain extant in future years.

ACKNOWLEDGEMENTS

Mark Telfer was instrumental in organizing the 2010 field trip to the Eden Project. Tim Petitt and Marc Mappley of the Eden Project allowed un-restricted access to the biomes. Kelly Inward and Angela Lidget (both Natural History Museum, London), Mark Telfer, Darren Mann (Oxford University Museum of Natural History), Tony Barber, Helen Read and Jo Clark freely offered their specimens for examination. Paul Harding and Stefano Taiti readily dealt with my requests for relevant literature. Stefano Taiti kindly identified specimens of *Pseudotyphoscia alba*, *Nagurus nanus*, *Gabunillo* n. sp. and *Venezillo parvus*, for which I am very grateful. Two referees provided useful comments and additional references.

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APPENDIX I: UPDATED CHECK LIST OF BRITISH AND IRISH NON-NATIVE TERRESTRIAL ISOPODS (WOODLICE) RESTRICTED TO HEATED GLASSHOUSES

Updated from Gregory (2009), Woodlice and Waterlice in Britain and Ireland.

* First species record for Britain
[#] First reported by Gregory (2009)

Sub-order ONISCIDEA – Terrestrial Woodlice

Section Synocheta

Family TRICHONISCIDAE
Miktoniscus linearis (Patience, 1908)

Family STYLONISCIDAE
Cordioniscus stebbingi (Patience, 1907)
Styloniscus mauritiensis (Barnard 1936)
Styloniscus spinosus (Patience, 1907)

Section Crinocheta

Family PHILOSCIIDAE
Burmoniscus meeusei (Holthuis, 1947)
Chaetophiloscia sicula Verhoeff, 1908*
Pseudotyphloscia alba (Dollfus, 1898)*
Setaphora patiencei (Bagnall, 1908)

Family PLATYARTHRIDAE
Trichorhina tomentosa (Budde-Lund, 1893)

Family PORCELLIONIDAE
Agabiformius lentus (Budde-Lund, 1885)
Lucasius pallidus (Budde-Lund, 1885)*

Family TRACHELIPODIDAE
Nagurus cristatus (Dollfus, 1889)
Nagurus nanus (Budde-Lund, 1908)*

Family ARMADILLIDIIDAE
Armadillidium Brandt *in* Brandt & Ratzeburg, 1831 **sp.**[#]

Family ARMADILLIDAE
Gabunillo Schmalfuss & Ferrara, 1983 **n. sp.***
Reductoniscus costulatus Kesselyák, 1930
Venezillo parvus (Budde-Lund, 1885)[#]