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Source: African Invertebrates, 51(2) : 289-312

Published By: KwaZulu-Natal Museum

URL: <https://doi.org/10.5733/afin.051.0204>

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Megadrile earthworm taxa introduced to South African soils (Oligochaeta: Acanthodrilidae, Eudrilidae, Glossoscolecidae, Lumbricidae, Megascolecidae, Ocnerodrilidae)

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ABSTRACT

The occurrence of 50 earthworm species of 22 genera from six families, namely Acanthodrilidae (Acanthodrilinae, Benhamiinae), Eudrilidae (Eudrilinae, Pareudrilinae), Glossoscolecidae, Lumbricidae, Megascolecidae, and Ocnerodrilidae, not native to South African soils, is reported. Some of the species of Pareudrilinae may be listed temporarily, possibly being indigenous to South Africa. Brief information on family status, species origin and broader distribution is included. Various laboratory and field experiments conducted in South Africa on some species are selectively indicated.

KEY WORDS: Acanthodrilidae, Acanthodrilinae, Benhamiinae, Eudrilidae, Eudrilinae, Pareudrilinae, Glossoscolecidae, Lumbricidae, Megascolecidae, Ocnerodrilidae, introduced species, exotic, South Africa.

INTRODUCTION

The southern part of the African continent may be ranked as extremely biologically diverse terrain. Soil diversity caused by variable factors in geology, climate, landscape, *etc.*, creates a great potential for associated biodiversity, which is of significant interest. However, our knowledge of the terrestrial earthworm fauna in South Africa is still insufficient. To date the best-documented megadrile earthworm species belong to indigenous families: Acanthodrilidae (5 genera with 146 species in Acanthodrilinae) and Microchaetidae (6 genera, 136 species), with numerous new species expected to be found. Data on the exotic taxa occurring in South African soils are usually restricted to inadequate notes. During the last century only three records of exotics were published. Michaelsen (1913*b*), identifying indigenous earthworms from Zululand, noted seven foreign species in Natal and one in the Free State. Ljungström (1972) recorded 23 nominal taxa introduced to this country intentionally or coincidentally during past centuries. Van Bruggen (1978) repeated similar information. The present record of the exotic terrestrial megadrile earthworms occurring in the soils of South Africa is drawn from various publications, supplemented by records kept in the Natal Museum database and observation gathered during years of earthworm collection and taxonomic study. Fifty nominal species (including subspecies) are accredited to 22 genera of six families: Acanthodrilidae: Acanthodrilinae (1 genus, 2 species); Benhamiinae (1 genus, 6 species); Eudrilidae: Eudrilinae (1 genus, 1 species); Pareudrilinae (2 genera, 4 species); Glossoscolecidae (1 genus, 1 species); Lumbricidae (8 genera, 19 species); Megascolecidae (4 genera, 12 species); Ocnerodrilidae (4 genera, 5 species).

It is usually accepted that earthworms may spread naturally, although very slowly, being carried by water (rivers, streams, rainfall), possibly by birds, and certainly transported intentionally or accidentally by humans. The majority of the species not native to South African soils are known worldwide, being distributed mostly by humans, as was pointed by Ljungström (1972). Pareudrilinae species listed in this paper, being ori-

ginally indigenous to West or Central Africa, might spread to South Africa naturally, or are possibly developed from ancestral taxa extending the family's distribution to the southern part of the African continent. Some ocnerodrilid species, with confusing taxonomic and distributional status, are recorded with uncertainty, but their status may be clarified when more information is obtained. The present list combines general information on the species' frequent or rare occurrence, indicating possible uncontrolled spread after accidental or intentional introduction.

MATERIAL AND METHODS

The information on megadrile earthworm species occurring in the soils of South Africa was drawn from publications containing taxonomic and distributional information, in some cases enriched with new data from the Natal Museum database, and the author's observations. The material, however, was not studied, and the location of the material identified by various authors and published in numerous publications, although possibly mentioned in the original papers, is not given here. Data on species distribution are occasionally enriched with some ecological observations. Data published for other than taxonomic purposes, and observations from field ecological studies with no preserved material, are given selectively. The whereabouts of material used for laboratory and field experiments, ecological study or any other purpose, are not indicated. Short information is provided on family status and the original description and distribution of the species. The systematic record of families, subfamilies, genera and species is presented in alphabetical order. The names of provinces are updated to those currently used, and are abbreviated.

Abbreviations, codens and acronyms used in the text:

BMNH – The Natural History Museum, London, UK; EC – Eastern Cape; FS – Free State; GP – Gauteng; HNHM – Hungarian Natural History Museum, Budapest, Hungary; KNP – Kruger National Park; KZN – KwaZulu-Natal; LP – Limpopo; MP – Mpumalanga; NC – Northern Cape; NMSA – Natal Museum, Pietermaritzburg, South Africa; NMSAD – Natal Museum database; NMSA/Olig. – Oligochaeta collection in the Natal Museum; NW – North West; RSA – Republic of South Africa; WC – Western Cape; ZMUH – Zoological Museum and Institute, University of Hamburg, Germany.

TAXONOMY

Family Acanthodrilidae Claus, 1880 emend. Csuzdi, 1996

Taxonomic status and geographical distribution of taxa currently accounted to this family are under continuous study, discussion and evaluation, with various generic and specific accreditation, and occasional indications on other family linkage (Csuzdi 1995, 1996; Jamieson *et al.* 2002; James 2005; Blakemore 2005, 2006*b*, 2007, 2008*b*; Pop *et al.* 2005; and many others). In this paper, a taxonomic endorsement is partly based on the family rank and its capacity proposed by Csuzdi (1995, 1996, 2000), with the inclusion of the Benhamiinae. Acanthodrilid taxa are known from the warmer parts of southern and eastern parts of North America and the southern and eastern regions of South America; on the African continent they occur in western, central and eastern regions, and in RSA; they are also known from New Zealand, New Caledonia and parts of Australia. In South Africa 146 indigenous species occur, probably pre- or Gondwanan and related to South American taxa (Pickford 1937; Plisko 2007,

2008; Moreno *et al.* 2008), and some *Eodriloides* possibly allied to Australian/New Zealandian taxa (Blakemore 2008c), are all placed in the subfamily Acanthodrilinae. Six Benhamiinae species of *Dichogaster* (*Diplotheocodrilus*): *affinis*, *anna*, *bolau*, *modiglianii*, *saliens* and *krugeri* possibly originating in West or Central Africa and described under numerous synonyms (presented chiefly by Csuzdi (1996, 2000)), have been passively transported by man to various parts of the world and also occur in South African soils. *Microscolex dubius* and *phosphoreus*, both possibly native to South America but introduced by man widely across the world, are also recorded from RSA.

Subfamily Acanthodrilinae Claus, 1880

Genus *Microscolex* Rosa, 1887

Microscolex dubius (Fletcher, 1888: 378)

Described from garden soil, Sydney, Mulwala, NSW Australia. The species' original home is most probably in the southern part of South America (Gates 1972). A synantropic species, distributed in tropical and subtropical regions intentionally, or accidentally by man. In RSA recorded by Michaelsen (1899a, 1913a, 1933), Pickford (1937), Ljungström (1972), and Zicsi (1998) from numerous collection sites: Boshof (FS); Port Elizabeth, Uitenhage and Craddock (EC); Cape Flats, Bergvleit, Cape Peninsula, Cape Town, French Hoek, Hout Bay and Chapman's Peak Road (WC). Occasionally found with the introduced lumbricid *Aporrectodea rosea* and the indigenous *Proandricus timmianus* (Michaelsen, 1933). Various authors expected species common distribution, however, during last decades no new material has been reported.

Microscolex phosphoreus (Dugès, 1837: 17)

Described from a greenhouse in France. Origin expected in southern part of South America (Gates 1972). Synantropic, known from various parts of the world, broadly distributed by man to tropical and subtropical regions. Recorded also in temperate zone from greenhouses and also in the field in Hungary (e.g. Csuzdi 1986).

In RSA recorded by Michaelsen (1899a, b, 1908, 1913a), Pickford (1937), Sciacchitano (1960), Ljungström (1972), and Zicsi & Pajor (1992) from a range of localities: Soutpansberg, small kloof near Louis Trichardt [= Makhado] (LP); near Lesotho border (FS); Kranzkop (KZN); Port Elizabeth (EC); 'Kafferlandet' (which is probably Cape Peninsula), Hout Bay and Mossel Bay (WC); Little Namaland and Komaggas [Namaqualand] (NC). Ljungström (1972) mentioned a sample collected in Pietermaritzburg (KZN), housed in ZMUH. In the NMSAD recorded from garden soil in St Lucia (KZN). Pickford (1937) found this species in native forest (Soutpansberg) and in a number of other sites in various provinces, and predicted its broad distribution, suggesting common occurrence in South Africa. However, during the last decades only one specimen was added to the NMSA collection.

Subfamily Benhamiinae Michaelsen, 1897 emend. Csuzdi, 1996

Genus *Dichogaster* Beddard, 1888

Subgenus *Dichogaster* (*Diplotheocodrilus*) Csuzdi, 1996

Dichogaster (*Diplotheocodrilus*) *affinis* (Michaelsen, 1890b: 29)

Described from Quilimane, Zanzibar. Tropical and subtropical; known from western and central Africa, Middle and South America, India, Burma and Indonesian islands. In

RSA occurs rarely; reported by Horn *et al.* (2007) from a few sites in the Soutpansberg (LP) and by Zicsi (1998) from Durban, Stamford Hill and Pietermaritzburg (Sunnyside, Celtis Rd, collected with *annae*) (all KZN).

Dichogaster (Diplotheodorilus) annae (Horst, 1893: 32)

Described from Java. Recorded from tropical parts of Africa and South America. From RSA, reported by Zicsi (1998) from one locality in Pietermaritzburg (suburb Sunnyside, at side of Celtis Rd) (KZN); collected with *affinis*.

Dichogaster (Diplotheodorilus) bolau (Michaelsen, 1891: 307)

Described from Bergedorf, Germany, being probably introduced from tropical or subtropical areas. Noted from various parts of the world, also from temperate zones when climatic conditions allow (greenhouses and various potted plants). Widely invaded the sewerage systems from Finland through Central Europe to Ireland (Rota & Schmidt 2006; Csuzdi *et al.* 2008).

In RSA known from numerous, distantly located sites: Entabeni State Forest, and Soutpansberg (Horn *et al.* 2007) in LP; Witbank (MP); Eshowe area (Dlamini 2002). Zicsi (1998) reported it from: Mapelane Nat. Res., Karkloof Nat. Res., Pietermaritzburg and its neighbourhood, and Oribi Gorge Nat. Res. (KZN). Ljungström (1972) record from 'Blinkpan coal mine', which probably refers to the area of the mine in GP. Fourteen records in the NMSAD refer to cultivated land under experimental study: Baynesfield, grassland; Eshowe citrus field, kikuyu grass, sugar cane; Greytown, vermicomposting farm; Merrivale, Arden Farm, Cedara Agriculture College – grassland. Five records are from greens, parks and gardens in Pietermaritzburg. Ten records are from natural habitats: Skyline Nat. Res., Bluff Nat. Res., Ngome Forest, Mvutshini River Valley and Karkloof Nat. Res. (KZN); Entabeni State Forest and Soutpansberg (LP). Occurs abundantly.

Dichogaster (Diplotheodorilus) krugeri Reinecke & Ackermann, 1977: 7

Described from Kruger National Park, LP, RSA. Type material location unknown. Species' endemic position not certain. Species introduction or synonymy possible.

Dichogaster (Diplotheodorilus) modiglianii (Rosa, 1896: 510)

Described from Padang, Sumatra. Known from tropical and subtropical areas in West Africa, South America, India, Burma, Pakistan, and some Indonesian Islands. In RSA recorded by Zicsi (1998) from three distant sites, all in KZN: Durban, Stamford Hill; Pietermaritzburg, Scottsville; and Umfolozi Game Reserve. Occurs in small populations in litter and between plant roots.

Dichogaster (Diplotheodorilus) saliens (Beddard, 1893: 683)

Type locality undesignated, described from potting soil in Kew Gardens, UK. Origin probably in West Africa. Known from Africa, South and North America, India, Burma, Australia, and various oceanic islands. In RSA, Horn *et al.* (2007) found it in natural habitats in the northern part of the Drakensberg (LP). In KZN, Ljungström (1972) repeated after Michaelsen (1913b) from two sites in Pietermaritzburg (Scottsville and Chapel St.); Zicsi (1998) referred to variable habitats in the Durban area (Bluff, Stamford Hill), the Pietermaritzburg area (Ashburton, Baynesfield, Merrivale farm, Montrose, Scottsville, Town Bush Valley, Voortrekkers Graveyard), Karkloof Nat. Res., Mapelane Nat. Res., the Richmond area, Umlalazi Nat. Res., and Vernon Crookes Nat. Res.; Dlamini (2002) collected it in grasslands and numerous agricultural fields in the Eshowe area. Five new records in the NMSAD refer to Mkhatabi Forest (EC).

Family Eudrilidae Claus, 1880

Representatives of the family Eudrilidae are confined to tropical and subtropical Central Africa (Stephenson 1930; Sims 1987). The genera and species are mostly endemic, not spreading out of their habitats. A few species, however, intentionally or accidentally transported by man to various parts of the world have been able to adapt to new conditions. *Eudrilus eugeniae* has a worldwide distribution. Primarily imported to RSA for a specific experimental study, it is adapting well to habitats in this country.

Information that *Eudriloides durbanensis*, transported from Durban to Kew Botanic Gardens (apparently together with *Ilyogenia africana*), is endemic to KZN, as reported by Beddard (1893) and Michaelsen (1913*b*), has been queried for many years (Michaelsen 1912, 1914; Blakemore 2002, 2006*a*). Collection of this species in Tanzania and KZN allowed Zicsi (1997*a*) to redescribe this species and confirm its validity, although endemicity to RSA is not confirmed. *Nemertodrilus kellneri*, nearly 100 years after being first described, has not been collected in any other part of RSA, or other areas of Africa. Two other species of this genus, *N. kruegeri* and *N. transvaalensis*, are known only from their type localities in north-eastern RSA, distant to the *kellneri* type locality. It is not clear if these species are endemic to this country, or introduced from other parts of Africa.

Subfamily Pareudrilinae Beddard, 1894

Genus *Eudriloides* Michaelsen, 1890*Eudriloides durbanensis* Beddard, 1893: 696

Sent from Durban, KZN, RSA in a box of plants to Kew Gardens, UK, and after description deposited in the BMNH; present housing of type material unknown (Blakemore 2006*a*; Reynolds & Cook 1976: 65). Michaelsen (1913*b*) repeated after Beddard that the species is endemic in Durban, although in his following paper (Michaelsen 1914) expressed uncertainty on its endemicity, supposing its earlier introduction. The species redescription by Zicsi (1997*a*) on the material collected in Margate (KZN) from garden soil confirms the species' occurrence in RSA. Its endemic status, however, is not confirmed for this country. In Tanzania, where it was also collected in garden soil or cultivated land, it is supposedly also introduced.

Genus *Nemertodrilus* Michaelsen, 1890*Nemertodrilus kellneri* Michaelsen, 1912: 57

Described from Bloemfontein, FS, RSA. Reported from the type locality and Kummernais in Namibia. Known also from the banks of the Orange River (FS). Stephenson (1930: 870) stated this species to be a "peregrine". Michaelsen (1914) supposed a limited distribution, suggesting natural transportation to RSA by rivers. However, it is not known if this species was introduced from other part of Africa or, being indigenous to central western- or eastern Africa, its occurrence in southern Africa is habitual. To date, 100 years after the species was described, and after its second reporting by Michaelsen (1914), it has not been collected in any other part of RSA. Two other species of this genus, recorded below, were found distantly to the *kellneri* type locality, in the north-eastern part of RSA. It is also not clear if these two species are indigenous or are introduced from neighbouring Mozambique, where congeners occur (Michaelsen 1890*b*).

Nemertodrilus kruegeri Zicsi & Reinecke, 1992: 151

Described from Marumbeni, KNP, LP, RSA. Known only from the type locality and a few nearby sites, all in KNP: Marumbeni, Eileen, Sndwini, Mafagalamba and between Masitonto and Incomati rivers running in the park. It is not clear if this species is indigenous to RSA, or introduced with planted bushes or trees from neighbouring areas (compare notes for *transvaalensis*).

Nemertodrilus transvaalensis Zicsi & Reinecke, 1992: 153

Described from Shabarumbe, KNP, LP, RSA. Known from the type locality and other 19 localities in the central part of KNP, between the Letaba and Olifants rivers flowing to the Limpopo River, and slightly north of the Letaba River (LP). This species is the second of this genus found in north-eastern RSA. Both occur not far apart, and to date have not been collected elsewhere in RSA or in Africa. However, another species of this genus, *griseus*, is known from the banks of the Zambesi River in Mozambique (Michaelsen 1890b). It is possible that *kruegeri* and *transvaalensis* are indigenous to South African soil, extending the range of the eudrilids' occurrence to the south. However, their introduction and spread in the adapted areas are not excluded.

Subfamily Eudrilinae Claus, 1880

Genus *Eudrilus* Perrier, 1871*Eudrilus eugeniae* (Kinberg, 1867: 98)

Described from St Helena Island (South Atlantic). One of the commonest species in West African soils, which are probably its original home. With its high potential for adaptation to new environmental conditions, it is intentionally transported and commercially used in composting, protein production, and agriculture. Viljoen and Reinecke imported this species to RSA from Germany (the stock originated in West Africa) for a variety of experimental studies (Reinecke & Viljoen 1988, 1994; Reinecke *et al.* 1992; Viljoen & Reinecke 1994; and many others). After laboratory experimental use, this species is presently used in vermicomposting production in RSA farms. Two samples from Potchefstroom and Durban compost heaps are in the NMSA collection.

Family Glossoscolecidae Michaelsen, 1900

Indigenous South African Microchaetidae and South American Glossoscolecidae, having a known Gondwanan origin (Mischis 2004; Plisko 2009), are commonly accepted as closely related (Michaelsen 1900; Stephenson 1930; Brinkhurst & Jamieson 1971). To date, 136 microchaetid species recorded in South Africa are indigenous with high endemism and very low ability to adapt to other than original habitats. Similar observations apply to the majority of the glossoscolecids occurring in South American biotopes. However, one glossoscolecid species, *Pontoscolex corethrurus* has been reported from numerous countries, being transported purposely or passively by humans, and adapting easily to variable environments where climatic conditions allow.

Genus *Pontoscolex* Schmarda, 1861*Pontoscolex (Pontoscolex) corethrurus* (Müller, 1857: 113)

Type locality possibly in Amazonian Brazil. Considered a cosmopolitan species. Showing high potential for crop improvement (Fragoso *et al.* 1999) is commonly used

in agriculture practices. In RSA it is recorded from numerous sites in subtropical north-eastern areas of the country, with a selection of coastal zone and hinterland sites along the Indian Ocean (Plisko 2001). Known from protected areas of KNP (Reynolds & Reinecke 1976; Zicsi & Reinecke 1992), and other sites in LP, MP, KZN, EC and WC (Michaelsen 1913b; Ljungström 1972). In inland areas (GP, NW), it has been noted only under or in plant pots, or in greenhouses. The records in the NMSAD increase the number of sites in natural habitats in protected areas: Bluff Nat. Res.; Eastern Shores (Greater St Lucia Wetland Park); Kosi Bay at the edge of Lake Zilonde; Krantzkloof Nat. Res.; Langeba Natural Heritage Site; Mbumbazi Nat. Res.; Ngoye Forest Reserve; Oribi Gorge Nat. Res.; and Skyline Nat. Res. (KZN), and in the northern Drakensberg at New Agatha and Soutpansberg Ratombo (LP). Found with microchaetids: *Geogenia tuberosa* (Plisko, 1998) at the border of sugar cane plantation (Plisko 1998); in Dlinza Forest Nat. Res. with *Tritogenia douglasi* (Plisko, 1997), *Proandricus entumeni* (Plisko, 1992); in the area of Port Shepstone, in polluted sites with *Geogenia parva* (Michaelsen, 1913) and *G. tuberosa* (Plisko, 1998) (Plisko 2003). Often occurs with megascolecid *Amyntas* sp.

However, it must be said that the material accredited to this species in various papers and in material housed in the NMSA, may include more than only one glossoscolecoid taxon. Moreno (2004) has recognized more species in various collections earlier accredited to *corethrurus*, applying more characters for the *Pontoscolex* species identification. Although up till now only *P. corethrurus* is reported outside the Neotropics, a new revision of the *P. corethrurus* collection gathered in the NMSA and recorded in its database may disclose more glossoscolecoid species.

Family Lumbricidae Rafinesque-Schmaltz, 1815

The recognition of *Lumbricus terrestris* by Linnaeus (1758) was a first step for earthworm taxonomy; however, worldwide dispersal of lumbricids accredited mainly to human activities for many years confused the Palaearctic origin of the Lumbricidae. In later years many of the already described species, being collected in distant parts of the world, were described as synonyms. In addition, numerous lumbricid taxa reproducing parthenogenetically in variable morphs, suggested new taxonomic accreditation and were described under various synonyms. The recently published checklist of internationally recognized lumbricid species includes nearly 1000 nominal names, of which 700 species names in 39 genera, are accepted as valid, although many of them are still awaiting a new evaluation (Blakemore 2004a).

In RSA 18 lumbricid species occur, attributed to eight genera: *Allolobophoridella* (2); *Aporrectodea* (4); *Dendrobaena* (3); *Dendrodrilus* (2); *Eisenia* (2); *Eiseniella* (1); *Lumbricus* (2); and *Octolasion* (2). Most of the species are synantropic, known from many parts of the world. To this country they were introduced at various times in many ways (Ljungström 1972). These species, reproducing in variable parthenogenetic or polyploid morphs, were recorded under variable synonyms, which now makes correct qualification difficult. The collection sites were often supplied incorrectly, giving misleading species distributions, as happened with *Lumbricus infelix* Kinberg, 1867, described apparently from Durban. Michaelsen (1899b) after revision of the original material identified it as *L. terrestris* L., however, data referring to the type locality as 'Pt. Natal' (what may be understood as Durban in KZN) was uncertain. Michaelsen

(1899b: 421) expressed his doubt in the words “...*Ich glaube demnach berechtigt zu sein, die Fundorts-Angabe ‘Pt. Natal’, deren Richtigkeit mehr als zweifelhaft ist, zu annulliren*”, and this declaration allows us to take *L. infelix* = *L. terrestris* out of the record of the species occurring in RSA. Ljungström (1972) expressed a similar opinion. Thus the report on the occurrence of *L. terrestris* in South Africa given by Gates (1972: 119) is not correct. No *L. terrestris* were collected in South Africa during consecutive earthworm collections undertaken in the past decades by a number of researchers (Michaelsen, Pickford, Ljungström, Reinecke, Reynolds, Pajor, Zicsi, Plisko, members of Ezemvelo Wildlife KZN, members of the University of KwaZulu-Natal (Pietermaritzburg), and others). Experimental introduction of mature individuals of this species into gardens and grasslands near Durban and Pietermaritzburg did not bring the expected results. It seems that *L. terrestris* does not reproduce under South African ecological and climatic conditions. However, once in a while some information on its occurrence in this country has been given. Some specimens identified incorrectly as *terrestris* (Mallett *et al.* 1987) probably belong to the Megascolecidae, giving at the time of their identification a wrong impression by some external resemblance, as specimens have similar dimensions and a violet colouring, both features characteristic of some megascolecids occurring in this country, and also known from the literature for the *Lumbricus* species.

Genus *Allolobophoridella* Mršić, 1990 emend. Csuzdi & Zicsi 2003

Two species *Allolobophoridella eiseni* and *Allolobophoridella parva* accredited to this genus are morphologically much alike, undoubtedly differing in the histology of their muscles. Unfortunately, no histology was conducted on the material collected in RSA, and it is possible that it may be qualified differently. Both species were recorded under various synonyms.

Allolobophoridella eiseni (Levinsen, 1884: 241)

Known from Atlantic Oceania Islands, the Himalayas, European countries, the UK and Ireland, and North and South America. Probably introduced to RSA with imported plants and trees; reported by Ljungström (1972) and Horn *et al.* (2007) from a few distantly located sites: Cape Peninsula (Kirstenbosch and Table Mt, Brockenhurst, Queens’s Bower) (WC); Grotebosh, Drakensberg North escarpment (LP); noted in NMSAD from Qudeni State Forest and Karkloof Benvie Farm near Pietermaritzburg (KZN); and Newlands Forest in Cape Peninsula (WC). Found in patches of foreign plantations set in indigenous forests. Lives under and in fallen logs, rotten wood, under bark and in moist litter. Found with lumbricids *Dendrobaena cognettii*, *D. octaedra*, *Aporrectodea caliginosa*, *A. rosea*, *Lumbricus castaneus*, *L. rubellus*, juvenile anthodrilids *Dichogaster* sp., *Parachilota* sp., and the endemic microchaetid *Tritogenia lunata* Plisko, 1997.

Allolobophoridella parva (Eisen, 1874: 46)

Described from Mount Lebanon, USA. Broadly distributed where climatic and ecological conditions allow. In RSA reported by Michaelsen (1899a, 1913a, 1914), Sciacchitano (1960), Reinecke & Ryke (1969), Ljungström (1972) from: Port Elizabeth (EC); Table Mt, Wynberg Cave, and Heidelberg (WC). New data in NMSAD refer to: nurseries in Pretoria (GP) and Hilton (KZN); experimental field at Cedara Agriculture

College, and Impendle Nat. Res. (KZN). Lives under decayed bark, between grass roots, in moist litter, and under pot plants in greenhouses. Once noted together with *Aporrectodea longa* (Reinecke & Ryke 1969).

Genus *Aporrectodea* (Örley, 1885)

Aporrectodea caliginosa (Savigny, 1826: 180) (s.l.) includes *A. caliginosa* (Savigny, 1826) (s. str.) and *A. trapezoides* (Dugès, 1828).

Known under numerous synonymies applied to various parthenogenetic and polyploid morphs, differing (among other morphological characters) in the shape and position of tubercula pubertatis. For those with knob-shaped tubercles on segments 31 and 33 the name *caliginosa* is commonly used; the other form with a continuous pad-like organ on segments 31–33 is named *trapezoides*. Specimens characterized by *caliginosa* or *trapezoides* characters usually occur together in variable ratios, often with a preponderance of *caliginosa*. In South Africa, however, the *trapezoides* form is dominant, found at over 100 sites, against *caliginosa* found only at 15 or so localities. These two are shown under *caliginosa* s. str. (applied in this paper) and *trapezoides* (used in majority of publications).

Aporrectodea caliginosa (Savigny, 1826: 180) (s. str.)

Type locality unknown. Native to the Palaearctic; introduced to many parts of the world, broadly and commonly occurring in the natural and cultivated fields, elsewhere where climatic and ecological conditions allow. Synantropic, reproducing in variable parthenogenetic forms. In RSA reported by Michaelsen (1899*a*, 1908, 1913*a, b, c*), Ljungström (1972), Pickford (1937), Zicsi & Reinecke (1992), and Plisko (2009) from: Zoological Gardens, Pretoria, Krugersdorp and Witportje Falls (GP); Potchefstroom and Styfontain (NW); Port Elizabeth (EC); Stellenbosch, Kirstenbosch area, “Kapland”, Cape Flats, farm Bergvliet (WC); and Komaggas, Namaqualand (NC). Records from NMSAD refer to: Edendale farm in Drakensberg foothills (FS); Potchefstroom (NW); Cradock, Tarkastadt and Tsitsikamma (EC); and Ceres, Newlands Forest and Wellington (WC). Occasionally collected with endemic acanthodrilids: *Eodriloides peringueyi* (Michaelsen, 1913), *E. arundinis* (Beddard, 1897), *E. purcelli* (Michaelsen, 1913), *E. kirstenboschensis* Pickford, 1937, *E. drygalskii castelli* (Michaelsen, 1913), *Parachilota bergvlietanus* (Michaelsen, 1908), *Chilota purcelli purcelli* (Beddard, 1897), *Parachilota wahlbergi* (Michaelsen, 1899), and with the lumbricids *Allolobophoridella eiseni*, *Dendrobaena cognettii*, *Eiseniella tetraedra* and some *Pheretima* sp.

Although its occurrence is noted as less common than *trapezoides*, its wider distribution may be found. It was recently used in various field experiments (Maleri *et al.* 2007, 2008).

Aporrectodea trapezoides (Dugès, 1828: 289) (s. str.)

Type locality is Montpellier, France. Described worldwide under numerous synonyms. Its occurrence is usually similar to *caliginosa* s. str. Both occur habitually together, although in various ratios. In RSA, reported from numerous sites. For years its identification was usually confused with *caliginosa*, and placed under synonymy. Reported by Michaelsen (1913*a, b*) from Knysna rain forest (EC) and Umgeni Falls (KZN); by Ljungström (1972) from Pietersburg (LP), Ermelo (MP), Potchefstroom

(NW), Heidelberg and Roodepoort (GP), Groot Brak River Staasie and Uitenhage Kerkstraat (EC) and Cape Town (WC). Jamieson (1967) reported it from the Krom River, a tributary of the Erste River and north of Stellenbosch. Reinecke and Ljungström (1969) collected it in the area of Potchefstroom with *Proandricus modestus* (Michaelsen, 1899). Visser and Reinecke (1977) record it from Moi River irrigation area near Potchefstroom. Found common in cultivated fields and natural habitats by Dlamini *et al.* (2001). Collected with the acanthodrilid *Parachilota timothyi* Plisko, 2008, other lumbricids: *Aporrectodea rosea* and *Dendrodrilus rubidus rubidus*, and various megascolecids. The NMSAD records the common occurrence of this subspecies at over 100 sites in all provinces. A specimen from "Cape", identified by Kinberg (1867) as *Lumbricus capensis*, was placed by Michaelsen (1899b) in the genus *Allolobophora* with no species identification; by Blakemore (2004a) it was indicated as a synonym of *trapezoides*.

Aporrectodea longa (Ude, 1885: 136)

Described from garden soil in Göttingen, Germany. Noted from many parts of the world. In RSA reported twice, from garden soil in Roodepoort (GP) and Heidelberg (WC). Collected together with *Allolobophoridella parva* and *Eisenia fetida* by Reinecke and Ryke (1969).

Aporrectodea rosea (Savigny, 1826: 182)

Described from Paris, France. Distributed by man widely over the world, synantropic. Parthenogenetic morphs described in numerous synonyms. Common in RSA. Records (Michaelsen 1913a, 1933; Pickford 1937; Ljungström 1972) refer to: George, Uitenhage, "North-west Port Elizabeth"; East London area, King William's Town and Debie Neck (EC); Paradise Estate near Kirstenbosch (WC); and various sites in the Potchefstroom area (NW). Horn *et al.* (2007) report it from numerous sites in the North Drakensberg forest Swartbos. Recorded in variable morphs from nearly 200 sites in all provinces in variable biotopes. In NMSAD recorded from 127 sites from natural and cultivated fields. Often found with microchaetids: *Proandricus timmianus* (Michaelsen, 1933), *Tritogenia palusicola* Plisko, 1997, the indigenous acanthodrilid *Parachilota timothyi* Plisko, 2008, with the introduced acanthodrilid *Microscolex dubius*, and with the lumbricids *A. trapezoides*, *Allolobophoridella eiseni* and *Dendrodrilus rubidus rubidus*. Once recorded with *Eukerria saltensis* by Visser and Reinecke (1977).

Genus *Dendrobaena* Eisen, 1873

Dendrobaena cognettii (Michaelsen, 1903: 130)

Described from Sassari, Northwest Sardinia. Known from a few European countries also from USA and Chile. In RSA, recorded in NMSAD: two clitellate specimens found in litter of the indigenous part of the Newlands Forest partly covered by pine plantation, at the Cape Peninsula (WC). Collected with *Allolobophoridella eiseni* and *Lumbricus rubellus*, near *Aporrectodea caliginosa*, and indigenous juvenile acanthodrilids.

Dendrobaena hortensis (Michaelsen, 1890a: 15)

Described from Hamburg, Germany. Known from many parts of the world, although not commonly. Transported with various plants; recorded in manure, composting, and rich organic soil, also in greenhouses. Reproducing in various morphs. Polymorphism noted, parthenogenesis not confirmed (Gates 1972). In RSA reported twice under the

synonym *D. veneta* var. *hortensis* collected from garden soil in Port Elizabeth (Michaelsen 1899a) (EC), and from Cape Town (Michaelsen 1913a) (WC).

Dendrobaena octaedra (Savigny, 1826: 183)

Described from Paris, France. Occurring widely over the world under variable climatic conditions, in forested areas and plantations, also in golf course greens and grasslands. Broadly known from high altitudes, and cold climatic areas. In RSA recorded mostly from Drakensberg sites at variable altitudes, often reaching 1700 m; common in forested Drakensberg area in LP; 29 records in NMSAD refer to protected areas: Karkloof Nat. Res., Qudeni State Forest, Qudeni Forest Reserve, Mount Currie Nat. Res., Monks Cowl, Kamberg, Cavern, Ndema Grotto (KZN); occurs commonly in indigenous forests, plantations, and grasslands (EC, WC), possibly introduced with planted foreign trees, as suggested by the owner of Benvie Farm, where it was found with the lumbricids *Allolobophoridella eiseni*, *Octolasion lacteum* and *Dendrodrilus rubidus rubidus*, and the megascolecid *Amyntas* sp.

Dendrobaena veneta veneta (Rosa, 1886: 674)

Widely distributed, with high morphological variability. During recent decades used for vermicomposting practices. Introduced to RSA for experimental study, with a possible application in compost production (Viljoen *et al.* 1991; Muyima *et al.* 1994). It is not known if these experiments have been completed, or if the species has spread into neighbouring soils in RSA.

Genus *Dendrodrilus* Omodeo 1956

Dendrodrilus rubidus (Savigny, 1826: 182) (s.l.) includes *D. r. rubidus* (Savigny, 1826) and *D. r. subrubicundus* (Eisen, 1873). Both subspecies reproduce parthenogenetically in variable morphs and have been described under numerous synonymic names. These parthenogenetic and polyploidy forms are often separated into subspecies, but sometimes are identified under “*rubidus*” s.l. Following the observations of Csuzdi & Zicsi (2003), and Blakemore (2004a), two subspecies are recognised in this paper.

Dendrodrilus rubidus rubidus (Savigny, 1826: 182)

Described from Paris, France. Distributed widely all over the world. In RSA reported from numbering localities. Large populations were observed by Horn *et al.* (2007) in Limpopo forests, and in the Drakensberg North mountain range at altitudes over 1700 m (LP). The 88 recent records in the NMSAD confirm its broad distribution in KZN protected areas: Pongola Bush Nat. Res., Itala Game Reserve, Ngele Forest, Mapelane Nat. Res., Karkloof Nat. Res., Karkloof Benvie farm, Newcastle Incandu Forest, Vryheid Hill Nat. Res., the central part of the Drakensberg at Cathedral Peak, Rainbow Gorge Forest and Doreen Falls, Oribi Gorge, Good Hope Farm (Mondi), Impendle Nat. Res., Gxalingenwa Nat. Res., and Swartkop Forest. Common in arable soils in KZN, FS, GP, EC and WC. Occurs abundantly in natural and cultivated soil, from sea level to high altitudes of the Drakensberg mountains. Under favourable SA climate this species is active throughout year, appearing in large populations. Being such a great consumer of organic matter (Csuzdi & Zicsi 2003) it may compete for food with native invertebrates, and possibly should be controlled in RSA.

Found together with the microchaetids *Tritogenia ngelensis* Plisko, 1997, *T. liveragei* Plisko, 1997, *Proandricus adriani* Plisko, 2000, *Geogenia idechorita* Plisko,

2003; and juvenile *Proandricus* sp.; and with the indigenous acanthodrilids *Parachilota timothyi* Plisko, 2008, *P. uysae* Plisko, 2008; *P. bavenda* Pickford, 1937, *P. hutchinsoni* Pickford, 1937; also with other introduced lumbricids *Aporrectodea trapezoides*, *A. rosea*, *Octolasion lacteum*, *D. r. subrubicundus* and *Dendrobaena octaedra*, and nearly always with *Amyntas diffringens* and *Dichogaster* sp.

Dendrodrilus rubidus subrubicundus (Eisen, 1873: 51)

Distributed widely over the world, appears usually together with *D. r. rubidus*. In RSA reported by Michaelsen (1899a) from 'Oranje-Kolonie' (FS), 'Kapland' (WC), and Zicsi (1998) from Otto's Bluff near Pietermaritzburg (KZN). Recorded in NMSAD from greens in Pretoria (GP) and near the road in the area of Pietermaritzburg (KZN). Reproducing parthenogenetically in variable morphs, often much similar to *rubidus*, frequently identified under *rubidus* and variable synonyms. It is possible that some part of the material identified earlier as *rubidus* may belong to this subspecies.

Genus *Eisenia* Malm, 1877

Eisenia andrei (Bouché, 1972: 381)

Selected from batches of *Eisenia fetida*, identity confirmed by DNA. Widely distributed all over the world, usually occurring with *fetida* in vermicomposting heaps, composts, and decaying organic matter. Being externally and anatomically similar to *fetida*, and usually occurring together with it, *andrei* is often not recognized and separated, but is recorded as *fetida*. It is possible that in composting hips and vermiculture farms in the RSA this species also occurs with *fetida*. A sample imported from France containing *fetida* and *andrei* was studied under laboratory and field experiments for biology and reproductive abilities by Reinecke *et al.* (1991). The material housed and recorded in the NMSAD under *E. fetida* may include *andrei*. DNA study is necessary to separate these two species, and this has not yet been applied to the material in the NMSA collection. Easton (1983) placed it in synonymy with *E. fetida*. Blakemore (2004a) supported *andrei* arbitrarily, in selection of specific or sub-specific status.

Eisenia fetida (Savigny, 1826: 182)

Described from Paris, France. Widely distributed over the world for variable reasons. In RSA known from composting hips, vermicomposting farms, nurseries, around barns and from rich decaying organic matter. Reported by Ljungström (1972) from Pietersburg (LP); Heidelberg and Roodeport (GP); and Cape Town, Cape Flats and Bergvliet (WC). Zicsi (1998) reported its occurrence in Durban, Stamford Hill (KZN). In the NMSAD recorded at 27 sites in GP, NW, KZN, EC and WC. Synantropic. Found once with *Aporrectodea longa*.

This species reproduces abundantly under favourable conditions, being the most profitable earthworm species for vermicomposting. Commonly used for fishing, vermiculture and protein production, and as an indicator in polluted habitats. Undergoing worldwide variable experimental study, *fetida* also aroused interest in this country. Various experiments were and are being conducted by vermiculture producers at universities and agriculture institutions, and the members of the Earthworm Interest Group in South Africa, with an extended literature on the use of this taxon. From the number of published notes, only a few are cited: Venter & Reinecke (1987); Reinecke *et al.* (1990, 1991); Reinecke *et al.* (1992); Reinecke & Alberts (1994); Maleri *et al.* (2008).

Genus *Eiseniella* (Michaelsen, 1900)*Eiseniella tetraedra* (Savigny, 1826: 184)

Described from Paris, France. Amphibiosus/limicolous, with a high preference for damp habitat; widespread worldwide. In RSA recorded from banks of natural inland watercourses, man-made lakes and damp, decomposing organic matter. Found at Pretoria Zoological Garden (Michaelsen 1913c) and the Jukskey River near Bryanston (Jamieson 1967), both sites in GP. Michaelsen (1913a), Pickford (1937), Jamieson (1967) and Ljungström (1972) noted it from Port Elizabeth, Knysna (EC); the Potchefstroom area (NW); Howick, at the Umgeni River (KZN); Cape Flats, Krom River, French Hoek stream, tributary of Erste River, and north Stellenbosch (all WC). In the NMSAD are records from Cedara Agriculture College and Ixopo (KZN), and from Newlands Forest in the Cape Peninsula (WC).

Genus *Lumbricus* Linnaeus, 1758*Lumbricus castaneus* (Savigny, 1826: 180)

Noted from various parts of the world. In RSA known (NMSAD) from only one site, at Benvie Farm garden, Karkloof (KZN), where it was found with the introduced lumbricids *A. eiseni*, *D. rubidus*, *L. rubellus* and *Octolasion lacteum*, and with the endemic microchaetid *Tritogenia lunata* Plisko, 1997.

Lumbricus rubellus Hoffmeister, 1843: 18

Type locality unknown. Distributed all over the world. In RSA reported from cultivated land in Cape Flats (EC) and Karkloof Benvie Farm (KZN); from natural biotopes in Ndema/Grotto, Wodwo Farm near Nottingham Road, and Sevenoaks (KZN); and from Newlands Forest in the Cape Peninsula (WC). Occurs usually in small populations. Found with *A. eiseni* and *L. castaneus*.

Genus *Octolasion* Örley, 1885*Octolasion cyaneum* (Savigny, 1826: 181)

Described from Paris, France. Distributed in many parts of the world. In RSA found only at one site in Eagle Ridge Forest Resort, near Stutterheim (EC). Collected from garden soil (6 clitellate, 10 juvenile) on the property of a German family who planted imported flowers a few weeks before the species was found. It is not known if the species presently occurs in the locality, or if it has spread to neighbouring fields.

In Europe it is known from isolated sites and usually occurs in small populations (Plisko 1973; Csuzdi & Zicsi 2003). Gates (1972) repeated, after Karppinen and Nurminen (1964) that in Finland, this species was introduced to greenhouses and spread within a short time to neighbouring gardens. Recently Kuu and Ivask (2010) recorded rapid spread of large populations of this species in northern and western Estonia.

Octolasion lacteum (Örley, 1881: 584)

Widely distributed over the world. In RSA reported under numerous synonyms, from a Cape Town garden (WC), a Potchefstroom plant pot (NW), Sabie (MP), and the Limpopo forests (LP). In NMSAD, recorded from over 200 sites in all RSA provinces, from natural and cultivated biotopes. Reproduces in variable parthenogenetic and polyploid forms. Under favourable climatic conditions occurs abundantly in moist soils, dispersing widely in natural and cultivated land. Occasionally found together with

the introduced lumbricids *D. rubidus*, *D. octaedra* and *L. castaneus*, and with the indigenous microchaetids *Tritogenia ngelensis* Plisko, 1997 and *Proandricus martensi* Plisko, 2002, and with the acanthodrilid *Parachilota timothyi* Plisko, 2008.

Family Megascolecidae Rosa, 1891

Taxa accounted presently to Megascolecidae are continuously under study, discussion and evaluation, with various genera and families being accredited. Many species commonly distributed across the world have been frequently described as synonyms in various genera. The most common species were assembled in species groups assigned under the earliest erected species names (Sims & Easton 1972; Easton 1982). Blakemore (2004b), in a revision of pheretimoid earthworms, eliminated numerous synonyms and relocated some of the commonest species into different genera. In the present paper, for all cosmopolitan pheretimoid species recorded in the literature under various synonyms, comprehensive synonymies are not included. A large part of the material collected during last twenty years and housed in NMSA is recorded in the NMSAD under the broad name “*Pheretima*-group”, waiting for accreditation to valid taxa. Species collected in RSA and recorded in the present paper are accommodated in the genera *Amyntas* (8), *Metaphire* (1), *Perionyx* (1) and *Pontodrilus* (1).

Genus *Amyntas* Kinberg, 1867

Amyntas aeruginosus Kinberg, 1867: 101

Described from Guam (*sub lapidibus prope rivulum*). Distributed worldwide, recorded under numerous synonyms (Blakemore 2004b). In RSA Dlamini (2002) reported it from the Eshowe area (KZN). Recorded in the NMSAD from greens of Pretoria Country Club and Hartbeespoort Dam (GP). Twenty-three records refer to KZN cultivated land under experimental study in Baynesfield grassland, Eshowe avocado field, and grassland at Cedara Agriculture College. Ten records refer to natural habitats in the Doreen Clark Nat. Res., in Queen Elizabeth Park at its border with the Victoria Country Club, and at Ngome Forest (all KZN).

Amyntas corticis (Kinberg, 1867: 102)

Described from Oahu, Hawaii (*sub cortice arborum*). Known from tropical and temperate regions, transported by man. In RSA known from numerous natural, often protected, areas and cultivated sites. Reported from number of localities in MP, GP, NW, FS, KZN, EC and WC by Zicsi & Pajor (1992), Zicsi & Reinecke (1992) and Zicsi (1998). Common in decomposed litter in indigenous forests, and plantations. Occurs in small populations. Found with other introduced megascolecids, and the microchaetid *Proandricus pajori* (Plisko, 1993). Blakemore (2004b), Sims (1987) and some other authors place *Amyntas diffringens* in synonymy with *corticis*. In the present paper *diffringens* is accepted as a valid species (see below).

Amyntas diffringens (Baird, 1869: 40)

Described from Plas Machynleth, North Wales. Broadly distributed by man all over the world. In RSA reported by Michaelsen (1913a, c), Ljungström (1972), Dlamini (2002) and Horn *et al.* (2007) from nearly 50 natural and cultivated habitats in LP, GP, NW, FS, KZN, EC, and WC. Occurs in variable morphs, in large populations. Reproduces parthenogenetically in morphs often recorded under synonyms. In the material

collected during the last 20 years commonly observed variations may include: variably sized spermathecae and variably shaped diverticula; prostate glands single or paired, juvenile, rudimentary, usually variously reduced in size, or lacking. Male sterility was commonly observed in material collected in chemically contaminated, polluted fields, greenhouses and composting heaps (unpubl. notes). Gates (1972) also recorded male sterility and various reductions of prostatic glands in Burmese individuals.

Sims and Easton (1972) designated this species name for a species-group, inserting a number of related species. Blakemore (2004b) synonymized it with *corticis*. However, the material accredited in this paper to this species differs from *corticis* by highly developed male sterility.

Amyntas gracilis (Kinberg, 1867:102)

Described from Rio de Janeiro ('*in horto botanico*'). The indigenous range of this species is probably in South-East Asia; presently widely distributed and known from warm temperate zones, and numerous greenhouses, from all continents and many islands. In RSA recorded by Zicsi and Reinecke (1992) from Nelspruit and Sabie (MP), and Zicsi (1998) from Tsitsikamma National Park (WC), collected together with *D. r. rubidus*.

Amyntas hawayanus (Rosa, 1891: 396)

Described from Hawaii. The original species range is believed to be China (Gates 1972); currently distributed all over the world. In RSA broadly distributed in LP, MP GP, NW, KZN, and EC, occurring in moderate populations in natural biotopes and agricultural fields. Recorded by Ljungström (1972), Reynolds & Reinecke (1976), and Dlamini (2002). In the NMSAD recorded from 71 sites.

Sims and Easton (1972) designated the species name for a species-group assembling species with related features. Easton (1982) and others found this species to be a junior synonym of *gracilis*; however, it is considered valid in this paper.

Amyntas minimus (Horst, 1893: 66)

Described from Tjibodas, Java. Distributed worldwide in tropical and subtropical zones. In RSA occurs in numerous sites in indigenous forests with exotic plantations (LP). Occurs commonly in natural habitats in protected areas, and in grasslands, cultivated fields, and arable fields undergoing experimental cultivation on a number of farms (KZN). Recorded in large populations by Ljungström (1972), Zicsi (1998) and Dlamini (2002) from numerous sites in KZN. Horn *et al.* (2007) recorded it from LP; Zicsi and Reinecke (1992) reported it from Sabie and Nelspruit (MP). Once reported from the Stutterheim area (Zicsi 1998). In the NMSAD recorded 27 times from various biotopes, confirming its broad distribution and its abundance.

Amyntas morrisi (Beddard, 1892: 166)

Described probably from Pengang, (?) Malaysia. Known worldwide from tropical and temperate regions, natural and agriculture fields, and numerous greenhouses. In RSA collected by Zicsi and Reinecke (1992) from the riverbank in Potchefstroom (NW), and the Sabie area (MP). Recorded in the NMSAD from Pretoria city parks and greens (GP).

Amyntas rodericensis (Grube, 1879: 554)

Described from Rodriguez. Known from many parts of the world, from variable habitats; distributed by man. In RSA collected from over 100 sites in natural and cultivated fields by Ljungström (1972) from numerous sites in LP, KZN and EC, and by Zicsi and

Reinecke (1992) from Skukuza (LP), Sabie area, Nelspruit, Graskop (MP) and various sites in KZN. Zicsi (1998) and Dlamini (2002) collected it from a number of localities in KZN. Horn *et al.* (2007) reported it from Drakensberg North, New Agatha (LP).

Genus *Metaphire* Sims & Easton, 1972

Metaphire californica (Kinberg, 1867: 102)

Described from Sausalita Bay, San Francisco, California, USA. Known from many parts of the world from variable habitats. In RSA recorded only from experimental plots at Cedara Agriculture College and their close neighbourhood (KZN). Possibly this species has been introduced with seedlings of maize.

Metaphire quadragenaria (Perrier, 1872: 122)

Described from 'Cape of Good Hope. Kapland' [RSA]. Redescribed by Horst (1883) as *Megascolex capensis*. Its occurrence in South Africa was noted by Beddard (1895*b*) and Michaelsen (1900, 1910*b*, 1913*a, b*, 1922), although its endemicity was questioned. Its actual origin is unspecified. Collected from number of sites on oceanic islands, and described under various synonyms. The numerous repetitions under various generic accreditations indicate the species' appearance in the Cape Peninsula. However, the species' derivation in this country may not be accepted, because the origin of pheretimoids does not extend to South Africa. Some of the revisions performed on original and synonymic material suggested an optional taxonomic evaluation. Michaelsen (1922) judged both the species *capensis* and *quadragenaria* as valid, although indicating noted disaccords. Sims and Easton (1972) and Blakemore (2008*c*) place both species in the genus *Metaphire*.

Genus *Perionyx* Perrier, 1872

Perionyx excavatus Perrier, 1872: 126

The species is sometimes assigned to the acanthodrilids, but after a recent molecular study its megascolecid status has been confirmed (Jamieson *et al.* 2002).

Described from the Himalayas (Gates 1972). Common in Asia; distributed by man around the world. Extensively used in experimental and applied practices in the breakdown of organic wastes, vermicomposting, protein production and soil toxicology, and as indicator of soil quality. A batch of specimens imported to RSA for experimental study (Hallatt *et al.* 1990, 1992; Reinecke *et al.* 1992; Reinecke & Alberts 1994; Reinecke & Pieters 1997, 1998) initiated the growth of small populations in compost heaps near Potchefstroom (NW). Also found at a vermicomposting farm in Camperdown (KZN).

Genus *Pontodrilus* Perrier, 1874

Pontodrilus litoralis (Grube, 1855: 127)

Described from Villa Franca on the French Riviera. Widely distributed along seashores in the tropics and subtropics of the Pacific, Indian and Atlantic oceans. Littoral, sand- and mud- dwelling species. Euryhaline, easily dispersed by drifting on debris, or transported by various ways. Described in the megascolecoidea, but in recent years accredited by various authors to the acanthodrilids. Recently after revision it was accepted as megascolecid, and was placed in the genus recommended by Beddard (1891) with Blakemore (2008*a*) suggesting its placement in the restored family Pontodrilidae

Vejdovsky, 1884, although with no final decision made. In RSA recorded by Michaelsen (1913*b*) from the coastal zone at Kosi Bay in Zululand (KZN) under the synonym *P. bermudensis* f. *typicus*, which Blakemore (2008*a*) accredits to *litoralis*. Michaelsen (1910*a*) gives comparative descriptions of *bemudensis* and *litoralis*, including a list of synonyms.

Family Ocnerodrilidae Beddard, 1891

Genus *Eukerria* Michaelsen, 1935

Eukerria saltensis (Beddard, 1895*a*: 225)

Originating probably from South America; spread with substantial human involvement widely over warm and temperate zones. Recorded throughout the southern hemisphere from various regions. Noted also from Burma, India and Australia. In RSA known from numerous natural littoral habitats, man-made water catchments, and variable moist biotopes elsewhere, where collections have been undertaken. Michaelsen (1913*c, b*) reported it from Pretoria Zoological Gardens (GP) and Howick, near Umgeni Falls (KZN). Jamieson (1967) collected it from numerous sites along rivers in FS, NW, MP, KZN, EC and WC. Ljungström (1972) found it in variable biotopes, mainly on river banks and in irrigated areas, in NW, FS, EC and KZN. Visser and Reinecke (1977) reported it from the Mooi River area, near Potchefstroom (NW). Zicsi (1998) recorded it from a number of sites in MP, NW, KZN and EC. This species may be aquatic or littoral, seldom terrestrial, usually occurring between roots of aquatic vegetation. Twenty-two records in the NMSAD refer to samples collected in littoral biotopes.

Genus *Nematogenia* Eisen, 1900

Nematogenia lacuum (Beddard, 1893: 259)

Type locality uncertain. Distribution and species adaptation observed in many parts of the world. In RSA reported only by Zicsi (1998) from a few sites in the Durban and Pietermaritzburg areas (KZN).

Genus *Ocnerodrilus* Eisen, 1878

Two ocnerodrilid species, *africanus* and *occidentalis*, produce variable morphs and are often not clearly identified. Both species are recorded from RSA but probably belong to one taxon. In this paper, they are given separately.

Ocnerodrilus africanus Beddard, 1893: 703

Type locality indicated for Durban, KZN, RSA, not confirmed. Specimens of *Ilyogenia africana* Beddard, 1893 and *Eudriloides durbanensis* Beddard, 1893 have been described from Kew Gardens (UK) on material apparently received from Durban, KZN, in a box containing various plants. Although both types were initially deposited in the British Museum, the present housing of the type material is unknown, leaving its origin in uncertainty (Blakemore 2006*a*; Reynolds & Cook 1976: 65). Michaelsen's (1913*b*) statement that this species is "endemic for Natal" cannot be accepted as this species, before being transported to UK, was probably introduced to South Africa, and Michaelsen (1914) was also of this opinion. To date, this species' distribution is not certain, possibly being the southern part of Africa. Taxonomic evaluation of

material known from RSA is not clear. Described in *Ilyogenia* by Beddard (1893); by Michaelsen (1913b) acknowledged under *Ocneorodrilus* (*Ilyogenia*), accepting Beddard accreditation to *Ocnerodrilus* (*Enicmodrilus*) when reporting it from garden soil in Chapel Street, Pietermaritzburg. Zicsi and Pajor (1992) record it under *Ocnerodrilus* for the material collected from garden soil near the Cathedral Peak hotel in Drakensberg. Zicsi (1998) placed it in *Ilyogenia* when recording it from Ashburton (near Pietermaritzburg) grassland, at the edge of neighbouring garden. Reynolds and Cook (1976), confusing the generic names *Ilyogenia* and *Ilyodrilus*, placed it in the tubificid genus, adding uncertainty to the species' origin and its identity. According to Blakemore (2006a) *I. africana* may be a junior synonym of *Ocnerodrilus occidentalis* Eisen, 1878.

Ocnerodrilus occidentalis Eisen, 1878: 10

Typus amissus (Reynolds & Cook 1976: 146). Type locality unknown. Widely distributed in tropical and temperate zones by human activity (Righi 1984). Zicsi (1996, 1997b) reported it from the eastern part of Africa. This species, with great variability in the male genital system and with reduction of spermathecae creating variable morphs, has been accounted to a variety of species. A not clearly elucidated generic relationship between *Ocnerodrilus* and *Ilyogenia* (Righi 1984) misled species generic identification, adding synonyms to taxa accounted to both genera. Blakemore (2006a) is of the opinion that *Ilyogenia africana* is a junior synonym of *occidentalis*. Csuzdi (pers. comm.) supposes that *africanus* is a thecate form of *occidentalis*, although *africanus* has not been recorded from South America and possibly also not outside Africa.

In RSA recorded by Černosvitov (1940) from soil transported from FS to Israel. Zicsi (1998) found this species in the same province, in the Fouriesburg area on the bank of Vaal River near Parys (NW). Ljungström (1972), following information on the species's occurrence in FS, expressed his disappointment at not finding it during his extended collecting of earthworms in this country. However, during many years of earthworm collection in South Africa by numerous members of Ezemvelo Wildlife KZN and by Plisko, this species was rarely recorded. All material reported by Zicsi from RSA is kept in the HNHM.

Genus *Pygmaeodrilus* Michaelsen, 1890

Pygmaeodrilus arausionensis Michaelsen, 1910a: 114

Described from Bothaville, FS, RSA. The type depository is unknown; however, it might be housed in ZMUH. Known from Namibia (Grootfontain) and a few sites in RSA, where recorded only from the type locality and few sites in the same province: at Vaal Dam catchments at Kalkspruit, Grootvlei coal mine, and the Sabie River, Lover Sabie Rest Camp in KNP (LP) (Jamieson 1967). One of the smallest megadriles, being 25 to 40 mm in length and 1.5–1.6 mm in diameter. Its indigenous status is not confirmed. It is rather expected that this species is indigenous to south-western Africa, and to southern African continent is transported naturally by rivers.

DISCUSSION

Fifty introduced earthworm species were selected from published sources and drawn from the NMSA database. The majority of species are well known as broadly

distributed all over the world. A few taxa described from South Africa at various times, sometimes with an indication of their endemic status, need reappraisal. *Metaphire quadragenaria* and *Ocnerodrilus occidentalis* are recorded with uncertainty on their taxonomic and distributional status. The eudrilins *Nemertodrilus kellneri*, *N. kruegeri* and *N. transvaalensis*, and the ocnerodrilid *Pygmaeodrilus arausionensis*, might be native to RSA or indigenous to neighbouring territories, extending the geographical distribution of the Eudrilidae and the Ocnerodrilidae to the southern part of the African continent. Their inclusion in introduced taxa might be temporary.

The collection of *Eudriloides durbanensis* in Margate (KZN) from garden soil, and its redescription by Zicsi (1997a) confirms the species's taxonomic position and its occurrence in RSA. Its endemic status, however, is not confirmed for this country. The reports from Tanzania, where it was also collected in garden soil or cultivated land, suggest its possible introduction from a not yet established origin.

Most of the taxa not native to RSA soils belong to widely dispersed lumbricids, megascolecids and glossoscolecids, which have been introduced variably, mostly by human activity, although natural transportation might play a possible role. Some of them are now well adapted to South African soils and climatic conditions, and have developed into large communities. Two lumbricids, *Aporrectodea caliginosa* s.l. and *A. rosea*, have become common in various habitats, occurring in numerous sites in all provinces. Large populations usually occur in arable fields, often replacing indigenous taxa, which were partly or fully exterminated from these habitats by unfavourable agriculture or industrial practices. *Eisenia fetida* and *E. andrei* play a large role in generating compost in gardens, and in commercial vermicomposting practices, with *Eudrilus eugeniae* and *Perionyx excavatus* possible adaptation to composting practices.

It was observed that the lumbricids *Dendrodrilus rubidus* s.l. and *Octolasion lacteum*, the megascolecids *Amyntas corticis*, *diffringens*, *hawayana*, *minimus*, *rodericensis*, the glossoscolecid *Pontoscolex corethrurus*, and two species of the Benhamiinae, *Dichogaster (Diplothecodrilus) bolau* and *saliens*, occur abundantly in natural habitats, often in protected areas. These species are great eaters of organic matter and might be competitive consumers of food needed for native invertebrates. These species also show a tendency to spread and to colonize neighbouring biotopes. Because no appropriate protection against deliberate or occasional earthworm introduction is yet applied in RSA, concern is felt about infestation of soils by further introduction of these, or other, competitive species. A unit, falling under government control, should be established to regulate the transportation of earthworm samples between countries, or nationally for vermicomposting, sugar cane cultivation, experimental study, or any other reason.

ACKNOWLEDGEMENTS

The University of KwaZulu-Natal and Natal Museum, Pietermaritzburg, are greatly appreciated for a productive affiliation that allows me to continue research on South African earthworms. I am grateful to Dr C. Csuzdi of the HNHM and Dr R. Blakemore of the National Museum, Tokyo, for information on some taxonomic topics. Dr M. Mostovski (NMSA) is thanked for providing laboratory space and contributing to the preparation of this paper. Special thanks go to Mrs Th. Nxele (NMSA) for help in selecting references. Dr C. Csuzdi and Prof. P.F. Hendrix are thanked for useful comments on the manuscript.

REFERENCES

- BAIRD, W. 1869. Description of a new species of earthworm (*Megascolex diffringens*) found in north Wales. *Proceedings of the Zoological Society of London* **1869**: 40–43.
- BEDDARD, F.E. 1891. New genera of aquatic Oligochaeta. *Transactions of the Royal Society of Edinburgh* **36**: 273–305.
- 1892. On some species of the genus *Perichaeta* (sensu stricto). *Proceedings of the Zoological Society of London* **1892**: 153–172.
- 1893. On some new species of earthworms from various parts of the world. *Proceedings of the Zoological Society of London* **1892** [1893]: 666–706.
- 1895a. Preliminary account on new species of earthworms belonging to the Hamburg Museum. *Proceedings of the Zoological Society of London* **1895**: 210–238.
- 1895b. *A monograph of the order of Oligochaeta*. Oxford: Clarendon Press.
- 1897. On a collection of earthworms from South Africa belonging to the genus *Acanthodrilus*. With an Appendix: on a new genus of earthworms belonging to the family Eudrilidae. *Proceedings of the Zoological Society of London* **1897**: 336–349.
- BLAKEMORE, R.J. 2002. *Cosmopolitan earthworms – an eco-taxonomic guide to the peregrine species of world families*. Monograph. CD ROM.
- 2004a. A provisional list of valid names of Lumbricoidea (Oligochaeta) after Easton, 1983. In: Moreno, A.G. & Borges, S., eds, *Advances in earthworm taxonomy (Annelida: Oligochaeta)*. Madrid: Editorial Complutense, S.A., pp. 75–120.
- 2004b. Checklist of Pheretmoid earthworms after Sims & Easton (1972). In: Moreno, A.G. & Borges, S., eds, *Advances in earthworm taxonomy (Annelida: Oligochaeta)*. Madrid: Editorial Complutense, S.A., pp. 127–162.
- 2005. Whither Octochaetidae? – A review of its family status (Annelida: Oligochaeta). In: Pop, V.V. & Pop, A.A., eds, *Advances in earthworm taxonomy II (Annelida: Oligochaeta)*. Cluj: University Press, pp. 63–84.
- 2006a. British and Irish earthworms – a checklist of species updated from Sims & Gerard (1999). A series of searchable text on earthworm biodiversity, ecology and systematics from various regions of the world. Vol. II (2006) Supplemental. CD ROM.
- 2006b. Checklist of Myanmar taxa updated from Gates (1972) ‘Burmese Earthworms’. A series of searchable text on earthworm biodiversity, ecology and systematics from various regions of the world. Vol. II (2006) Supplemental. CD ROM.
- 2007. Origin and means of dispersal of cosmopolitan *Pontodrilus litoralis* (Oligochaeta: Megascolecidae). *European Journal of Soil Biology* **43** (Suppl. 1): S3–S8.
- 2008a. Phylogeny of Megascolecoida revisited with recourse to non-molecular means. In: Pavliček, T. & Cardet, P., eds, *Advances in earthworm taxonomy III (Annelida: Oligochaeta)*. Nicosia: Imprinta LTD, pp. 11–21.
- 2008b. Review of Oriental pheretmoids (*Pheretima* auct. Megascolecidae) with description of a new genus. In: Pavliček, T. & Cardet, P., eds, *Advances in earthworm taxonomy III (Annelida: Oligochaeta)*. Nicosia: Imprinta LTD, pp. 23–36.
- 2008c. Review of Southern Ocean, South Atlantic and Subantarctic Island earthworms updated from Lee (1994). In: Kaneko, N. & Ito, M.T., eds, *A Series of Searchable Texts on Earthworm Biodiversity, Ecology and Systematics from Various Regions of the World*. 3rd Ed. Yokohama: COE Soil Ecology Research Group, Yokohama National University. CD ROM.
- BOUCHÉ, M.B. 1972. *Lombriciens de France. Écologie et systématique*. Paris: Institut National de la recherche agronomique.
- BRINKHURST, R.O. & JAMIESON, B.G.M. 1971. *Aquatic Oligochaeta of the world*. Edinburgh: Oliver & Boyd.
- ČERNOSVITOV, L. 1940. On some Oligochaeta from Palestine. *The Annals and Magazine of Natural History London* (11) **6**: 438–447.
- CSUZDI, C. 1986. Über ein Vorkommen von *Microscolex phosphoreus* Dugès, 1837 Oligochaeta: Acanthodrilidae in Ungarn. *Opuscula zoologica* **22**: 63–66.
- 1995. A catalogue of Benhamiinae species (Annelida: Oligochaeta: Acanthodrilidae). *Annalen des Naturhistorischen Museums in Wien* **97B**: 99–123.
- 1996. Revision der Unterfamilie Benhamiinae Michaelsen, 1897 (Oligochaeta: Acanthodrilidae). *Mitteilungen aus dem Museum für Naturkunde in Berlin* **72** (2): 347–367.
- 2000. A review of the Benhamiinae collection of the Natural History Museum, London (Oligochaeta: Acanthodrilidae). *Opuscula zoologica* **32**: 51–81.
- CSUZDI, C., PAVLIČEK, T. & NEVO, E. 2008. Is *Dichogaster bolau* (Michaelsen, 1891) the first domicole earthworm species? *European Journal of Soil Biology* **44** (2): 198–201.
- CSUZDI, C. & ZICSI, A. 2003. *Earthworms of Hungary (Annelida: Oligochaeta, Lumbricidae)*. Budapest: Hungarian Natural History Museum.

- DLAMINI, T.C. 2002. *Influence of land use on soil organic matter status, microbial biomass C and size and composition of earthworm communities in northern KwaZulu-Natal*. MSc (Agric) dissertation. Pietermaritzburg: University of Natal.
- DLAMINI, T.C., HAYNES, R.J. & VAN ANTWERPEN, R. 2001. Exotic earthworm species dominante in soils on sugarcane estates in the Eshowe area of the North Coast of KwaZulu-Natal. *Proceedings of the South African Technologists Association* **75**: 217–225.
- DUGÈS, A. 1828. Recherches sur la circulation, la respiration et la reproduction des Annélides abranches. *Annales des Sciences Naturelles* **15**: 284–337.
- 1837. Nouvelles observations sur la zoologie et l'anatomie des Annelides abranches sétigères. *Annales des Sciences Naturelles, Sér. 2* **8**: 15–35.
- EASTON, E.G. 1982. Australian pheretmoid earthworms (Megascolecida: Oligochaeta): a synopsis with the description of a new genus and five new species. *Australian Journal of Zoology* **30**: 711–735.
- 1983. A guide to the valid names of Lumbricidae (Oligochaeta). In: Satchell, J.E., ed., *Earthworm ecology – from Darwin to Vermiculture*. London: Chapman & Hall, pp. 475–487.
- EISEN, G. 1873. Om Skandinavians Lumbricider. *Öfversigt af Kongliga Vetenskaps-akademiens Förhandlingar* **30** (8): 43–56.
- 1874. New Englands och Canadas Lumbricider. *Öfversigt af Kongliga Vetenskaps-akademiens Förhandlingar* **31** (2): 41–49.
- 1878. On the anatomy of *Ocnerodrilus*. *Nova Acta Regiae Societatis Scientiarum Upsaliensis, Series 3* **10**: 1–12.
- FLETCHER, J.J. 1888. Notes on Australian earthworms. Part III. *Proceeding of the Linnaean Society, NSW* (2) **2**: 375–402.
- FRAGOSO, C., KANYONYO, J., MORENO, A., SENEPATI, B.K., BLANCHART, E. & RODRIGUEZ, C. 1999. A survey of tropical earthworms: taxonomy, biogeography and environmental plasticity. In: Lavelle, P., Brusard, L. & Hendrix, P., eds, *Earthworm management in tropical ecosystems*. Wallingford: CABI.
- GATES, G.E. 1972. Burmese earthworms, an introduction to the systematics and biology of megadrile oligochaetes with special references to southeast Asia. *Transactions of the American Philosophical Society* **62** (7): 1–362.
- GRUBE, E. 1855. Beschreibungen neuer oder wenig bekannter Anneliden. *Archiv für Naturgeschichte* **21**: 81–136.
- 1879. Annelida. *Philosophical Transactions of the Royal Society of London* **168**: 554–556.
- HALLATT, L., REINECKE, A.J. & VILJOEN, S.A. 1990. Life cycle of the oriental compost worm *Perionyx excavatus* (Oligochaeta). *South African Journal of Zoology* **25** (1): 41–45.
- HALLATT, L., VILJOEN, S.A. & REINECKE, A.J. 1992. The moisture requirement and life-cycle of *Perionyx excavatus* (Oligochaeta). *Soil Biology and Biochemistry* **24** (12): 29–34.
- HOFFMEISTER, W. 1843. Beitrag zur Kenntnis deutscher Landanneliden. *Archiv für Naturgeschichte* **91**: 183–98.
- HORN, J.L., PLISKO, J.D. & HAMER, M.L. 2007. The leaf-litter earthworm fauna (Annelida: Oligochaeta) of forests in Limpopo Province, South Africa: diversity, communities and conservation. *African Zoology* **42** (2): 172–179.
- HORST, R. 1883. New species of the genus *Megascolex* Templeton (*Perichaeta* Schmarida) in the collection of the collection of the Leyden Museum. *Notes from the Leyden Museum* **5**: 182–196.
- 1893. Earthworms from the Malayi Archipelago. In: Weber, M., ed., *Zoologische Ergebnisse einer Reise in Niederländisch Ost-Indien*. Vol. 3. Leiden: E.J. Brill, pp. 28–77.
- JAMES, S.W. 2005. Preliminary molecular phylogeny in the *Pheretima* group of genera (Crassicitellata: Megascolecidae) using Bayesian analysis. In: Pop, V.V. & Pop, A.A., eds, *Advances in earthworm taxonomy II (Annelida: Oligochaeta)*. Cluj: University Press, pp. 129–142.
- JAMIESON, B.G.M. 1967. New records of Ocnerodrilidae and Lumbricidae (Oligochaeta) from South African Rivers. *Zoologica Africana* **3** (1): 59–86.
- JAMIESON, B.G.M., TILLIER, S., TILLIER, A., JUSTINE, J.L., LING, E., JAMES, S., MCDONALD, K. & HUGALL, A. 2002. Phylogeny of Megascolecidae and Crassicitellata (Annelida, Oligochaeta): combined versus partitioned analysis using nuclear (28S) and mitochondrial (12S, 16S) rDNA. *Zoosystema* **24** (4): 707–734.
- KARPPINEN, E. & NURMINEN, M. 1964. Records of the lumbricids (Oligochaeta) in Finland. *Annales zoologici fennici* **1**: 44–47.
- KINBERG, J.G.H. 1867. Annulata nova. *Öfversigt af Kongliga Vetenskaps-akademiens Förhandlingar* **23**: 97–100.
- KUU, A. & IVASK, M. 2010. Distribution of *Octolasion cyaneum* (Savigny, 1826) in Estonia 1993–2008. *Zoology in the Middle East Suppl.* **2**: 75–81.
- LEVINSEN, G.M.R. 1884 [1883]. Systematisk-geografisk oversigt over de nordiske Annulata, Gypherea, Chaetognathi og Balanoglossi. *Videnskabelige Meddelelser fra den naturhistoriske Forening i Kjøbenhavn* **43**: 92–350.

- LINNAEUS, C. 1758. *Systema naturæ per regna tria naturæ, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis*. 10th Ed. Holmiae [= Stockholm]: Salvius.
- LJUNGSTRÖM, P.O. 1972. Introduced earthworms of South Africa. On their taxonomy, distribution, history of introduction and on the extermination of endemic earthworms. *Zoologische Jahrbücher. Abteilung für Systematik* **99**: 1–81.
- MALERI, R.A., REINECKE, S.A., MESIASZ-PRZYBYLOWICZ, J. & REINECKE, A.J. 2007. Growth and reproduction of earthworms in ultramafic soils. *Archiv of the Environmental Contamination and Toxicology* **52**: 363–370.
- MALERI, R.A., REINECKE, S.A. & REINECKE, A.J. 2008. Metal uptake of two ecophysiologically different earthworms (*Eisenia fetida* and *Aporrectodea caliginosa*) exposed to ultramafic soils. *Applied Soil Ecology* **38**: 42–50.
- MALLETT, J.B., LANG, P.M. & ARATHON, A.J. 1987. Changes in a Doveton clay loam after 12 years of direct-drill maize production. *South African Journal of Plant and Soil* **4** (4): 188–192.
- MICHAELSEN, W. 1890a. Die Lumbriciden Norddeutschlands. *Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten* **7**: 3–19.
- 1890b. Beschreibung der von Herrn Dr. Franz Stuhlmann im Mündungsgebiet des Sambesi gesammelten Terricolen. *Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten* **7**: 21–50.
- 1891. Oligochaeten des Naturhistorischen Museums in Hamburg. IV. *Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten* **8**: 301–340.
- 1899a. Terricolen von verschiedenen Gebieten der Erde. *Mitteilungen aus dem Naturhistorischen Museum in Hamburg* **16** (2): 1–122.
- 1899b. Revision der Kinberg'schen Oligochaeten-Typen. *Öfversigt af Kongliga Vetenskaps-akademiens Förhandlingar* **56**: 413–448.
- 1900. *Oligochaeta*. In: *Das Tierreich*. Lief. 10. Berlin: R. Friedländer & Sohn, pp. 1–575.
- 1903. *Die geographische Verbreitung der Oligochaeten*. Berlin: R. Friedländer & Sohn.
- 1908. III. Annelida. A. Oligochäten aus dem Westlichen Kapland. In: Schultze, L., *Zoologische und Anthropologische Ergebnisse Forschungsreise im westlichen und zentralen Südafrika*. Bd 1. Lief. 2. *Denkschriften der medizinisch-naturwissenschaftlichen Gesellschaft zu Jena* **13**: 30–42.
- 1910a. Oligochäten von verschiedenen Gebieten. *Mitteilungen aus dem Naturhistorischen Museum in Hamburg* **27** (2): 47–169.
- 1910b. Die Oligochaeten fauna vorderindisch-Ceylonischen Region. *Abhandlungen aus dem Gebiete der Naturwissenschaften herausgegeben von dem Naturwissenschaftlichen Verein in Hamburg* **19** (5): 1–108.
- 1912. Die terrestrischen Oligochaeten des tropischen Afrikas und ihre geographischen Beziehungen. Bd 3. Zoologie 1. In: *Wissenschaftliche Ergebnisse der Deutschen Zentral-Afrika Expedition 1907–1908*. Leipzig: Klinkhardt & Biermann, pp. 1–90.
- 1913a. Die Oligochaeten des Kaplandes. *Zoologische Jahrbücher. Abteilung für Systematik* **34**: 473–556.
- 1913b. The Oligochaeta of Natal and Zululand. *Annals of the Natal Museum* **2** (4): 397–457.
- 1913c. Oligochaeten vom tropischen und südlich-subtropischen Afrika. Teil II. *Zoologica* **68**: 1–63.
- 1914. Oligochaeta. In: Michaelsen, W., ed., *Beiträge zur Kenntniss der Land- und Süßwasserfauna Deutsch-Südwestafrikas. Ergebnisse der Hamburger Deutsch südwestafrikanischen Studienreise 1911*. Lief. 1. Hamburg: L. Friederichsen & Co., pp. 139–182.
- 1922. Oligochaeten aus dem Rijks Museum van Natuurlijke historie zu Leiden. *Capita zoologica* **1** (3): 1–74.
- 1933. Opisthophore Oligochäten aus dem mittleren und dem südlichen Africa hauptsächlich gesammelt von Dr F. Haas während der Schomburgh-Expedition 1931–1932. *Abhandlungen Senckenbergischen Naturforschenden Gesellschaft* **40** (4): 409–433.
- MISCHIS, C.C. 2004. Earthworms in Argentina: faunistic and biogeographic aspects. In: Moreno, A.G. & Borges, S., eds, *Advances in earthworm taxonomy (Annelida: Oligochaeta)*. Madrid: Editorial Complutense, S.A., pp. 261–274.
- MORENO, A.G. 2004. Who is *Pontoscolex (Pontoscolex) corethrurus* (MÜLLER, 1857) (Annelida, Glossoscolecidae)? In: Moreno, A.G. & Borges, S., eds, *Advances in earthworm taxonomy (Annelida: Oligochaeta)*. Madrid: Editorial Complutense, S.A., pp. 63–73.
- MORENO, A.G., BORGES, S. & TEISAIRE, E. 2008. The family Acanthodrilidae Claus, 1880 in South America. In: Pavliček, T. & Cardet, P., eds, *Advances in earthworm taxonomy III (Annelida: Oligochaeta)*. Nicosia: Imprinta LTD, pp. 71–78.
- MÜLLER, F. 1857. *Lumbricus corethrurus*, Bürstenschwanz. *Archiv für Naturgeschichte* **23**: 113–116.
- MUYIMA, N.Y.O., REINECKE, A.J. & VILJOEN, S.A. 1994. Moisture requirements of *Dendrobaena veneta* (Oligochaeta), a candidate for vermicomposting. *Soil Biology and Biochemistry* **26** (8): 973–976.

- OMODEO, P. 1956. Contribution to alla revisione dei Lumbricidae. *Archivio Zoologico Italiano* **41**: 129–212.
- ÖRLEY, L. 1881. A magyarországi Oligochaeták faunája. I. Terricolae. *Mathematikai és természettudományi Közlemények* **16**: 562–611.
- PERRIER, E. 1872. Recherches pour servir à l'histoire des lombriciens terrestres. *Nouvelles Archives du Museum d'Histoire Naturelle, Paris* **8**: 5–198.
- PICKFORD, G.E. 1937. *A monograph of the Acanthodrilinae earthworms of South Africa*. Cambridge: W. Heffer & Sons Ltd.
- PLISKO, J.D. 1973. *Lumbricidae, dżdżownice (Annelida: Oligochaeta)*. In: *Fauna Poloniae*. No. 1. Warszawa: Państwowe Wydawnictwo Naukowe.
- 2001. Notes on the occurrence of the introduced *Pontoscolex corethrurus* (Müller, 1857) in South Africa (Oligochaeta: Glossoscolecidae). *African Invertebrates* **42**: 323–334.
- 2003. Eleven new South African earthworms (Oligochaeta: Microchaetidae) with new information on some known species, and an inventory of the microchaetids of KwaZulu-Natal. *African Invertebrates* **44** (2): 279–325.
- 2007. New species of South African acanthodrilinae earthworms of the genera *Eodriloides* and *Chilota quindecimus* (Oligochaeta: Acanthodrilidae). *African Invertebrates* **48** (2): 33–40.
- 2008. New South African Acanthodrilinae earthworm species, with new data for some earlier known members of the genus *Parachilota* (Oligochaeta: Acanthodriidae). *African Invertebrates* **49** (2): 21–36.
- 2009. Pre-testical spermathecal pores and unusual setal arrangement in the South African endemic microchaetid earthworms of presumed Gondwanan origin (Oligochaeta: Microchaetidae). *African Invertebrates* **50** (2): 237–254.
- POP, A.A., CSUZDI, C. & WINK, M. 2005. Remarks on the molecular Phylogeny of Crassiclitellata families using the mitochondrial 16S rDNA gene (Oligochaeta, Opisthophora). In: Pop, V.V. & Pop, A.A., eds, *Advances in earthworm taxonomy II (Annelida: Oligochaeta)*. Cluj: University Press, pp. 143–154.
- REINECKE, A.J. & ACKERMAN, D. 1977. New earthworm species (Octochaetinae) from the northeastern Transvaal, South Africa. *Wetenskaplike Bydraes van die PU vir CHO, Reeks B: Natuurwetenskappe* **90**: 1–12.
- REINECKE, A.J. & ALBERTS, J.N. 1994. Earthworm research in southern Africa since W. Michaelsen, with emphasis on the utilization of the earthworm (*Eisenia fetida*) as a protein source. *Mitteilungen aus dem Naturhistorischen Museum in Hamburg* **89** (2): 23–36.
- REINECKE, A.J. & LJUNGSTRÖM, P.O. 1969. An ecological study of the earthworms from banks of the Mooi river in Potchefstroom, South Africa. *Pedobiologia* **9**: 106–111.
- REINECKE, A.J. & RYKE, P.A.J. 1969. A new species of the genus *Geogenia* (Microchaetidae, Oligochaeta) from Lesotho, with notes on two exotic earthworms. *Revue d'Ecologie et de Biologie du Sol* **6** (4): 515–523.
- REINECKE, A.J., VENTER, J.M. & VILJOEN, S.A. 1990. The influence of feeding patterns on growth and reproduction of the vermicomposting earthworm *Eisenia fetida* (Oligochaeta). *Biology and Fertility of Soil* **10**: 184–187.
- 1991. A comparison of the biology of *Eisenia fetida* and *Eisenia andrei* (Oligochaeta). *Biology and Fertility of Soil* **11**: 295–300.
- REINECKE, A.J. & VILJOEN, S.A. 1988. Reproduction of the African earthworm *Eudrilus eugeniae* (Oligochaeta) cocoons. *Biology and Fertility of Soil* **7**: 23–27.
- REINECKE, A.J., VILJOEN, S.A. & SAAYMEN, R.J. 1992. The suitability of *Eudrilus eugeniae*, *Perionyx excavatus* and *Eisenia fetida* (Oligochaeta) for vermicomposting in southern Africa in terms of their temperature requirements. *Soil Biology and Biochemistry* **24** (12): 1295–1307.
- REINECKE, S.A. & PIETERS, R. 1997. The morphology of male reproductive structures of *Perionyx excavatus* (Oligochaeta). *South African Journal of Zoology* **32** (3): 64–71.
- 1998. The morphology of female reproductive structures of *Perionyx excavatus* (Oligochaeta). *South African Journal of Zoology* **33**: 166–171.
- REYNOLDS, J.W. & COOK, D.G. 1976. *Nomenclatura Oligochaetologica. A catalogue of names, descriptions and type specimens of the Oligochaeta*. Ottawa: Runge Press.
- REYNOLDS, J.W. & REINECKE, A.J. 1976. A preliminary survey of the earthworms of the Kruger National Park, South Africa (Oligochaeta: Glossoscolecidae, Megascolecidae and Octochaetidae). *Wetenskaplike Bydraes van die PU vir CHO, Reeks B: Natuurwetenskappe* **89**: 1–19.
- RIGHI, G. 1984. On a collection on neotropical megadrile Oligochaeta I. Ocnodrilidae, Acanthodrilidae, Octochaetidae, Megascolecidae. *Studies on Neotropical Fauna and Environment* **19** (1): 9–31.
- ROSA, D. 1886. Note sui lombrici del Veneto. *Atti del Reale Istituto Veneto di Scienze* **4**: 673–687.
- 1891. Die exotische Terricolen des k.k. Naturhistorischen Hofmuseums. *Annalen des K. K. Naturhistorischen Hofmuseums Wien* **6**: 381–406.

- 1896. I lombrichi raccolti a Sumatra dal Dott. Elio Modigliani. *Annali del Museo di Storia Naturale di Genova, Ser. 2* **16**: 502–532.
- ROTA, M.E. & SCHMIDT, O. 2006. *Dichogaster bolau* (Oligochaeta: Octochaetidae), an unusual invader in a swimming pool in Ireland. *Journal of Natural History* **40** (3–4): 161–167.
- SAVIGNY, J.C. 1826. [La multiplicite des espèces de ver de tere]. In: Cuvier, G: Analyse des Travaux de l'Academie royale des Sciences, pendant l'année 1821, partie physique. *Mémoires de l'Académie des Sciences de l'Institut de France (Physique), Paris* **5**: 176–184.
- SCIACCHITANO, I. 1960. Oligochaeta part. In: Hanström, B., Brinck, P. & Rudebeck, G., eds, *South African animal life: results of the Lund University Expedition in 1950–1951*. Vol. 7. Uppsala: Almqvist & Wiksells, pp. 9–12.
- SIMS, R.W. 1987. Review of the central African earthworm family Eudrilidae (Oligochaeta). In: Bonvicini, A.M. & Omodeo, P., eds, *On Earthworm Selected Symposia and Monographs U. Z. I., 2*. Modena: Mucchi, pp. 359–388.
- SIMS, R.W. & EASTON, E.G. 1972. A numerical revision of the earthworm genus *Pheretima* auct. (Megascolocidae: Oligochaeta) with the recognition of new genera and an appendix on the earthworms collected by the Royal Society North Borneo Expedition. *Biological Journal of the Linnean Society* **4** (3): 169–268.
- STEPHENSON, J. 1930. *The Oligochaeta*. Oxford: Clarendon Press.
- UDE, H. 1885. Über die Rückenporen der terricolen Oligochaeten, nebst Beiträgen zur Histologie des Leibesgeschlauchs und zur Systematik der Lumbriciden. *Zeitschrift für wissenschaftliche Zoologie* **43**: 87–143.
- VAN BRUGGEN, A.C. 1978. Megadrilacea (Oligochaeta). In: Werger, M.J.A., ed., *Biogeography and ecology of Southern Africa*. The Hague: W. Junk, pp. 663–676.
- VENTER, J.M. & REINECKE, A.J. 1987. Can the commercial earthworm *Eisenia fetida* (Oligochaeta) reproduce parthenogenetically or by self-fertilization? *Revue d'Ecologie et de Biologie du Sol* **24** (2): 157–470.
- VILJOEN, S.A. & REINECKE, A.J. 1994. The life cycle and reproduction of *Eudrilus eugeniae* under controlled environmental conditions. *Mitteilungen aus dem Naturhistorischen Museum in Hamburg* **89** (2): 149–157.
- VILJOEN, S.A., REINECKE, A.J. & HARTMAN, L.E. 1991. Life-cycle of the European compost worm, *Dendrobaena veneta* (Oligochaeta). *South African Journal of Zoology* **26** (1): 43–48.
- VISSER, F.A. & REINECKE, A.J. 1977. The earthworms of the Mooi river irrigaton area in Potchefstroom, South Africa (Oligochaeta: Lumbricidae, Acanthodrilidae, Microchaetidae and Ocneodrilidae). *Publicaciones del Centro Pirenaico de Biología Experimental* **9**: 95–108.
- ZICSI, A. 1996. Neue und bekante Regenwürmer (Oligochaeta) aus Ost-Afrika. *Mitteilungen aus dem Naturhistorischen Museum in Hamburg* **93**: 17–37.
- 1997a. Revision der Gattung *Eudriloides* Michaelsen, 1890 (Oligochaeta: Eudrilidae). *Mitteilungen aus dem Naturhistorischen Museum in Hamburg* **94**: 49–71.
- 1997b. Weitere Regenwürmer (Oligochaeta) aus der Volksrepublik Kongo. *Revue Suisse de Zoologie* **104**: 171–183.
- 1998. Neue und seltene terrestrische Oligochaeten aus Südafrika. *Mitteilungen aus dem Naturhistorischen Museum in Hamburg* **95**: 59–77.
- ZICSI, A. & PAJOR, I. 1992. Über die Regenwürmer (Oligochaeta) in den Natal-Drakensbergen Südafrika. *Opuscula zoologica* **25**: 125–136.
- ZICSI, A. & REINECKE, A.J. 1992. Regenwürmer aus dem Krüger National Park in Süd Afrika (Oligochaeta: Eudrilidae). *Acta zoologica Academiae scientiarum hungaricae* **38** (1–2): 149–158.