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The Distribution of Earthworms in the Perth Metropolitan Area

Ian Abbott*

Abstract

Thirteen species of earthworm were collected on the coastal plain near metropolitan Perth between 1977 and 1980. Six of these species were introduced following European settlement in 1829. The present known distribution of each species in the metropolitan region is mapped at a scale of 1:400 000; that of the more common species in temperate Western Australia is mapped at a smaller scale (1:8 500 000).

All introduced species were found only in disturbed habitats (gardens, man-made parks, etc.) but only two of the seven native species were confined to undisturbed habitat, principally woodland or swampland. Settlement of the region by European man has resulted in the fragmentation of the range of some of the native species, but the replacement of woodland by gardens has enabled the introduced species to establish. It is unlikely that the local decline in distribution of native earthworm species in the metropolitan area is a result of the introduction of peregrine earthworm species.

Each species is keyed out using external features.

Introduction

In 1905 Professor Wilhelm Michaelsen, one of the world's authorities on the taxonomy of earthworms, spent six months collecting in the settled districts of temperate Western Australia as part of the Hamburg/south-western Australia expedition. Although metropolitan Perth then comprised a small area (Figure 1), Michaelsen examined 23 sites in and around suburban Perth as well as six localities in the Darling Range to the immediate east (Michaelsen 1907). These collections were important for two reasons: Perth had been settled by Europeans only 76 years earlier, and outside the suburban limits there were still extensive areas of pristine *Banksia* woodland.

Michaelsen recorded five species around Perth: one lumbricid *Aporrectodea trapezoides* (as *Helodrilus caliginosus* [Savigny, 1826]) and five megascolecids *Diplotrema cornigravei* (as *Eodrilus cornigravei* Michaelsen, 1907), *Graliophilus levis* (as *Plutellus levis* Michaelsen, 1907), *Microscolex dubius*[1] (Fletcher, 1887) and *Woodwardiella libferti* (as *Woodwardia libferti* Michaelsen, 1907). Because lumbricid earthworms are not native to Australia (Jamieson

* Department of Soil Science and Plant Nutrition, University of Western Australia, Nedlands, Western Australia 6009. *Present address:* Institute of Forest Research and Protection, Hayman Road, Como, Western Australia 6152.

[1] Michaelsen also recorded *Microscolex phosphoreus* (Dugès, 1837). According to Jamieson (1974*a*), this species is indistinguishable from *M. dubius*.

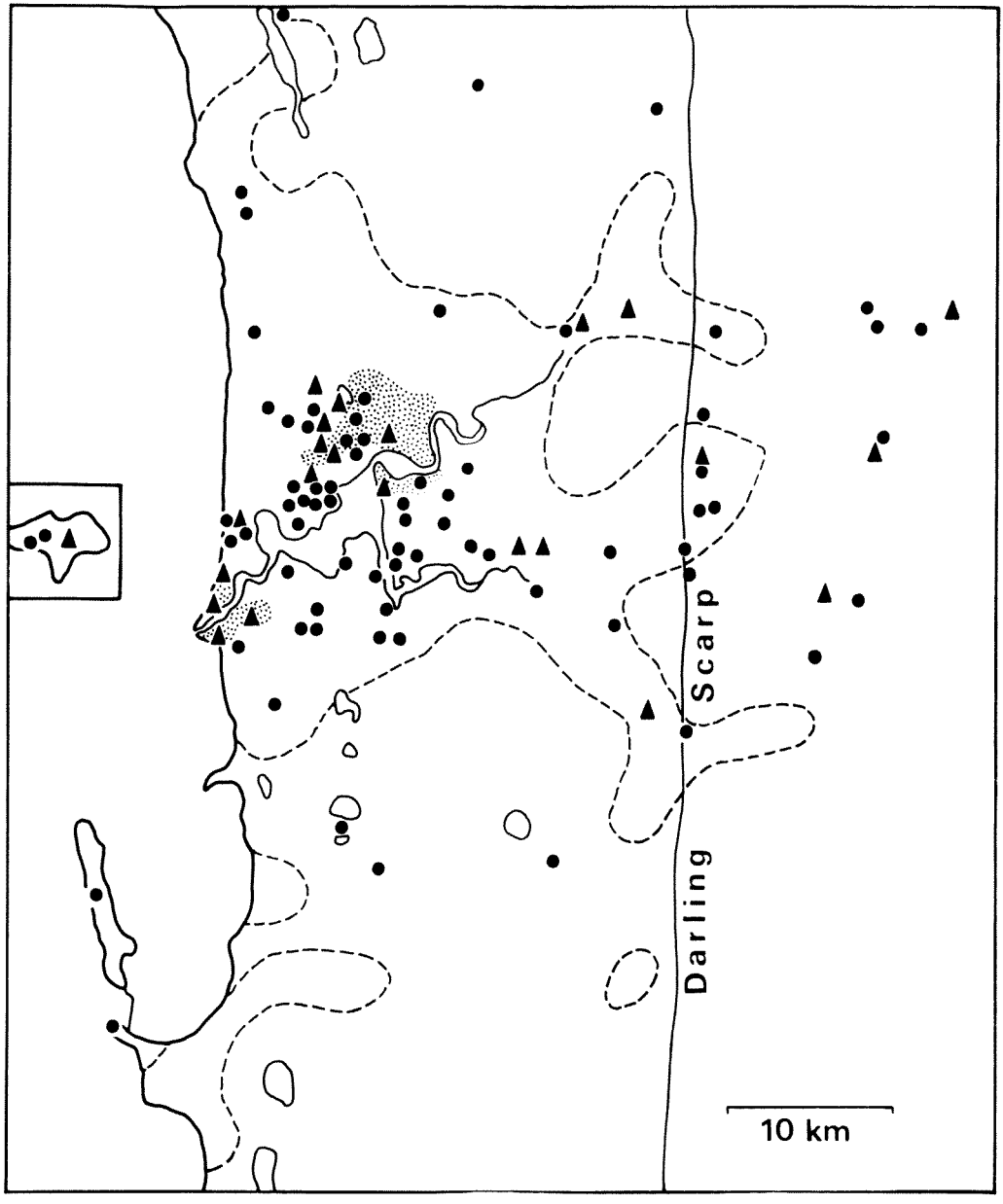

Figure 1 Approximate suburban limits of Perth metropolitan area, 1905 (dotted area) and 1979 (inside dashed line). After Morison 1979 and Department of Lands and Surveys, Perth, 1979. ▲ Sites sampled in 1905 (Michaelsen 1907); ●, sites sampled 1977-1980.

1981), it is certain that *A. trapezoides* was introduced after 1829. In addition, it is almost certain that *M. dubius* was also introduced (Ljungström 1972). The remaining species are indigenous to Western Australia.

In the late 1920s, Ada Jackson collected at a small but undisclosed number of sites 'in the neighbourhood of Perth', and added five species to Michaelsen's list (Jackson 1931). These were the lumbricids *Eisenia fetida*[2] (as *E. foetida* (Savigny, 1826) and *Eiseniella tetraedra*[2] (Savigny, 1826), and the megascolecids *Amynthas corticus*[2] (as *Pheretima heterochaeta* (Michaelsen, 1903), *Megascolex imparicystis* Michaelsen, 1907 and *M. longicystis* Nicholls and Jackson, 1926. Both Michaelsen and Jackson described new species collected from the Darling Range behind Perth: *Graliophilus strelitzi* (as *Plutellus strelitzi* Michaelsen, 1907), *Notoscolex hortensis* Michaelsen, 1907, *N. rubescens* Michaelsen, 1907, *Woodwardiella molaeleonis* (as *Woodwardia molaeleonis* Michaelsen, 1907), *Graliophilus candidus* (as *Plutellus candidus* Jackson, 1931) and *W. magna*[3] (as *Woodwardia magna* Jackson, 1931). Michaelsen also collected the lumbricid *Bimastos parvus*[2] (as *Helodrilus parvus* [Eisen, 1874]). These species are omitted from consideration here because the Darling Range in 1905 and the late 1920s was only sparsely settled, and was not part of suburban Perth as it is now. The Darling Range native earthworm fauna is more properly considered in the context of the northern jarrah forest.

The purpose of this paper is to document the distribution in the Perth metropolitan area of all species of earthworm found there in the late 1970s. Between 1977 and 1980 collections of earthworms were made at 70 sites in and around suburban Perth (Figure 1). The scale of mapping, 1:400 000, is large enough that any real expansion or contraction of distribution of species in the future will be detectable.

A key and glossary of specialist terminology is also provided so that all species can be readily identified from external features. It is hoped that this key will enable naturalists to be better able to realize the significance of new material as it is collected. All the specimens examined for this paper, with details of their places of collection, have been lodged in the Western Australian Museum.

Species Diagnoses and Distributions

Thirteen earthworm species were collected (Table 1). Five of these had not been recorded before: *Aporrectodea caliginosa*, two indeterminate *Megascolex* species, and two indeterminate species belonging to a non-perichaetine genus. These await formal description by a specialist. None of these four indeterminate species can be matched with the descriptions of Michaelsen (1907), so they will probably prove to be new to science. I failed to relocate *Diplotrema cornigravei* and *Graliophilus levis*, collected earlier by Michaelsen. According to Jamieson (1971: 502), *D. cornigravei* is 'widespread in swamps on the Swan Coastal Plain (pers. obs.)'. The only specimens of these species in the Western Australian Museum are those collected by Michaelsen and none of these is suitable for study now. Both species are therefore omitted from the diagnoses and key. All species diagnoses, except where otherwise noted, are based on the material collected, and are composite. The external coloration and maximum length are taken from specimens preserved as follows: held in 35-40% alcohol for one minute: transferred to 4% formaldehyde for 3 hr; and preserved in 75% alcohol.

[2] Introduced to Western Australia.

[3] According to Jamieson (1970:105), this species is a synonym of *W. affinis* (Michaelsen, 1907).

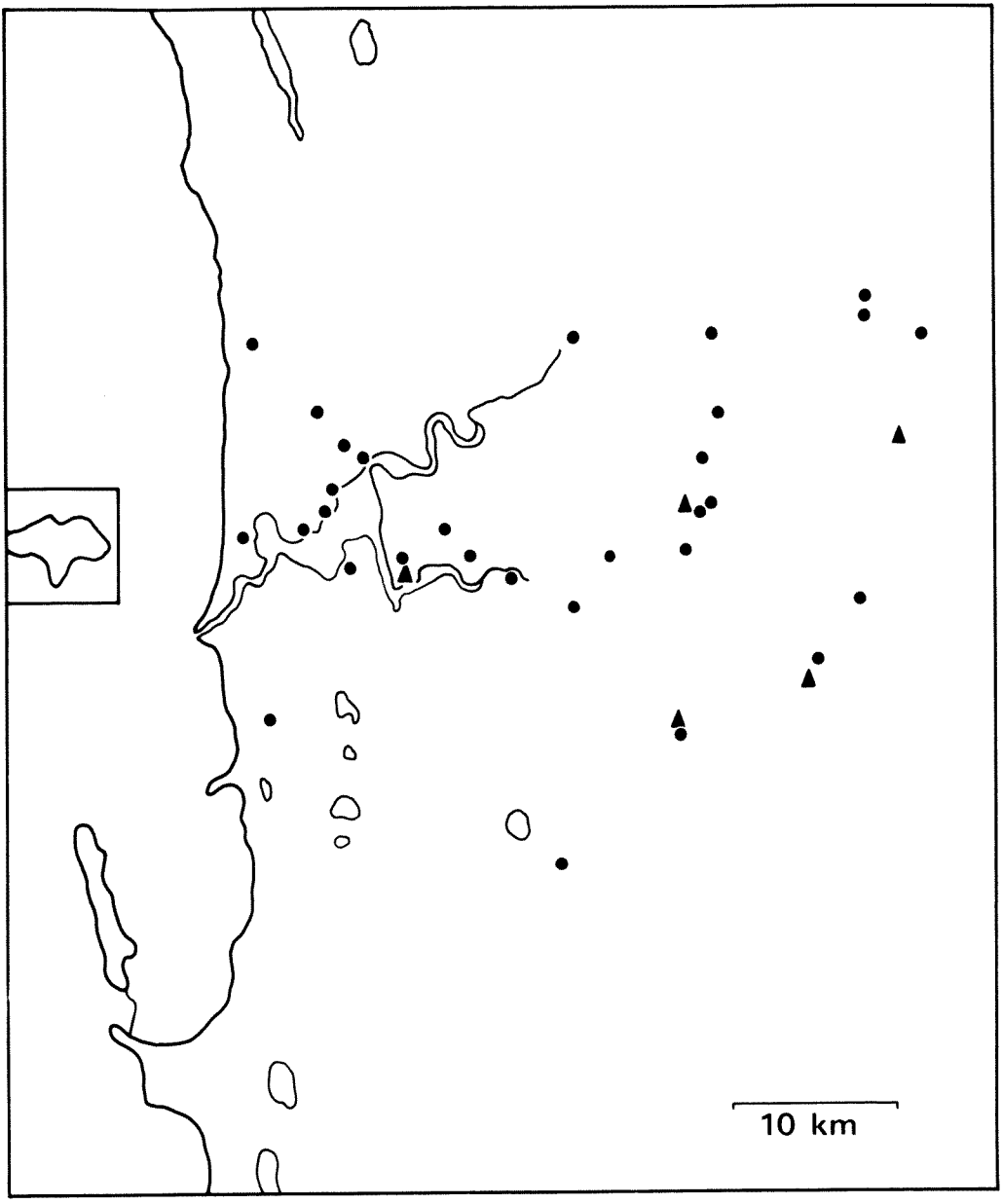

Figure 2 Known distribution in 1977-79 of *Aporrectodea caliginosa* (▲) and *A. trapezoides* (●) in Perth metropolitan area.

Family Lumbricidae

Aporrectodea caliginosa (Savigny, 1826)

Enterion caliginosa Savigny, 1826: 180.
Allolobophora turgida Eisen, 1873: 46.
Aporrectodea caliginosa—Örley 1885: 22.
non Helodrilus caliginosus—Michaelsen 1907: 229; —Michaelsen 1911: 142; —Jackson 1931: 126.

Diagnosis (external)

Length: to 70mm. Colour: pale yellow; pale fawn; pale yellow anterior to segment 15, otherwise light grey; fawn except dorsally on segments 15-29 which are dark grey. Male pores: on segment 15, spreading slightly to neighbouring segments, and lying between *b* and *c* setal lines. Clitellum: variants noted are 27-35, 28-34, 28-½35, ½28-½35, 29-34 (3 specimens), 29-35 (2 specimens), 29-½35. Tubercula pubertatis: Segments 31-33, rarely 31-34, 30-33, or 32-34; always very narrow on the middle segment, and occurring between *b* and *c* setal lines. Genital tumescences: between *a* and *b* setal lines and usually paired. Variants noted are 9-11; 9-11, 27, 30-34; 27 (RHS), 30, 32-33; 9-11, 27; 27 (LHS), 30, 32-33. Setae: closely paired. Behaviour when handled: sluggish.

Gates (1972a) provides a very detailed description of this species.

Distribution

Rare (Figure 2), recorded from only five sites—all gardens (Table 1). From the distribution map it is evident that this species is found in the higher rainfall zone. The range outside the metropolitan area is shown in Figure 9.

Distribution outside Australia: cosmopolitan (Gates 1972*a*).

Aporrectodea trapezoides (Dugès, 1828)

Lumbricus trapezoides Dugès, 1828: 289.
Aporrectodea trapezoides—Örley 1885: 22.
Helodrilus caliginosus—Michaelsen 1907: 229; —Michaelsen 1911: 142; —Jackson 1931: 126.

All of Michaelsen's specimens held in the W.A. Museum and labelled *Helodrilus caliginosus* belong to *A. trapezoides* and not *A. caliginosa* (pers. obs.).

Diagnosis (external)

Length: to 115 mm. Colour: pink to segment 15, thereafter grey; dark grey to segment 13, thereafter brown; all grey but darker dorsally; greyish-fawn; dark grey but nearly purple dorsally; fawn; pale yellow. Male pores: paired on segment 15 with papillae extending on to segments 14 and 16, and lying between setal lines *b* and *c*. (In immature specimens without clitellum and tubercula pubertatis, the male pores do not extend beyond segment 15.) Clitellum: white, fawn or light grey; usually on segments 27-34, occasionally on 27-35, rarely ½26-34, 26-34, ½26-½35, 26-35, 27-33, 28-34 or 28-35. Tubercula pubertatis: usually on segments 31-33, 30-33 or ½30-33; rarely on 30-32, 30-½34, ½30-½34, 31-34 or 31-33; occurring between setal lines *b* and *c*. The tubercula may be either translucent or the same colour (whitish) as the clitellum. Genital tumescences: paired, lying between *a* and *b* setal lines in any of the following arrange-

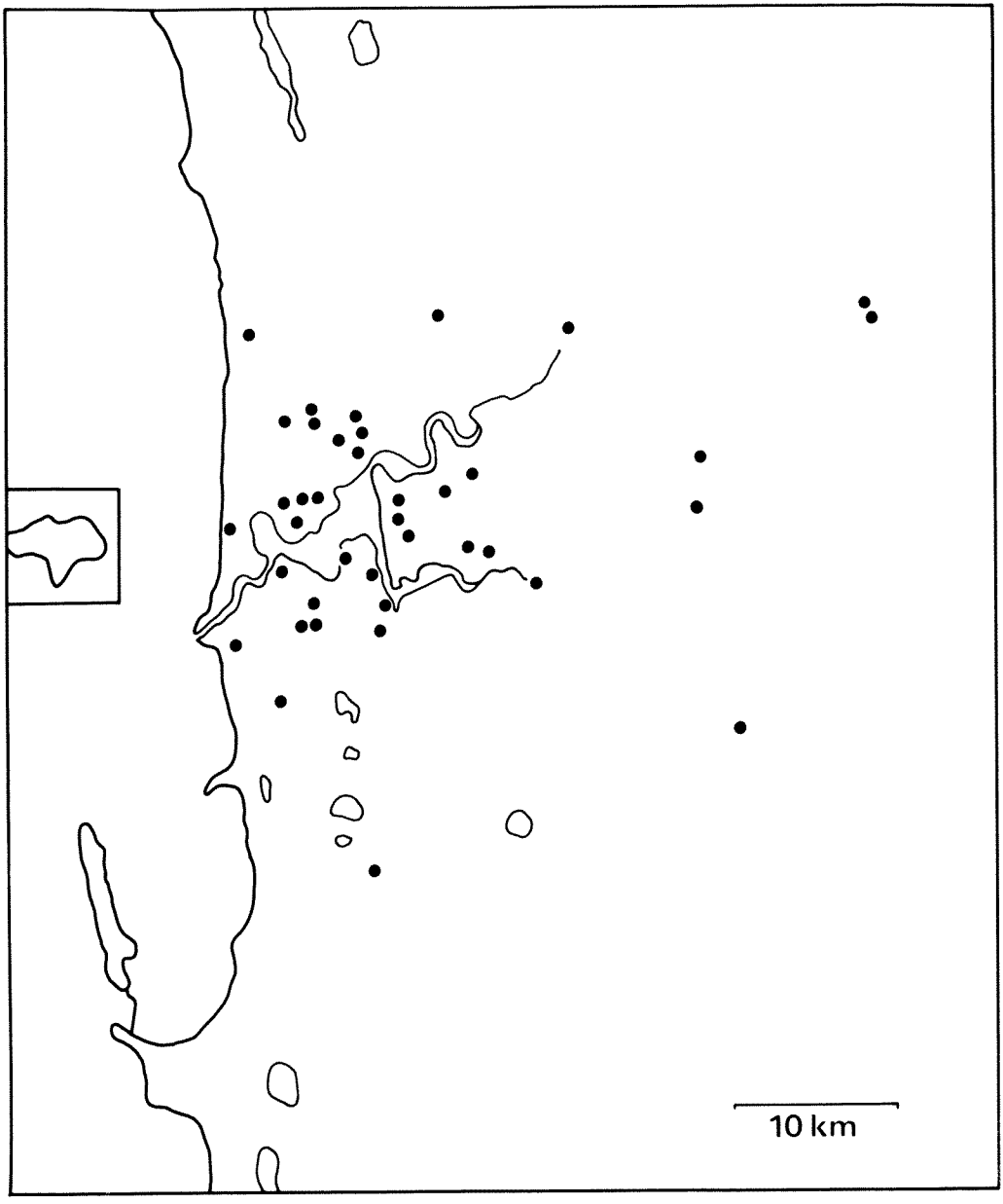

Figure 3 Known distribution in 1977-79 of *Eisenia fetida* in Perth metropolitan area.

ments: 9-11, 32-34; 9-11; 9-11, 27-29, 31-34; 9-11, 27-34; 9-11, 27-30, 32-33; 9-11, 27-29, 29/30, 31/32; 9-11, 30-35; 9-11, 30-31, 32-34; 9-11, 30-34; 9-11, 26-35; 9-11, 26-28, 31-33; 9-11, 30, 32-34; 30, 32-33. Setae: closely paired with *aa* > *bc*. Behaviour when handled: sluggish.

Gates (1972*a*) provides a detailed description.

Distribution

Recorded at 30 sites (Figure 2), associated with gardens and other man-made areas (Table 1). This species is found more frequently in the Darling Range than *Eisenia fetida*. In 1905, *A. trapezoides* was recorded at four widely distributed sites in the metropolitan area. Range outside metropolitan area: widespread (Figure 10), extending farther into semi-arid parts of south-western Australian than *A. caliginosa*. Range outside Australia: cosmopolitan (Gates 1972*a*).

Table 1 Frequency of occurrence of earthworm species in metropolitan Perth region, 1977-1980.

Family and species	Frequency		
	Uncleared sites[1]	Man-affected sites[2]	Total sites
Lumbricidae			
**Aporrectodea caliginosa*	0	5	5
**A. trapezoides*	0	30	30
**Eisenia fetida*	0	38	38
**Eiseniella tetraedra*	0	1	1
Megascolecidae			
**Amynthas corticus*	0	8	8
Megascolex imparicystis	0	3	3
M. longicystis	0	1	1
M. sp. indet. A	0	16	16
M. sp. indet. B	2	0	2
**Microscolex dubius*[3]	0	46	46
Woodwardiella libferti	4	0	4
sp. indet. C	0	1	1
sp. indet. D	0	1	1

*These species are introduced to Western Australia.

[1] Areas that still carry native vegetation with substantial undergrowth of native species, though some weeds may be present.

[2] Includes gardens, plant nurseries, man-made parks, compost areas, stables, lawns, pine plantations, orchards, weedy roadside verges, areas with native trees but with completely weedy undergrowth (native understorey destroyed).

[3] Records from adjacent islands are omitted.

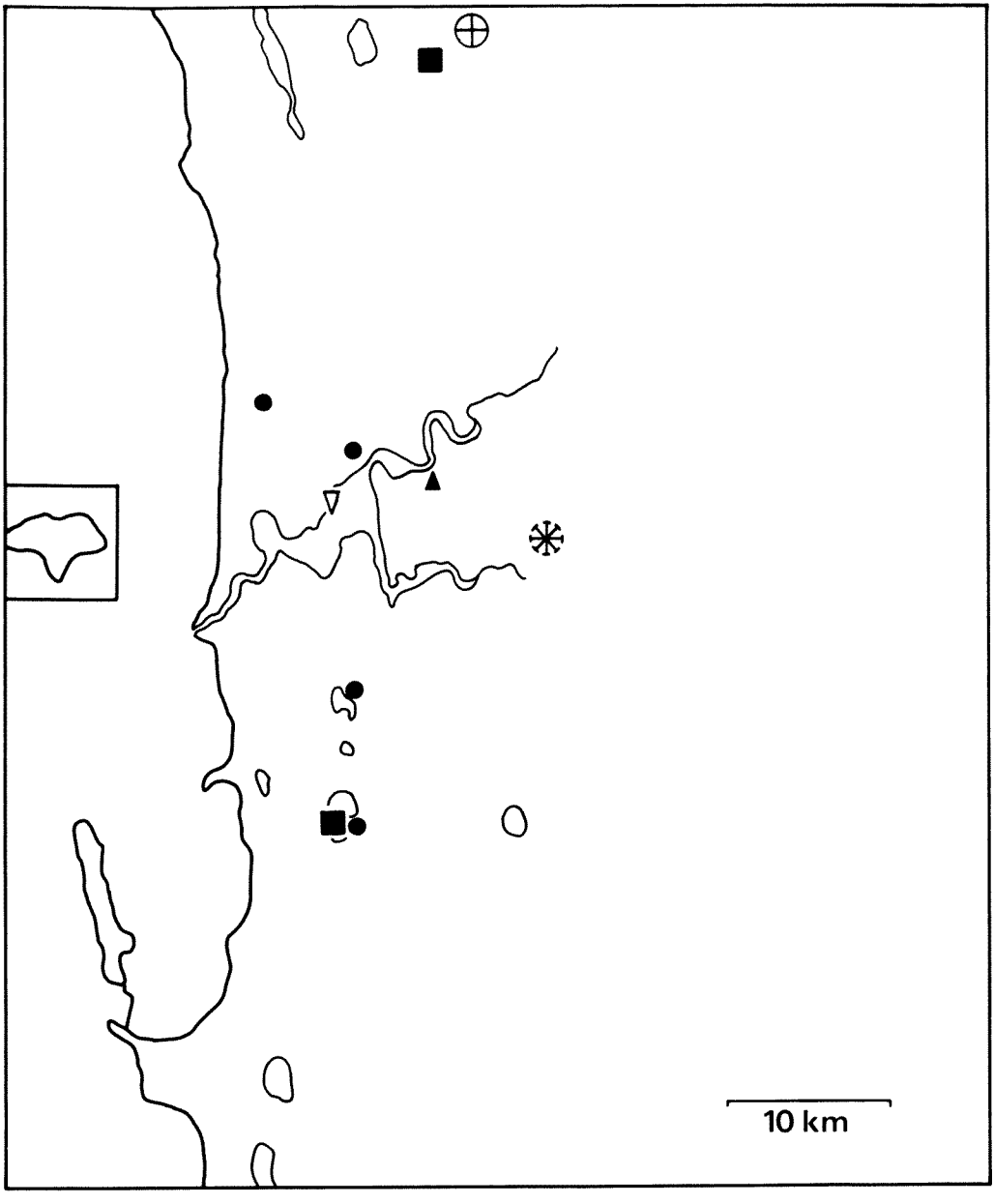

Figure 4 Known distribution in 1977-79 of *Eiseniella tetraedra* (▲), *Megascolex longicystis* (▽), *Megascolex* sp. indet B. (■), *Woodwardiella libferti* (●), sp. indet C. (*), and sp. indet D. (⊕) in Perth metropolitan area.

Eisenia fetida (Savigny, 1826)

Enterion fetidum Savigny 1826: 182.
Eisenia foetida—Malm 1877: 45; —Michaelsen 1907: 228; —Michaelsen 1911: 142; —Jackson 1931: 126.

Diagnosis (external)

Common name: Tigerworm, Brandling, Red Wriggler. Length: to 105 mm. Colour: dorsally purplish-red, ventrally fawn or pale yellow and posteriorly with yellow between the segments. Sometimes purplish-red all over except for the ventral parts of the first ~20 segments, which are yellow. Male pores: paired, on segment 15 between *b* and *c* setal lines. Papillae do not extend onto segments 14 and 16. Clitellum: fawn or off-white, covering on most specimens segments 26-32, occasionally ½24-33, 25-30, 25-32, 26-31, 26-½32, 26-½33, 26-33, or 27-32. Tubercula pubertatis: between *b* and *c* setal lines on segments 28-30 or 28-½31 on majority of specimens examined, occasionally on 25-30, 27-½30, 28-31, ½28-32 or 29-31. Genital tumescences: usually paired, but variably developed: 9-13, 19 (RHS), 23, 26-32; 9, 11 single, 26-32; 8-11, 14, 21, 23, 26-33; 9-12, 14, 16, 26-32; 28-31; 9, 11, 12, 23-32; 8-11, 23-32; 24-32; 9, 12, 26-32; 9-12; 9-12, 26-32; 26-31; 22 (RHS), 23 (LHS), 27-33; 8-12, 26-32; 22-33. On segments before 15 they usually occur between the *c* and *d* setal lines whereas on segments after 15 they occur between the *a* and *b* setal lines. Setae: closely paired, *aa* = *bc*. Behaviour when handled: wriggles and squirms excitedly. A yellow foul smelling fluid is also ejected.

Distribution

Collected at 38 localities (Figure 3), in contrast to Jackson (1931) who noted it at only one locality. Recorded only from man-made habitats such as gardens, stables and chicken runs (Table 1). Range outside metropolitan area: Very localized, see Figure 9. Range outside Australia: cosmopolitan (Michaelsen 1907).

Eiseniella tetraedra (Savigny, 1826)

Enterion tetraedrum Savigny, 1826: 184.
Eiseniella tetraedra Michaelsen 1900: 473; —Michaelsen 1907: 228; —Michaelsen 1911: 142; —Jackson 1931: 123.
Eiseniella intermedius Jackson, 1931: 123; —Michaelsen 1935: 40.

Diagnosis (external)

Length: to 45 mm. Colour: reddish-purple except fawn ventrally. Male pore: on segment 13, between *a* and *c* setal lines. Clitellum: on segments 22-27. Tubercula pubertatis: on segments 23-26 or 23-½26 between *b* and *c* setal lines but closer to *c*. Genital tumescences: obvious only on segments 23-25. Setae: closely paired, with *aa* = *bc*. Note: Segments anterior to 22 are of circular cross-section in contrast to those after the clitellum which are square in transverse section.

Distribution

This species was collected from only one locality, much disturbed, in South Perth close to the left bank of the Swan River (Figure 4). In the 1920s, it was collected only near

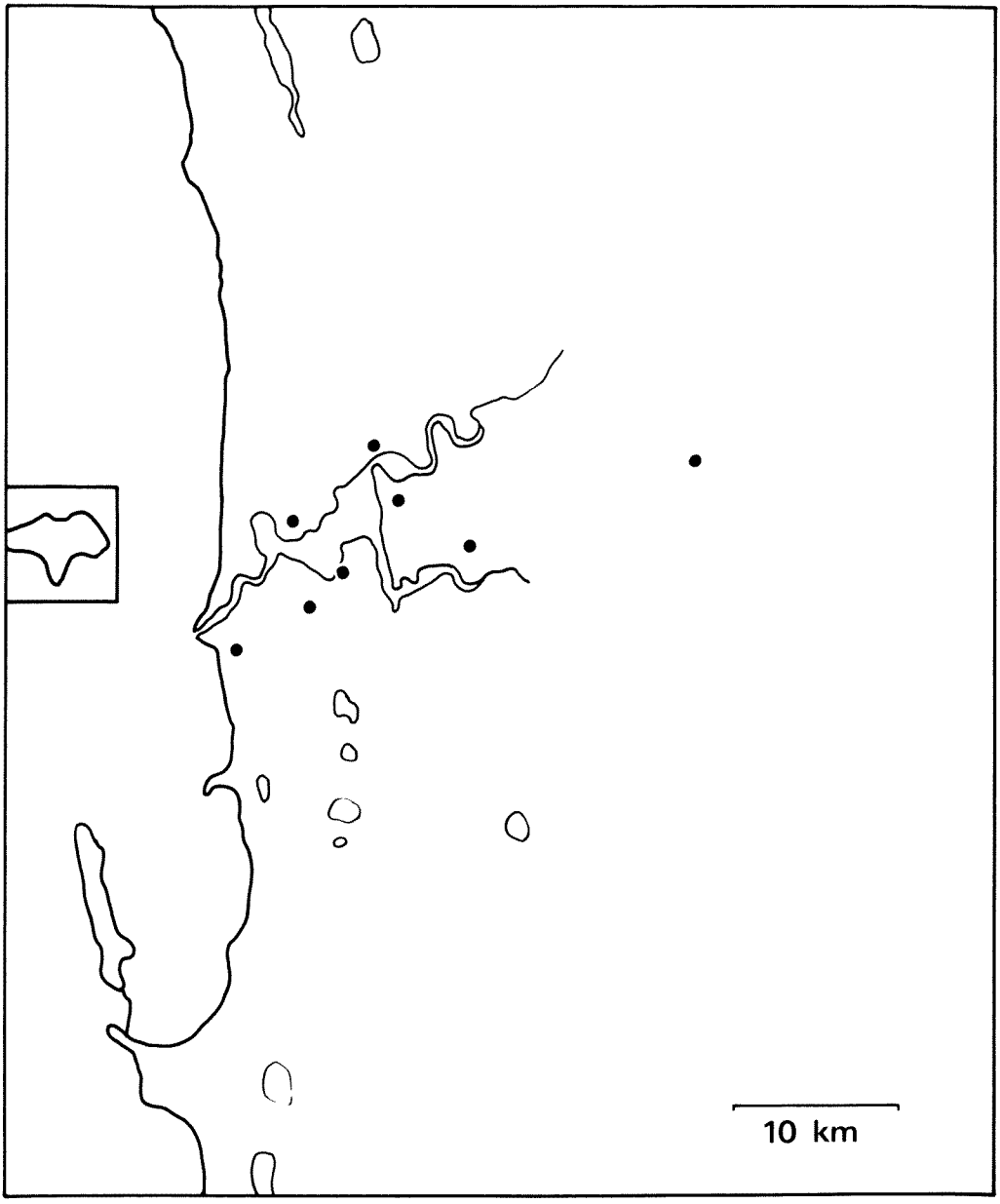

Figure 5 Known distribution in 1977-79 of *Amynthas corticus* in Perth metropolitan area.

Lake Monger (Jackson 1931). Range outside metropolitan area: the only record is near Albany (Michaelsen 1907). Range outside Australia: cosmopolitan (Michaelsen 1907). This species would be expected to occur only in or close to water.

Family Megascolecidae

Amynthas corticus (Kinberg, 1867)

Perichaeta corticis Kinberg, 1867: 102.
Amynthas corticus Sims & Easton 1972: 235.
Pheretima heterochaeta Michaelsen 1903: 96; –Michaelsen 1907: 226; –Michaelsen 1911: 142; Jackson 1931: 119.

Diagnosis (external)

Length: to 110 mm. Colour: pale brown-yellow dorsally and fawn ventrally; fawn; pale yellow-fawn; pale brown. Male pore: paired, eyelike, on segment 18, rarely segment 17. The slit may be centred on setal line *f*, *g*, *h*, or *j*, and usually extends to one or two setal lines on either side. Clitellum: chocolate coloured or light brown, usually covering segments 14-16, occasionally 14-½16 or ½13-16. Female pore: visible as a central white circle on ventral part of segment 14. Spermathecal pores: usually paired. Variants recorded are: single on 8 (*d* line); 5/6, 6/7, 7/8, 8/9 as small white bulbs on *h* line; 5/6, 6/7, 7/8; 5-8; 7-9 on *d* line; 7-8 on *d* line; 8-9 on *d* line; 8, single (RHS) on *d* line; 7 (paired) and 8 (single) on *c* line; 8 on *c* line. On the basis of such variation in position of these pores, E.G. Easton (pers. comm.) suggests that two species may be involved. However, there is still considerable variation in this feature in earthworms collected at the same locality. Setae: perichaetine with about 40-50 per segment, pointing forward, with the setal rings unbroken dorsally and ventrally. *aa* slightly > *ab*. Dorsal blood vessel not obvious. Behaviour when handled: snake-like in its movements.

Distribution

Rare (Figure 5), recorded in gardens only. In the 1920s, this species was first recorded in what are now Supreme Court Gardens in Perth (Jackson 1931). Range outside metropolitan area: Boyanup (Michaelsen 1907) and banks of Gooralong Brook, Jarrahdale. Range outside Australia: cosmopolitan (Michaelsen, 1907).

Megascolex imparicystis Michaelsen, 1907

Megascolex imparicystis Michaelsen, 1907: 209; –Michaelsen 1911: 141: –Jackson 1931: 109; –Michaelsen 1935: 39.

Diagnosis (external)

Length: mean 215 mm. Range 150-410 mm based on 27 specimens held in Western Australian Museum (mode of preservation not known). Colour: fawn with grey dorsum; very pale yellow with purplish dorsum; light grey but darker dorsally; pale yellow-fawn all over. Male pore: unpaired on segment 18 between *a* setal lines. Clitellum: rarely distinct, 14-19, with sides not meeting ventrally. Accessory glands: arrangement

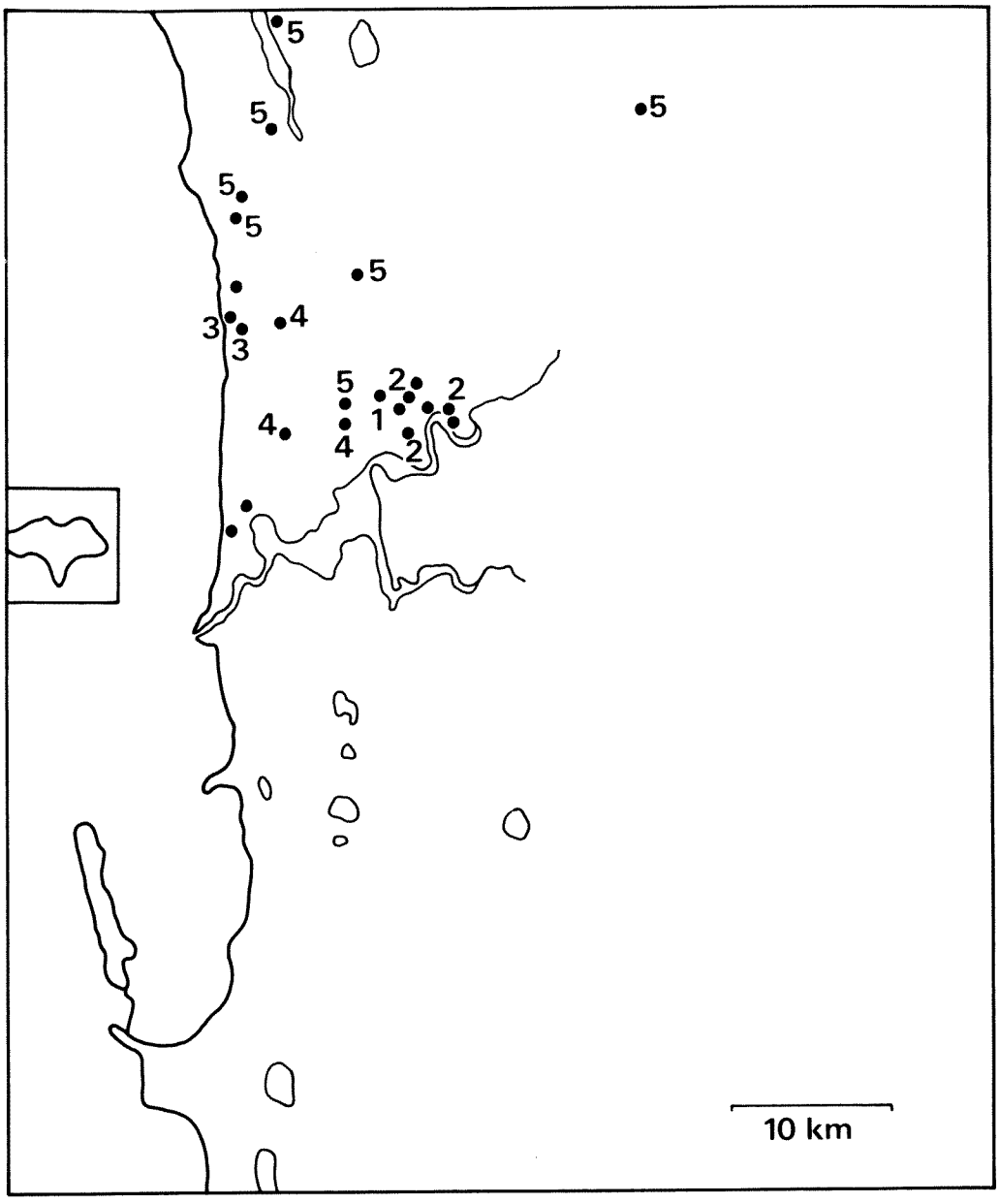

Figure 6 Known distribution of *Megascolex imparicystis*, coded by decades: 1 = 1920s, 2 = 1930s, 3 = 1950s, 4 = 1960s, 5 = 1970s. (Most records from specimens in Western Australian Museum.)

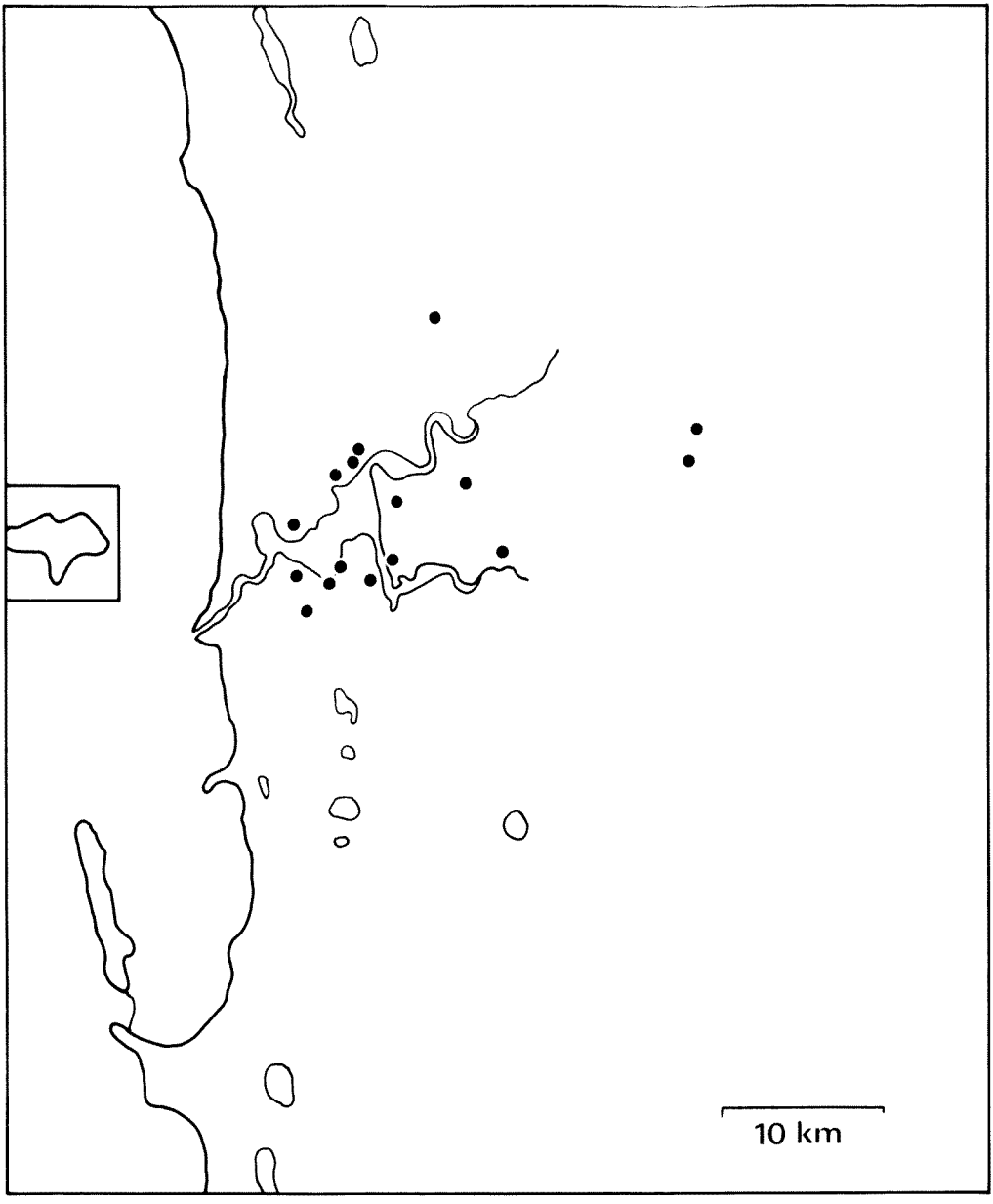

Figure 7 Known distribution in 1977-79 of *Megascolex* sp. indet A in Perth metropolitan area.

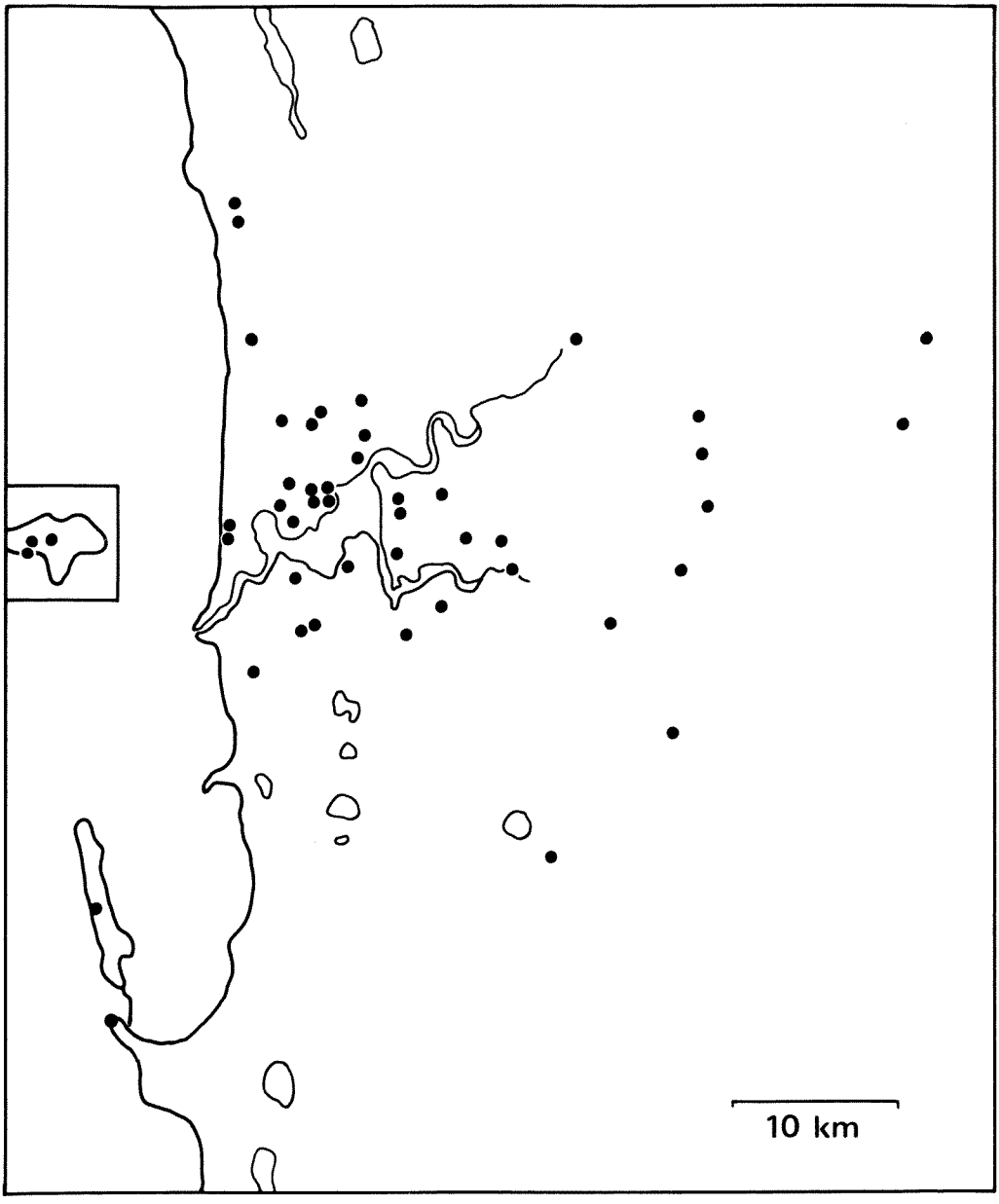

Figure 8 Known distribution in 1977-79 of *Microscolex dubius* in Perth metropolitan area.

quite variable, but always occurring singly and ventrally in furrows between segments: 17-18, 18/19 (twice); 17/18, 18/; 15/16, 16/17-23/24; 14/15-23/24; 15/16-22/23; 4/5-8/9, 17/18-25/26; 14/15-19/20; 16/17-19/20; 16/17-18/19; 6/7, 7/8, 15/16-21/22; 6/7-8/9, 15/16-23/24; 4/5-7/8, 15/16-18/; 16/17-20/21; 15/16-22/23; /16, 16/17, 18/19-23/24; 4/5-7/8, 16/17-25/26. Those before segment 10 lie between *a* setal lines and are not always present. Those accessory glands between segments 15 and 24 are large, but vary in size, lying between *c* setal lines to *g* setal lines. Setae: perichaetine, with 30-50 per segment. *aa* ~ 1.5 *ab*. Behaviour when handled: sluggish.

Distribution

I did not find this species in the metropolitan area in 1977-1980, although specimens from three metropolitan localities were brought into the Western Australian Museum. The date of collection (if available) has been coded by decades in Figure 6. This species has been collected as new suburbs were created from dune scrub or woodland and also

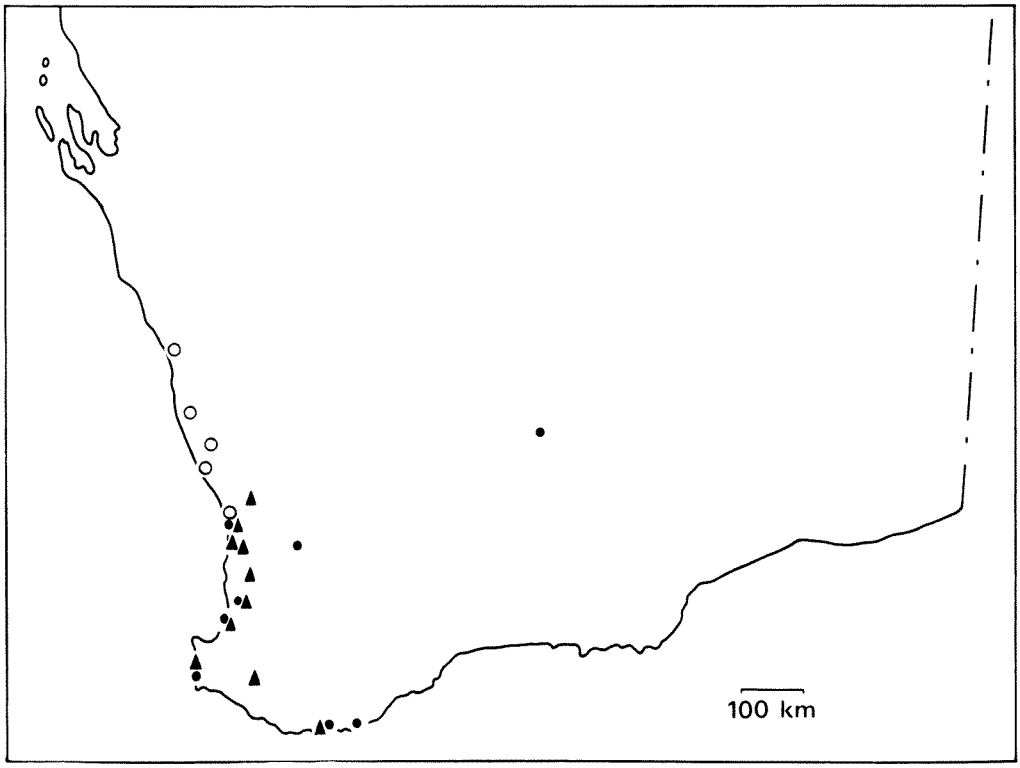

Figure 9 Known distribution of *Eisenia fetida* (●), *Aporrectodea caliginosa* (▲), *Megascolex imparicystis* (○) in temperate Western Australia (based on all records available, i.e. all localized specimens held in the Western Australian Museum, and the author's collection, now in the Western Australian Museum).

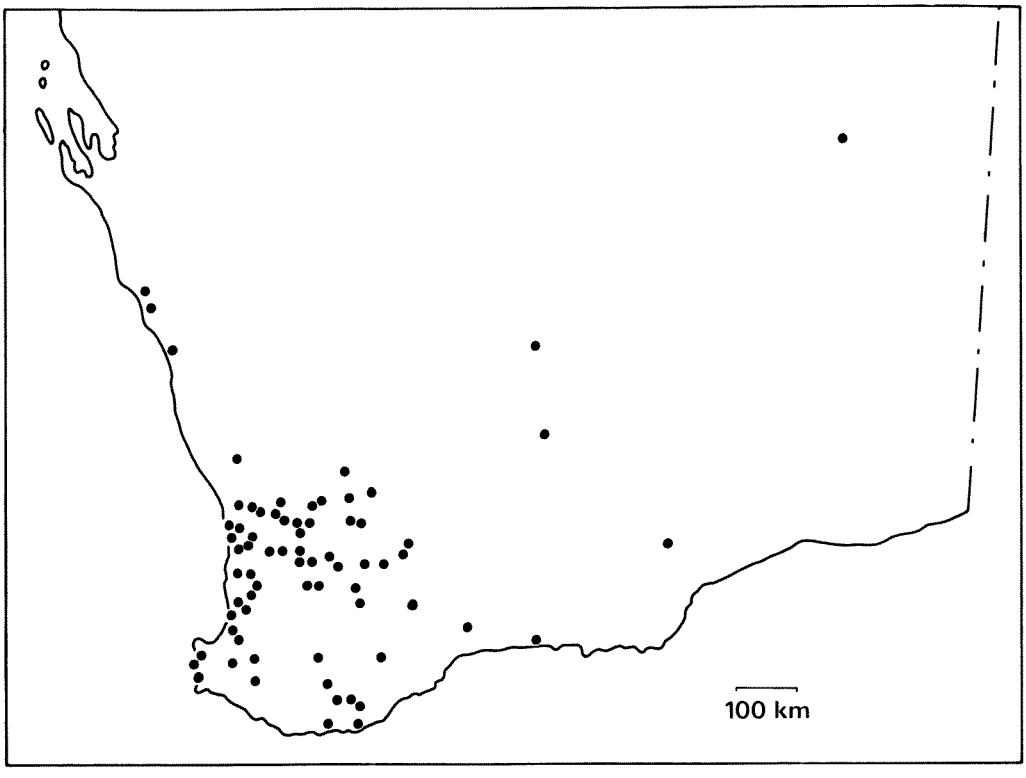

Figure 10 Known distribution of *Aporrectodea trapezoides* in temperate Western Australia (based on all records available).

from reserves and agricultural land remaining. Both Michaelsen (1935) and Jamieson (1971) characterized this indigenous species as peregrine, on the basis that the species has been found in gardens. *Megascolex imparicystis* has not been collected south of the Swan River or in the Darling Range.

Range outside metropolitan area: north of the metropolitan area this species still survives on the coastal plain (Figure 9). I have collected specimens from pasture near Lancelin and Dandarragan. During cultivation large numbers become caught in the tynes near Lancelin (personal observation) and near Upper Swan (R. Barrett-Lennard, pers. comm.).

Megascolex longicystis Nicholls and Jackson, 1926

Megascolex longicystis Nicholls and Jackson, 1926: 142; –Jackson 1931: 116.

Diagnosis (external)

The following description is based on the one specimen collected. Length: 55 mm (to 80 mm, according to Nicholls and Jackson). Colour: purplish-brown dorsally, fawn

ventrally, and anterior and posterior extremities tipped white. Male pore: paired on segment 18, centred on *b* setal line and extending from *a* to *c* setal lines. Clitellum, not distinct, 14-½17. Accessory glands, not visible but according to Nicholls and Jackson there are two pairs on anterior margins of 8 and 9 in *c* setal lines. Setae: perichaetine, with about 20-25 per segment. Setal ring is broken ventrally and dorsally, with *aa* ~ 1.5 *ab*.

Distribution

Found only at one locality (Figure 4), under eucalypts with a completely weedy undergrowth. Range outside metropolitan area: the two 1920s records, at Wungong and Armadale (Jackson 1931) are still the only non-metropolitan records.

Megascolex sp. indet. A

Diagnosis (external)

Length: to 105 mm. Colour: first 3-12 segments reddish or pinkish-fawn; rest of body grey or pale yellow. Male pore: paired on segment 18, rarely on 17; eyelike, centred on *b* setal line and extending from *a-c* lines or centred on *d* line and extending from *c-e* lines. Female pore: median and unpaired on ventral part of segment 14. Clitellum: chocolate coloured, on segments 14-16, occasionally 14-15, rarely 13-16. Accessory glands: nil. Setae: Perichaetine, with 20-30 per segment. $aa > ab > bc > cd$ ....$xy < zz$. Dorsal blood vessel is prominent. Behaviour when handled: wriggles excitedly and will often break in two.

Distribution

See Figure 7. Recorded only in gardens and a plant nursery (Table 1). There are no records from outside the metropolitan area. Note: The material has been registered in the Western Australian Museum collection as WAM 149-81 to 164-81 inclusive.

Megascolex sp. indet. B

Diagnosis (external)

Length: to 55 mm. Colour: dorsally dark red to purple, ventrally fawn; Male pore: paired on prominent papillae on segment 18, between *a* and *b* setal lines. Clitellum: covering segments 13 or 14-17. Genital markings: paired, lying in the furrow of 17/18 between *b* and *c* setal lines. In one specimen there is a single genital marking in the furrow of 19/20 between the LHS *a* and *b* setal lines. Setae: perichaetine, about 20 per segment, with setal ring broken dorsally and ventrally. *aa* = 1.5 *ab*. Dorsal blood vessel is visible through preclitellar segments only.

Distribution

Found only at two localities, one in black sand under *Melaleuca* at the edge of a freshwater lake, the other in sand under *Banksia* woodland (Figure 4). This species is not known to occur outside the metropolitan area.

Note: This material has been registered in the Western Australian Museum collection as WAM 165-81 and 166-81.

Microscolex dubius (Fletcher, 1887)

Eudrilus dubius Fletcher, 1887: 378.
Microscolex dubius—Rosa 1890: 511; —Michaelsen 1907: 146; —Michaelsen 1911: 140; — Jackson 1931: 85.
Microscolex phosphoreus Jamieson, 1974: 201.

Diagnosis (external)

Length: to 110 mm. Colour: pinkish or pinkish-white to about segment 12, otherwise pale grey, pale yellow; fawn-yellow to about segment 12, otherwise grey-yellow. Male pore: paired on *a* setal lines of segment 17 or 18 and surrounded by white papillae. Female pore: median ventral on segment 13 or 14, in clitellate specimens only though not always visible. Clitellum: yellow-fawn or light brown, usually on segments 13-16, or 14-17, occasionally on 13-17, 13-½17, ½13-½17, ½13-16, 14-16, 14-½17, or 14-18. Setae: widely spaced; $aa = 2ab$ except on segments 17-20 where *b* is close to *a*. The *a* and *b* setae on 17 are about twice the length of those on 18. $ab < cd < bc$. Behaviour when handled: sluggish.

Jamieson (1974b) provides a very detailed description of both external and internal features.

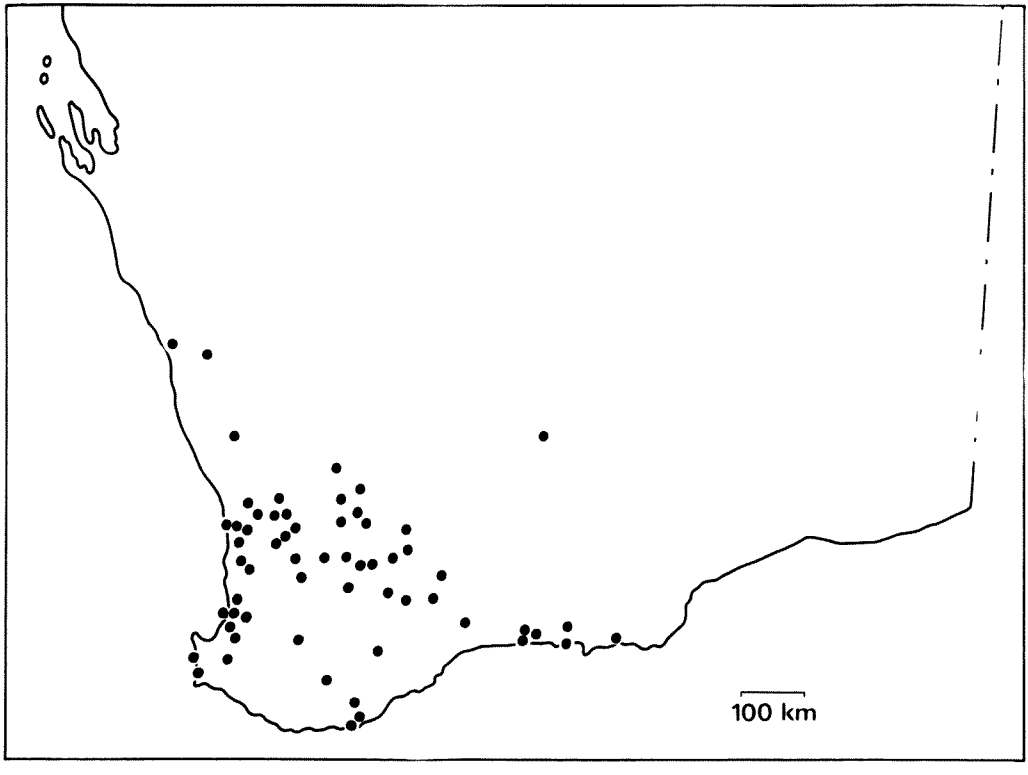

Figure 11 Known distribution of *Microscolex dubius* in temperate Western Australia (based on all records available).

Distribution

See Figure 8. Recorded from man-disturbed sites (Table 1). This species was collected from Green Island, a small stack adjacent to Rottnest Island. It is possible that nesting Silver Gulls *Larus novaehollandiae* have introduced it from nearby Rottnest Island, which is much disturbed by man. *Microcolex dubius* has a wider distribution on the coastal plain than *Aporrectodea trapezoides*. In 1905 this species was recorded at Rottnest Island and six metropolitan sites, and in the 1920s at Rottnest Island, Wungong and Cottesloe. Range outside metropolitan area: Extensive (Figure 11). This species is more widespread than stated by Jamieson (1971: 503). Range outside Australia: cosmopolitan (Michaelsen 1907).

Woodwardiella libferti (Michaelsen, 1907)

Woodwardia libferti Michaelsen, 1907: 193
Woodwardia lipferti—Michaelsen 1911: 141.
Woodwardiella libferti—Stephenson 1925: 888; —Jamieson 1970: 105.
Woodwardiella lipferti—Jackson 1931: 103.

Diagnosis (external)

Length: to 50 mm. Colour: Segments 10-50 are yellow, otherwise pale grey; Male pore: paired on papillae on segment 18, between *a* and *b* setal lines; Female pore: small, paired on segment 14, between *a* setal lines. Clitellum: not obvious in specimens examined. Genital markings: a pad lies in the ventral furrow of segments 11 and 12, and extends to between the *a* and *b* setal lines. Setae: *aa* = *2ab*. Behaviour when handled: sluggish.

Distribution

Recorded at four places (Figure 4), all in sand under *Banksia* woodland. This is the only species collected in the *Banksia* woodland of Kings Park and is not known to occur outside the metropolitan area.

Remarks: Michaelsen's text figures for *W. libferti* and *W. molaeleonis* (given on pp. 194 and 195 respectively) have inadvertently been reversed as they do not match his descriptions. This apparently has led to confusion by Jamieson (1971: 487).

Sp. indet. C

Diagnosis (external)

Length: to 55 mm. Colour: Segments 1-15 pale yellow, remainder grey: Male pores: paired on 18, between *a* setal lines; Clitellum: covering 14-17 or not obvious; Genital markings: single, in furrow 19/20 between *b* setal lines. Setae: four pairs, *aa* = 2-3 *ab*.

Distribution

Found in only one site in the metropolitan area (Figure 4). This species has been found at only one location outside the metropolitan area, under undisturbed woodland at Wilbinga Grove north of Perth.

Note: This material has been registered in the Western Australian Museum collection WAM 167-81 and 168-81.

Sp. indet. D

Diagnosis (external)

Length: to 90 mm. Colour: Segments 1-16 fawn, remainder grey; Male pores: paired on 18 on *a* setal lines: Clitellum: not obvious. Genital markings: paired on *a* setal lines of segments 8 and 9, and paired on large papillae in furrows of 15/16, 16/17, 19/20 on *a* setal lines. (Papillae lie between *b-c* setal lines). The only other variants noted were single (LHS) 14/15 (*a* line), and paired 15/16, 16/17, 19/20; and 16/17, 19/20, 20/21.

Distribution

Found only in Gnangara Pine Plantation in bank of a creek (Figure 4).

Note: This material has been registered in the Western Australian Museum collection as WAM 169-81.

Discussion

Causes of Differences in Distribution of Native and Introduced Earthworms

A clear-cut difference was not found between the distribution of native and introduced earthworm species in the Perth metropolitan area. All introduced species were found only in sites disturbed by settlement, but only a minority of native species were found only in uncleared sites. The first finding was expected, but the second was a surprise. The literature on Southern Hemisphere earthworm faunas has often noted that native and introduced species have exclusive distributions, and there has been controversy about the relative roles of interspecific competition between native and introduced species, and the replacement of native habitats by ones suitable for introduced species (Stephenson 1930, Barley 1959, Satchell 1967, Lee 1961, Ljungström 1972).

What is particularly curious is that of the seven native species collected only two *(Megascolex* sp. indet. B and *Woodwardiella libferti)* were found only in uncleared sites. It is not known whether the other five species are native to the Perth region and have adapted to land-clearing, or if they have been introduced from another part of south-western Australia. In either case, the possibility of interspecific competition between these five species and the introduced species cannot be ruled out. I constructed from Michaelsen (1907) a table similar to my Table 1. Unfortunately the number of cases for 1905 is so small that no useful conclusions can be drawn from a comparison with the 1977-9 data.

Introduced Earthworm Fauna Round Perth Compared with Other Australian Regions

Comparisons of the earthworm fauna of metropolitan Perth with that of other capital cities in Australia is difficult for several reasons. There has been inadequate collecting, particularly of introduced species, and many of the older specimens held in museums are in a poor state of preservation, often being impossible to identify.

I have examined the earthworm collection in the South Australian Museum, the catalogued part of the collection in the National Museum of Victoria, and the card indexes of specimens held in the Australian Museum.

Gates (1972*a*, 1973) provides authoritative information on the occurrence of certain lumbricid species in Australia.

The following lumbricid[4] species (with their known occurrence elsewhere in Australia) have not been recorded from the Perth metropolitan area: *Aporrectodea longa* (Tasmania), *A. tuberculata* (New South Wales), *Bimastos parvus* (New South Wales), *Dendrodrilus rubidus* (New South Wales, Victoria), *Lumbricus rubellus* (New South Wales, Victoria), *Octolasion tyrtaeum* (New South Wales). Both *Bimastos parvus* and *Dendrodrilus rubidus* in the above list were recorded in Western Australia in 1905 but outside the metropolitan area (Michaelsen 1907). In addition, *Eisenia rosea* and *Octolasion cyaneum* have recently been recorded in south-western Australia (Abbott 1981), and would seem to be good candidates for colonizing and establishing in the Perth metropolitan area.

Why some lumbricid species and not others have flourished in the Perth metropolitan area is a subject meriting more detailed analysis. At present it is not possible to state whether either opportunity of introduction to the area or difficulties with establishment because of unsuitable climate, soil type etc. is involved. Parthenogenesis is usually stated to be an advantage in a newly colonized environment if mates are scarce. Of the six introduced species present in metropolitan Perth, *Aporrectodea trapezoides, Eiseniella tetraedra, Amynthas corticus* and *Microscolex dubius* are parthenogenetic, *Aporrectodea caliginosa* and *Eisenia fetida* are amphimictic (Gates 1972*b*, Martin 1977, Reynolds *et al.* 1974). There thus seems to be no close association between breeding system and distribution of species in the Perth metropolitan area. Similarly for the eight lumbricid species recorded elsewhere in Australia but not in the Perth region, five species *(Bimastos parvus, Dendrodrilus rubidus, Eisenia rosea, Octolasion cyaneum, O. tyrtaeum)* are parthenogenetic and the remaining three *(Aporrectodea longa, A. tuberculata, Lumbricus rubellus)* are amphimictic. These comparisons suggest that breeding system is not a particularly important characteristic for peregrine earthworm species. Jaenike and Selander (1979) have proposed that 'parthenogenetic earthworms commonly occur in ephemeral or unstable habitats, in which r-selection may be expected, whereas sexual species tend to inhabit more stable environmental situations, where K-selection may be more important'. When this reasoning is applied to Western Australia, we should expect all earthworm species to be parthenogenetic.

It seems more likely that the frequency of human-assisted movements and the ecology of the soil of suburban areas will be of more relevance to understanding the distribution of peregrine species.

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[4]All introduced to Australia.

Key to Identification of Species

(*Diplotrema cornigravei* and *Graliophilus levis,* collected by Michaelsen [1907], were not sighted by me and are omitted.)

1	Male pores on segment 13 or 15	2
	Male pores on segment 17 or 18	3
2	Clitellum terminating on or before segment 33	4
	Clitellum terminating on segment 34 or 35	5
3(1)	Setae, 8 on each segment	6
	Setae, more than 8 on each segment	7
4(2)	Clitellum terminating on or before segment 27; tubercula pubertatis terminating on segment 26	*Eiseniella tetraedra*
	Clitellum terminating on or before segment 33; tubercula pubertatis terminating on segment 30, 31 or 32	*Eisenia fetida*
5(2)	Tubercula pubertatis rod-like	*Aporrectodea trapezoides*
	Tubercula pubertatis distinctly bilobed, the lobes joining on segment 32	*Aporrectodea caliginosa*
6(3)	Accessory genital markings present	8
	Accessory genital markings absent	*Microscolex dubius*
7(3)	Male pore single	*Megascolex imparicystis*
	Male pores paired	9
8(6)	Genital markings single	10
	Genital markings paired	Sp. indet. D
9(7)	Setae≥40 per segment; setal ring unbroken dorsally and ventrally	*Amynthas corticus*
	Setae<30 per segment; setal ring broken dorsally and ventrally	11
10(8)	Genital marking in furrow 11/12	*Woodwardiella libferti*
	Genital marking in furrow 19/20	Sp. indet. C
11(9)	Dorsal surface purplish or purplish-brown, ventral surface fawn or grey	12
	Dorsal and ventral surface fawn or grey	*Megascolex* sp. indet. A
12(11)	Both ends of body tipped white (genital markings never paired in furrow 17/18)	*Megascolex longicystis*
	Ends of body not white (genital markings often paired in furrow 17/18)	*Megascolex* sp. indet. B.

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Glossary

The following terms used in this paper are standard ones used in the literature of earthworms. Stephenson (1930) and most elementary books on invertebrates provide explanatory diagrams.

Accessory glands	Glands (sometimes called prostates) associated with the male reproductive organ.
Clitellum	A glandular thickening of the body wall associated with cocoon production.
Female pore	External opening of the female reproductive organ; the pore through which eggs leave the body.
Genital markings	Pads or ridges often associated with the male reproductive organs.
Genital tumescence	Papillae or ridges bearing modified setae, probably to facilitate mating.
Male pore	External opening of the male reproductive organ; the pore through which sperm leave the body.
Papillae	White lips surrounding the male pores.
Peregrine	Earthworm species easily transported by Man and which live in areas disturbed by Man e.g. gardens and pasture.
Perichaetine	More than 8 setae per segment. Figures quoted of number of setae per segment refer to segments 20-25.
Segments	These are numbered from the anterior backwards. The prostomium (a lobe over the mouth) is not numbered. The next segment = 1.
Setal lines	Setae are arranged in regular longitudinal lines around the body. The most ventral setae are each labelled *a*, the next *b*, etc. The most dorsal setae are each labelled *z*, the next *y*, etc. Intersetal distances are then quoted as (for example) *aa* = *ab*, or *aa* = 1.5 *ab*.
Spermathecal pores	External openings of the spermathecae (sperm-storage organs); the pores through which sperm leave the body after eggs are produced.
Tubercula pubertatis	In this paper used to designate genital markings found as ventrolateral swellings on the clitellum of lumbricid earthworms.

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