

**FIRST RECORDS OF TWO INTRODUCED MILLIPEDES  
*ANOPLODESMUS SAUSSURII* AND *CHONDROMORPHA XANTHOTRICHA*  
(DIPLOPODA: POLYDESMIDA: PARADOXOSOMATIDAE) IN SINGAPORE**

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**ABSTRACT.** — Two species of polydesmid millipedes: *Anoplodesmus saussurii* (Humbert) and *Chondromorpha xanthotricha* (Attems) are reported for the first time in Singapore. Both are believed to be non-native to the country, and appear to have recently arrived with imported plants and compost.

**KEY WORDS.** — Diplopoda, first record, alien myriapod, mass occurrence, public park

### INTRODUCTION

Millipedes are generally detritivores and prefer to eat decaying plant material rather than living vegetation. These ancient soil invertebrates have a significant impact on the soil due to burrowing, litter breakdown, and the mixing of organic and inorganic substances in their digestive system which are allocated to different soil layers (Hopkin & Read, 1992).

The introduction of millipedes throughout the temperate and tropical zones of the world as the result of commerce is well known. The juliform diplopods *Trigoniulus corallinus* (Gervais) and *Leptogoniulus sorornus* (Butler), as well as several members of the order Polydesmida, such as *Asiomorpha coarctata* (Saussure), are particularly known to be widely spread throughout the tropics on small islands and in urban areas (Shelley & Lehtinen, 1998, 1999).

Like many soil invertebrates, the myriapod fauna of Singapore is only poorly known. Records and descriptions are widely scattered in the literature. The most extensive works on the Singaporean millipede fauna were done by Wang (1967a, 1967b) and Wang & Tang (1965). About 38 species are known from Singapore thus far. A checklist of the millipedes and centipedes of Singapore is in preparation.

Here we report two millipede species of the order Polydesmida and the family Paradoxosomatidae that have recently been discovered in Singapore. They are believed to have been spread throughout Singapore's parks and gardens apparently within the last two years.

### MATERIAL AND METHODS

Samples of preserved material (70% ethanol) which are deposited in the Senckenberg Museum of Natural History Görlitz (SMNG) and the Zoological Reference Collection (ZRC), Raffles Museum of Biodiversity Research (RMBR) at the National University of Singapore were studied. All specimens listed in *Material examined* are from Singapore.

Photographic images of preserved specimens were taken with a Leica<sup>®</sup> Z6 Apo stereo microscope and Leica<sup>®</sup> DFC420 camera. Final images were assembled from 11–15 source images taken at different focal lengths using the software package Leica<sup>®</sup> Application Suite 3.8.

Species were identified by comparing the preserved material with the original descriptions by Attems (1898) and Humbert (1865), and the descriptions provided by Attems (1937) and Shelley & Lehtinen (1998).

## RECORDS AND OBSERVATIONS

### *Anoplodesmus saussurii* (Humbert, 1865)

Figs. 1–4

**Diagnosis.** — Length 21–33 mm, width 3.5–4.8 mm, body large and very broad. General colouration of adult individuals is shiny dark brown to black (Figs. 1, 2). Ventral part of collum and rounded short paraterga are bright yellow, and legs are light brown. The metaterga are smooth with a deep transverse groove (Fig. 3). The male gonopods are of unique shape (Fig. 4).

**Material examined.** — 7 males, 5 females, 6 juveniles, SMNG, Singapore Botanic Gardens, National Biodiversity Center, coll. Tertilt, 15 Sep.2011; 14 males, 8 females, SMNG, Singapore Botanic Gardens, National Biodiversity Center, coll. Tertilt, 14 Jun.2011; 18 males, 4 females, SMNG, Singapore Botanic Gardens, Healing Garden, coll. Tertilt, 20 Dec.2011; 13 males, 11 females, SMNG, Singapore Botanic Gardens, Raffles Building, coll. Tertilt, 16 Sep.2011; 5 males, 8 females, SMNG, Hortpark, coll. Tertilt, 16 Nov.2010; 4 males, 1 female, SMNG, Hortpark, coll. Decker & Tertilt, 14 Jul.2011; 8 males, 5 females, SMNG, Hortpark, coll. Rui Feng, 16 Sep.2011; 4 males, 9 females, SMNG, Hortpark, coll. Hau Rui, 17 Sep.2011; 18 males, 1 female, SMNG, Hortpark, coll. Hau Rui, 10 Nov.2011; 14 males, 5 females, SMNG, Hortpark, coll. Tertilt, 20 Dec.2011; 3 males, 3 females, 4 juveniles, SMNG, Gardens by the Bay, 18 Marina Gardens Drive, coll. Tertilt, 13 Sep.2011; 1 male, 2 females, 1 juvenile, SMNG, Gardens by the Bay, 18 Marina Gardens Drive, coll. Tertilt, 18 Nov.2011; 5 males, 17 females, SMNG, Senkang Riverside Park, Anchorvale Street, coll. Tertilt, 24 Nov.2011; 19 males, 12 females, 1 juvenile, SMNG, Sarimbun Recycling Park, Lim Chu Kang Road, coll. Tertilt, 24 Nov.2011; 15 males, 1 female, SMNG, Republic Polytechnic, 9 Woodlands Avenue, coll. Yiu Liang, 2 Dec.2011; 23 males, 5 females, SMNG, RMBR, Republic Polytechnic, 9 Woodlands Avenue, coll. Hau Rui, 2 Dec. 2011; 9 males, 16 females, SMNG, Republic Polytechnic, 9 Woodlands Avenue, coll. Rui Feng, 2 Dec.2011.

**Remarks.** — *Anoplodesmus saussurii* is probably native to Southern India or Ceylon and was introduced to the Pacific islands of Fiji, Vanuatu, and Mauritius (Shelley & Lehtinen, 1998). On Fiji, this species has been able to colonise undisturbed, natural habitats (Jeekel, 1980). It is one of the few tropical Asian millipede species in which the life cycle and ecology have been studied in detail.



Fig. 1. An adult male *Anoplodesmus saussurii* of about 25 mm total length at the Singapore Botanic Gardens in the morning of 25 Nov.2011.



*Anoplodesmus saussurii* is often found in large aggregations (Fig. 2) under the cover of decaying litter layers in the agricultural and horticultural land areas and forests on humid soils in India. The species feeds on various kinds of leaf litter, rotten vegetables, tree stems, wood, decaying fish, and cow dung (Bano & Krishnamoorthy, 1981a, 1981b; Prasad et al., 1981; Dutta & Joy, 1992, 1993). There have been no documented observations to suggest that it feeds on living plants. This species, like millipedes in general, plays an important role in the litter breakdown of the ecosystems in which it lives. Populations of *Anoplodesmus saussurii*, which occur often in high densities, can consume and break down up to 1 kg of dry litter per square meter per year (Bano, 1996).

The life cycle of *Anoplodesmus saussurii* is quite short for a millipede of this size (21–33 mm). 20–25 days after copulation, 100–400 eggs are laid in earthen nests constructed by the females 5–10 cm deep in the soil. One female can lay 2–4 egg masses during its life time. From egg to adult it takes seven moultings to reach maturity in stadium VIII. In the sixth and seventh stadia the larvae can undergo long diapauses to overcome dry periods. Therefore, adults appear in large numbers on the surface after the onset of the rainy season. Depending on temperature, moisture and food supply, *Anoplodesmus saussurii* needs 6–7 months to complete its life cycle. The adults are active on the surface, mate even during daylight hours, and live for 4–6 weeks. There are two generations per year, which overlap one another. The life cycle of *Anoplodesmus saussurii* was studied in detail by Bano & Krishnamoorthy (1985) and Prasad et al. (1981).

A very interesting fact of *Anoplodesmus saussurii*, besides its short life cycle and high reproduction rate, is its sociability with aggregations of up to nearly 200 individuals per square metre (Bano & Krishnamoorthy, 1985). These aggregations are probably induced by rhythmical secretion of pheromones. This species is most active at twilight hours and aggregate at midnight and during midday (Bano et al., 1976; Bano, 1978; Bano & Krishnamoorthy, 1979). Like nearly all Polydesmida, *Anoplodesmus saussurii* secretes hydrogen cyanide from the repugnatorial glands for defence against potential predators (Bano, 1978).



Fig. 2. Aggregation of *Anoplodesmus saussurii* at HortPark in the late afternoon on 14 Jul.2011.



The first records of mass invasions of ‘black millipedes with yellow stripes’ were made during the early 1980s, when houses were invaded from underneath doors and through windows. The species became more abundant, and also spread out into public parks. Incorrect names for this millipede species circulated, e.g., *Harpaphe haydeniana* (Wood) and *Orthomorpha weberi* (Pocock), probably based on the superficial similarity in the colour pattern of *Anoploidesmus saussurii* which is common among millipedes of the order Polydesmida. In 2010 this species was identified as *Anoploidesmus saussurii* by PD.

*Anoploidesmus saussurii* is very active on the soil surface during the daytime, and is therefore very conspicuous and easy to recognise. The species occurs in some places in high densities, with several dozen individuals per square metre, where its presence can become a nuisance to people. It was found in drainage canals and any type of newly built landscapes, especially where compost has been used. Typical sample locations are along road curbs, along concrete foot paths, under concrete walls of houses, and in all types of human structures. This species was even recorded on roof gardens. *Anoploidesmus saussurii* is also frequently found in connection to the compost used as mulch medium around landscape trees; after some weeks, the compost can be totally replaced by millipede faeces. Recently, the species has also been found to have an affinity for the coarse turf of tropical carpet grass (*Axonopus compressus* P.Beauv.).



Fig. 3. Dorsal view of segment ten of *Anoploidesmus saussurii*. Scale bar = 1 mm.



Fig. 4. Ventral view of gonopods of *Anoplodesmus saussurii*. Scale bar = 1 mm.

*Chondromorpha xanthotricha* (Attems, 1898)

Figs. 5–7

**Diagnosis.** — Length 20–26 mm, width 3.2–4.3 mm, body thin and fragile. General colouration of adult individuals is chestnut brown to dark grey (Fig. 5). Ventral part of collum and the angular acuminate caudal projection of paranota is whitish and very long light brown, with slender legs exceeding metatergites. The metaterga are covered with pappilae and with three rows of about ten setae; two additional setae are located on the lateral side of the paranota (Fig. 6). The setae easily break off after preservation. The male gonopods have a unique shape (Fig. 7). Very fast-moving species.

**Material examined.** — 6 males, 5 females, SMNG, Woodlands Waterfront Park, coll. Rui Feng, 10 May 2011; 6 females, 7 juveniles, SMNG, Singapore Botanic Gardens, National Biodiversity Center, coll. Tertilt, 14 Jun.2011; 1 male, 6 females, 2 juveniles, SMNG, Singapore Botanic Gardens, National Biodiversity Center, coll. Tertilt, 1 Sep.2011; 1 male, 3 females, 25 juveniles, SMNG, Gardens by the Bay, 18 Marina Gardens Drive, coll. Tertilt, 13 Sep.2011; 16 males, 18 females, 2 juveniles, SMNG, RMBR, Punggol Waterway Park, Punggol Road, coll. Tertilt, 16 Dec.2011; 6 females, 7 juveniles, SMNG, Dawson Road, Residential, coll. Tan Yiu Liang, 10 Jun.2011.





Fig. 5. A live *Chondromorpha xanthotricha* of about 22 mm total length at Gardens at the Bay on 2 Feb.2012. (Photograph by: Yixiong Cai).



Fig. 6. Dorsal view of segment ten of *Chondromorpha xanthotricha*. Scale bar = 1 mm.



**Remarks.** — Like *Anoplodesmus saussurii*, *Chondromorpha xanthotricha* is also probably native to Southern India and Ceylon, and has been widely distributed by human activity into Taiwan, Philippines, Bali, New Caledonia, Samoa, Fiji, Mauritius, Guadeloupe, Jamaica, Suriname, and Puerto Rico (Santiago-Blay & Vález, 1985; Shelley & Lehtinen, 1998; Hoffman, 1999; Korsós, 2004). In Puerto Rico it is common in synanthropic places like gardens and along roadsides (Santiago-Blay & Vález, 1985).

Nothing is known about the life history and ecology of this species but the numerous introductions imply that *Chondromorpha xanthotricha* occupies a broad ecological range, and therefore has the potential to colonise many new areas within the tropics.

Unlike *Anoplodesmus saussurii*, *Chondromorpha xanthotricha* seems to occur infrequently, with a maximum abundance of 20 individuals per square meter. This species seems to be even more active during the daytime than *Anoplodesmus saussurii*, so it can be assumed that it is more tolerant towards sun and high temperatures. The mobility of *Chondromorpha xanthotricha* is much higher than *Anoplodesmus saussurii*. According to the present data, this species has so far only been found in the most recently built parks in Singapore.



Fig. 7. Ventral view of gonopods of *Chondromorpha xanthotricha*. Scale bar = 1 mm.

## DISCUSSION

The myriapod fauna of cities in the tropics consists mainly of tropical tramp species that are spread by human activity. Also, in Singapore, the fauna of the parks and gardens are dominated by such species as *Trigoniulus corallinus*, *Leptogoniulus sorornus*, *Benoitolus flavicollis* (Mauriès), and *Asiomorpha coarctata* (unpublished data). Except for the presence of these common species, there are no observations documented in the literature that suggest they have ever been a nuisance to people. Millipedes are generally introduced as eggs, larvae or adults located within the root material of plants. If the conditions are suitable, populations can establish. *Anoploidesmus saussurii* has spread very fast during the recent years in Singapore, and has become a nuisance to people. Likely, the production and spread of compost earth by many compost companies is a major cause of the species' expansion. Both *Anoploidesmus saussurii* and *Chondromorpha xanthotricha* were found on the compost heaps at the Sarimbun Recycling Park, where all compost companies within Singapore are located. Millipedes were also observed crawling out of the rootballs of newly imported plants. It is assumed that both species will become established in the city of Singapore. Attention will be necessary if these species are found to invade natural forest habitats, such as the Bukit Timah Nature Reserve.

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