

FIRST REPORTS OF TWO TERRESTRIAL SLUGS (GASTROPODA: EUPULMONATA) FROM SOUTHERN AFRICA

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Abstract Two large slug species are reported from southern Africa for the first time. *Arion flagellus* Collinge, 1893 (Arionidae) was found in a pine plantation in KwaZulu-Natal, South Africa in 2014. It originates in western Europe, and may spread via commercial forestry to climatically similar areas. *Polytoxon robustum* (Simroth, 1896) (Urocyclidae) belongs to the less well-studied tropical African slug fauna. It has been established in Harare, Zimbabwe since the 1990s but was identified only in 2015. It may have been introduced from Central or East Africa, where it has broad habitat and climate preferences.

Key words introduced, non-native, pests, plantations, Mollusca, Arionidae, Urocyclidae

INTRODUCTION

New populations of non-native terrestrial slugs continue to be detected around the world. As most slug species are under-recorded, species introduced to a country's fauna are often not noticed until long after they become established (e.g. Rowson *et al.*, 2014a). Their spread results largely from the accidental movement of slugs or their eggs via soil, plants, other goods, livestock or vehicles, although other types of dispersal may play a role locally.

Most studies of introduced slugs concern temperate regions, although the spread of one originally European species has now been reviewed on a global scale (Hutchinson *et al.*, 2014). The human-mediated spreading of both native and introduced species within subtropical regions is also documented. In South Africa, for example, Herbert (2010) and Herbert & Kilburn (2004) list ten introduced slugs and four native ones (three in Urocyclidae, one in Veronicellidae) that appear to have been locally dispersed by people. Nearer the Equator, mollusc faunas are generally less well studied, making the movement of tropical species more difficult to detect unless the distributional disjunction is great. Examples among tropical African terrestrial snails can be found in Verdcourt (1961), de Winter (1988) and Rowson *et al.* (2010). The veronicellid slug *Laevicaulis alte* (Férussac, 1821) is now almost circumtropical, but is thought to have originated in East or Central Africa (Forcart, 1953; Herbert, 2010). The

native and introduced range of such species may be difficult to distinguish.

Here we report on two terrestrial slug species new to the known faunas of their respective countries. Both are reported from above 1400m elevation, where they were collected during the wettest time of year.

The examined material is at the National Museum of Wales, Cardiff, UK (NMW) and the KwaZulu-Natal Museum, Pietermaritzburg, South Africa (NMSA).

RESULTS AND DISCUSSION

Family Arionidae Gray, 1840

Genus *Arion* Férussac, 1819

Arion (A.) *flagellus* Collinge, 1893

Material examined NMSA W9643: SOUTH AFRICA: KwaZulu-Natal: Nottingham Road area, Gowrie Estate (29.3645°S, 30.0205°E), 1420m, pine plantation, under logs, leg. H. Grobler, 27.i.2014 (6 adults and 2 juveniles).

Comparative material NMW: many additional specimens of Arionidae from Britain and Ireland, including Irish topotypes of *A. flagellus* and others figured and cited in Rowson *et al.* (2014a, b).

Locality, habitat and observations The material recorded was collected fortuitously, by an observant conservation professional, in a pine

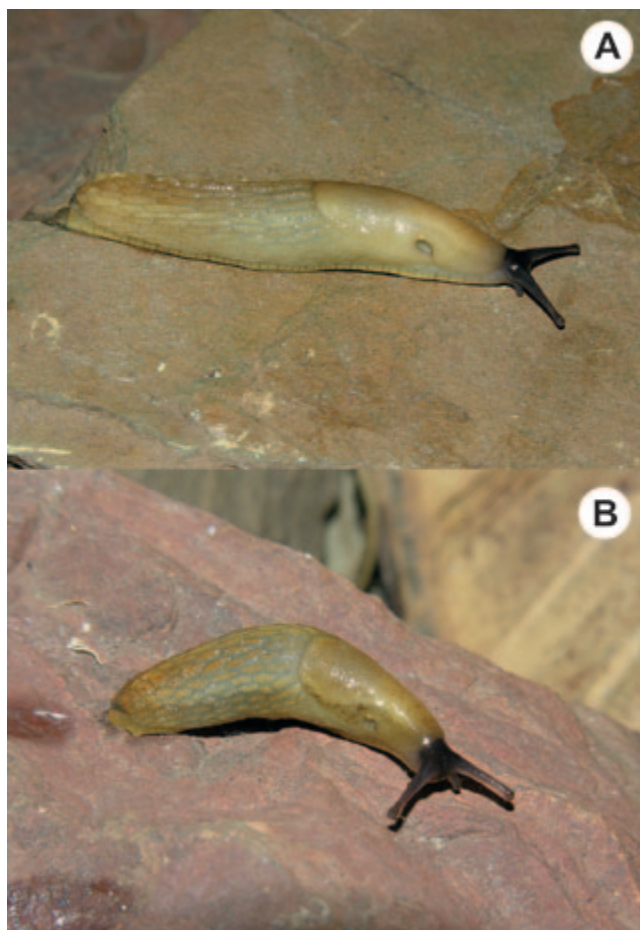


Figure 1 *Arion flagellus* from KwaZulu-Natal, South Africa. Living extended lengths 60mm (A) and 45mm (B). The animal in (A) was later dissected. Photos: D. G. Herbert.

plantation in the KwaZulu-Natal Midlands. From a malacological perspective, the region is relatively well known and, since there is only this single record, it is likely that the introduction is a relatively recent one. A number of other terrestrial molluscs of western Palaeartic origin are also established in this region (including the slugs *Arion intermedius*, *Deroceras laeve*, *D. reticulatum*, *Lehmannia nyctelia*, *L. valentiana*, *Limacus flavus* and *Milax gagates*), indicating that it is climatically and ecologically favourable to species originating from Europe.

Identification Two of the adult specimens, living extended lengths 60mm and 45mm (Fig. 1), were externally identified as *A. flagellus* using a draft version of Rowson *et al.* (2014b), in particular due to their size, characteristically coarse tubercles, colour, weak banding and lack of orange mucus. On dissection, the genitalia and ligula proved to

be a close match with the figures of *A. flagellus* in Rowson *et al.* (2014b).

A 622 bp COI barcode sequence was obtained from a South African specimen using the protocol in Rowson *et al.* (2014a). This was identical to sequences of *A. flagellus* from the UK (GenBank accessions AY987880–1 and JF950535) and one from a topotype from Ireland (specimen I9 in Rowson *et al.*, 2014a,b).

Status This species is new to the fauna of South Africa (and Africa as a whole). Herbert's (2010) review of the South African fauna included 11 European slugs of which at least ten were established. Two of these belong to the Palaeartic family Arionidae: *Arion (Kobeltia) hortensis* Férussac, 1819 (aggregate) and *A. (K.) intermedius* Normand, 1852. Two larger Arionidae were also mentioned as potential future introductions: *A. (A.) ater* (Linnaeus, 1758) and *A. (Mesarion) subfuscus* (Draparnaud, 1805). Although the larger Arionidae can be difficult to identify, all these species can be ruled out by the criteria in Rowson *et al.* (2014b). These authors noted that the pest status of *A. flagellus* in the UK is unclear, but that it has been observed feeding on garden flowers and seed heads. It can be common in woodlands, including conifer (*Larix*) plantations, as well as open and urban habitats.

Origin This species must have been introduced, directly or indirectly, from Europe. *Arion flagellus* is apparently native to Spain and Portugal, and is also increasingly common in Britain and Ireland, where it may have been introduced (Davies, 1987; Quinteiro *et al.*, 2005; Rowson *et al.*, 2014a, b). Identical COI sequences for the South African, British and Irish specimens suggest that either of these two European countries could be the source.

Potential for spread The South African finding further confirms that *A. (A.) flagellus* is capable of human-mediated dispersal. It appears to be spreading in this way in Britain and Ireland (Rowson *et al.*, 2014b). To date it is known from a single locality in South Africa. This locality lies within the KwaZulu-Natal Midlands, a rural but considerably transformed landscape dominated by agriculture and plantation forestry. The specimens were found in a pine plantation suggesting that the path of introduction may have been via the forestry industry. This in turn indicates

that there are likely to be additional populations at one or more of the silviculture nurseries that service the forestry industry. The potential for further dispersal via this means is therefore considerable. Herbert (2010) has already identified the plantation forestry industry as a potentially significant agent in the spread of both introduced and native terrestrial molluscs in South Africa.

Family Urocyclidae Simroth, 1888

Genus *Polytoxon* Simroth, 1897

***Polytoxon robustum* (Simroth, 1896)**

Material examined NMW.Z.2015.007.00001–00003: ZIMBABWE: Harare, Greystone Park, Warwick Road, near Greystone Park Nature Preserve (17.7461°S, 31.1298°E), 1483m, cultivated lawn and stone walls of garden, leg. E. F. Robertson, 9–20.i.2015 (3 adults).

Comparative material NMW: many additional specimens of *P. robustum* and other genera of Urocyclidae from Kenya, Tanzania, Uganda and South Africa, including topotypes of *P. robustum* from Mt. Kilimanjaro, Tanzania.

Locality, habitat and observations The large yellow slugs that are identified here as *P. robustum* were already well-established in a garden in Greystone Park, one of the north-eastern suburbs of Harare, by 1998. Although common on this particular property, the slugs were not then evident in neighbouring gardens (J. Michalowski pers. comm.). *P. robustum* was seen in a garden next to the Greystone Park Nature Preserve, some 2km east-north-east of this initial location, for the first time sometime during the period between 2008–2010 and photographed during January 2011. Since then there have been many reports of large yellow slugs found in other north-eastern suburbs of Harare, but not, so far, from elsewhere in the city.

Little is known of the ecology of *P. robustum* or other tropical urocyclid slugs. Observers of this slug in Harare remark that it is conspicuous, that they have not previously seen a slug so large and strikingly coloured, and that where it does occur it is common. No one has complained that it damages flowers, fruit or vegetables. Direct or indirect effects on other invertebrates are

unknown. In gardens in Harare, *P. robustum* has been seen eating pet food and dog faeces. The slug disappears during the dry season that lasts six to nine months and hides when the rainy season is interrupted by sunny days without rain. It often climbs plastered walls, leaving a trail of mucus and clusters of faeces, and during wet weather has been seen descending the trunks of palm trees.

Identification Externally, the living slugs were very large, reaching 165mm extended, and pale yellow-cream to mustard-yellow in colour, mottled to a variable extent with light brown (Fig. 2). The sole was pale. The mucus was copious, viscous and difficult to remove from the hands (which, incidentally, parallels that of the larger *Arion* species). A strong dorsal keel extends along the posterior half or third of the tail, which terminates in a short caudal appendage above a deep caudal pore. The mantle is warty and attached at the rear, with a small shell pore. The jaw has a strong median projection. Most of these external features are common to several urocyclid genera and species identification requires dissection of the distal genital tract, for which the essential work is the revision of Van Goethem (1977). Sometimes the tips of the darts protrude when a slug is drowned for preservation, but this is too rare an occurrence to be relied upon. On dissection, they key readily to *Polytoxon* in Van Goethem (1977) due to the characteristic genitalia. Obvious in the Harare slugs are the very large dart sac, lacking retractors, onto which the penis and vagina join on opposite sides near the atrium. A transverse section of the apical third of the dart sac shows 22 darts, with the tips of at least 8 protruding into the atrium, and the penial prepuce has calcareous spines. No spermatophores were present, but the above combination of features is unmistakable as that of *Polytoxon*.

Polytoxon was considered a monotypic genus by Van Goethem (1977) who reviewed over 5000 Urocyclidae from throughout Africa. He placed 12 previously recognised species and subspecies in synonymy with *P. robustum* because he did not consider the differences between them sufficiently well-established. Similarly, any peculiarities shown by the Harare slugs seem to be within the variations described and figured for *P. robustum* by Van Goethem.



Figure 2 *Polytoxon robustum* from Harare, Zimbabwe. Living extended lengths up to 165mm. The animal in (C) was later dissected. Photos: E. F. Robertson.

Status This species is new to the known fauna of Zimbabwe. Although Van Goethem's (1977) revision included many other Urocyclidae from Zimbabwe and other southern African countries, he reported *P. robustum* only from Tanzania, Kenya, Uganda, the eastern Democratic Republic of Congo, Rwanda, and South Sudan. Van Bruggen (1978) reported on slugs of southern Africa as a whole but did not mention *Polytoxon*; nor was it among the four introduced terrestrial molluscs

he reported from Zimbabwe (van Bruggen, 1981). The lists for Malawi by van Bruggen & Meredith (1984) and van Bruggen (1993; 2008) did not mention *Polytoxon* among the Urocyclidae known or expected to occur in that country, and it has not been reported in recent studies in Zambia (van Bruggen, 1988), Mozambique (Muratov, 2010) or South Africa (Herbert & Kilburn, 2004; Herbert, 2010). We have found no specimens or other records of *Polytoxon* south of central Tanzania, over 1000km north of Harare.

Nevertheless the mollusc fauna of Zimbabwe remains incompletely known, so the possibility that *Polytoxon* is native to Zimbabwe or even Harare cannot be ruled out. Van Bruggen (1978) records that the tropical genera *Dendrolimax* Heynemann, 1868 and *Leptichnoides* Van Goethem, 1975 have their southern limits in Zimbabwe. However, the sudden appearance of the conspicuous *P. robustum* in a city so far from its main range suggests that it is indeed an introduction.

Origin The source and the means of this slug's arrival in Harare are not known. The slug was detected before Zimbabwe's military intervention in the civil war in the eastern Democratic Republic of Congo during 1998 and its subsequent exploitation of the DRC's natural resources (Dashwood 2001/2002). There are long-established air and road links between Zimbabwe and East Africa and this region is perhaps a more probable source.

Potential for spread This species evidently has a wide habitat tolerance. The material listed by Van Goethem (1977) ranges from near sea level at Mombasa to 3200m on Mt. Elgon. In the eastern Democratic Republic of Congo, habitats include montane forest, bamboo forest, heather and *Hagenia* montane vegetation types, as well as woody and herbaceous savanna. In Kenya and Tanzania, habitats include forest, bamboo forest, and banana and coffee plantations, including those within forests on Mt. Kilimanjaro. Verdcourt (1981) noted that in East Africa, large populations of slugs can also exist in bushland, or grassland with scattered trees, where annual rainfall is as low as 20–30 inches (508–762mm). He described seeing hundreds of *Polytoxon* active on tree trunks in early morning dew near Lukenya Hill, Kenya (approx. 1.48°S, 37.06°E, where this

level of rainfall pertains). Mean annual rainfall in Harare is 800–900mm, and more than two-thirds of Zimbabwe receives at least 600mm of rain each year on average (Mazvimavi, 1989). Thus, it appears that relatively low average rainfall would not, alone, limit the distribution of *P. robustum* in Zimbabwe.

Horticulture and rural reforestation schemes that involve transplanting seedlings grown in Harare are possible means for the further spread of *P. robustum*. Tree-planting has been proposed in conservation areas such as Mana Pools National Park and the Urungwe Safari Area that, because of their remote location, are so far relatively free of alien invasive animals and plants.

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