Presentation to Darling Range Naturalists' Club
14 September 2001

EARTHWORMS

Ian Abbott
Department of Conservation
Kensington

Aristotle, ?350 BC

Recognized the role of earthworms as the 'intestines of the earth'

Gilbert White, 1777

- Earthworms a small & despicable link in the chain of nature, yet if lost would make a lamentable chasm
- perforate & loosen soil
- worm casts, a fine manure
- much addicted to venery

J C Savigny, 1826

First to state that there are many different earthworm species, not just the one species listed by Linnaeus in 1758

Charles Darwin

- 1837: Paper presented to Geological Society of London on the formation of vegetable mould
- 1881: Book (his last) 'The formation of vegetable mould through the action of worms'

'It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organized creatures'

FIG. 5. Section, reduced to half the natural scale, of the vegetable mould in a field, drained and reclaimed fifteen years previously; A, turf; B, vegetable mould without any stones; C, mould with fragments of burnt marl, coal-cinders and quartz pebbles; D, subsoil of black, peaty sand with quartz pebbles.

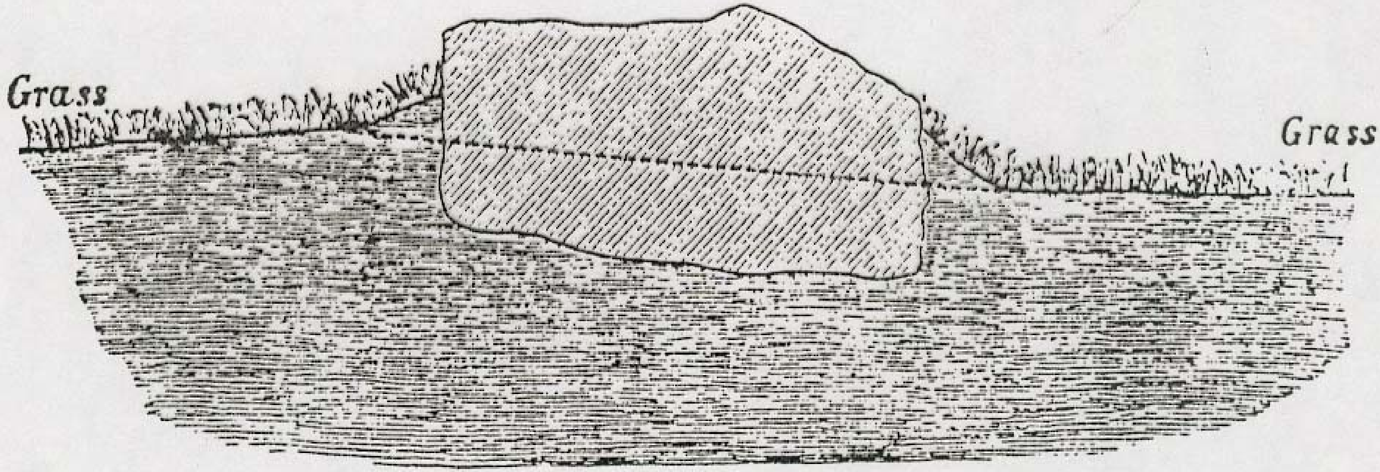


Fig. 26 Illustration showing a section through a fallen Druidical stone at Stonehenge, England, showing depth of burial due to earthworms and accumulation of a sloping fringe of "vegetable mould" around the edges of the stone. The width of the stone illustrated is c. 75 cm. (From Darwin 1881).

Stonehenge
UK

SW WA

- 1905: Hamburg Expedition, Wilhelm Michaelsen (monograph 1907)
- 1931: Ada Jackson
- 1970-1: Barry Jamieson
- 1977+: Ian Abbott, Tom McCredie

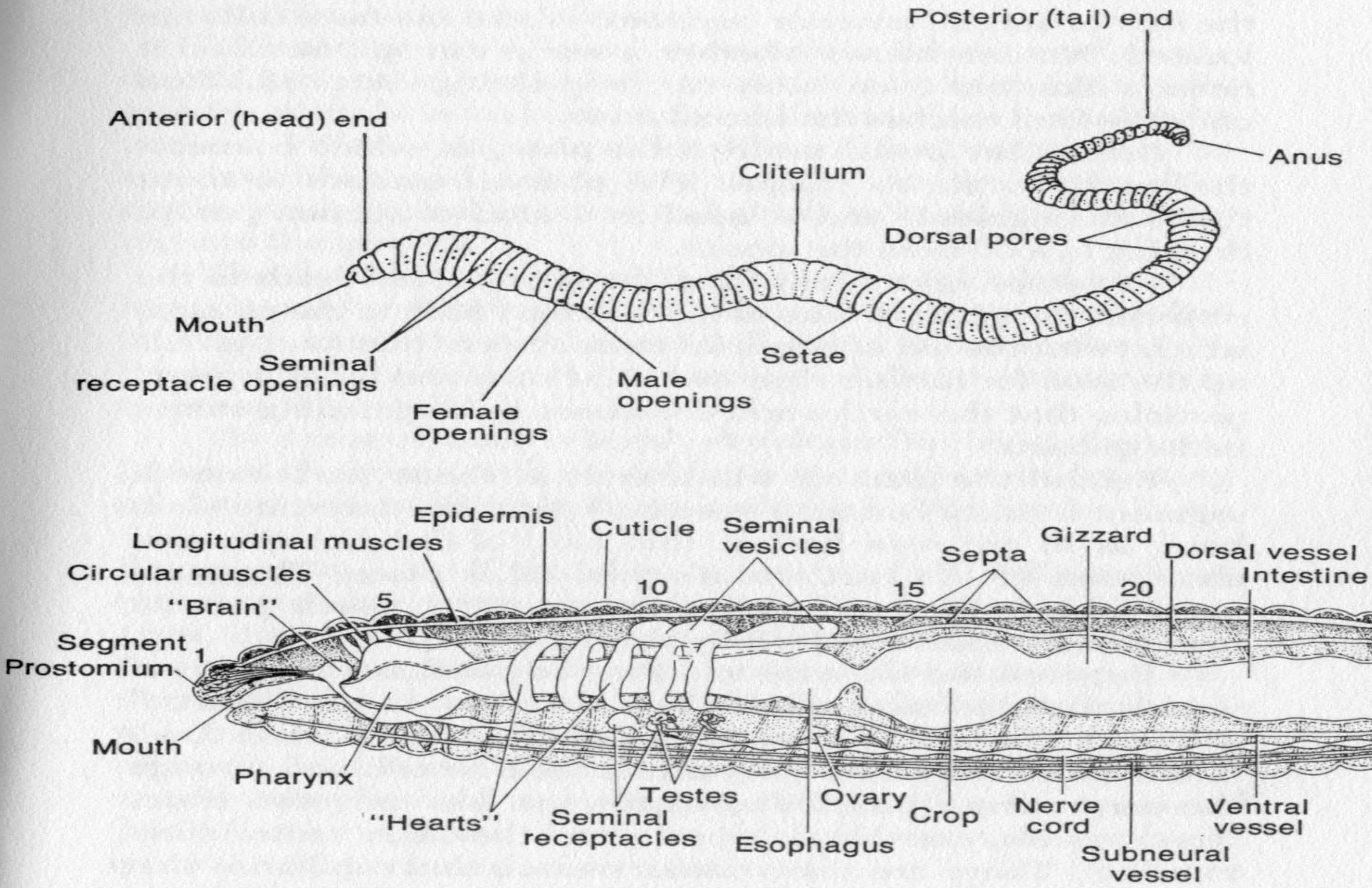
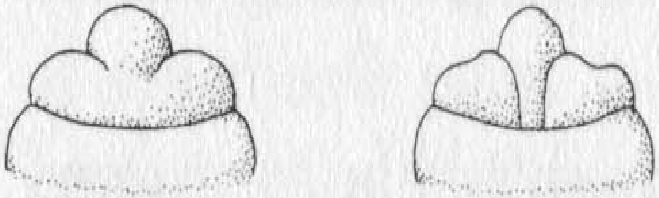


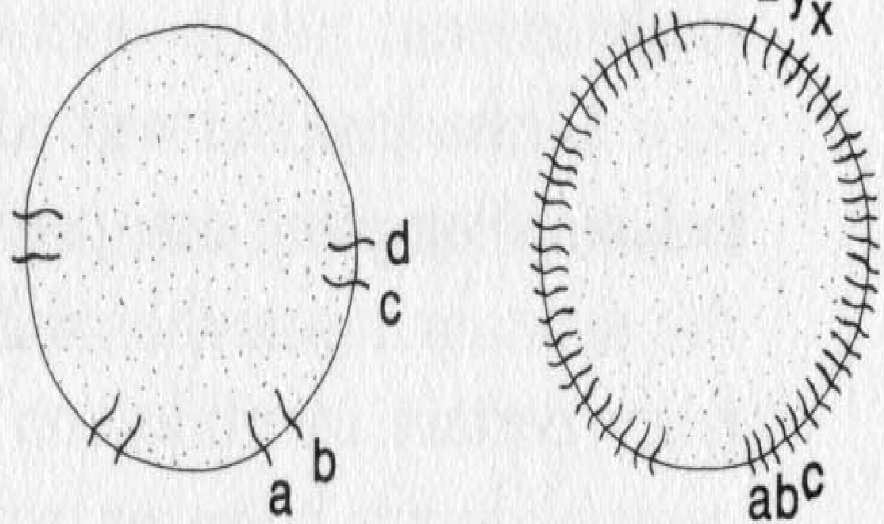
Figure 4 Structure of *Lumbricus terrestris*

Source: After Gaddie, R. E., North American Bait Farms, Inc.



epilobic tanylobic

Anterior end, showing types of prostomium. After Olson.

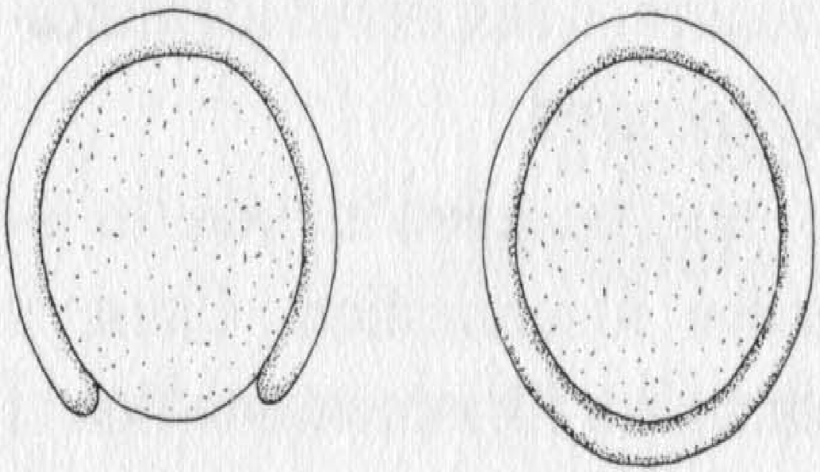


lumbricine perichaetine

Diagram of setal arrangements. After Stephenson.

a,b,c setae lettered from mid-ventral line

z,y,x setae lettered from mid-dorsal line

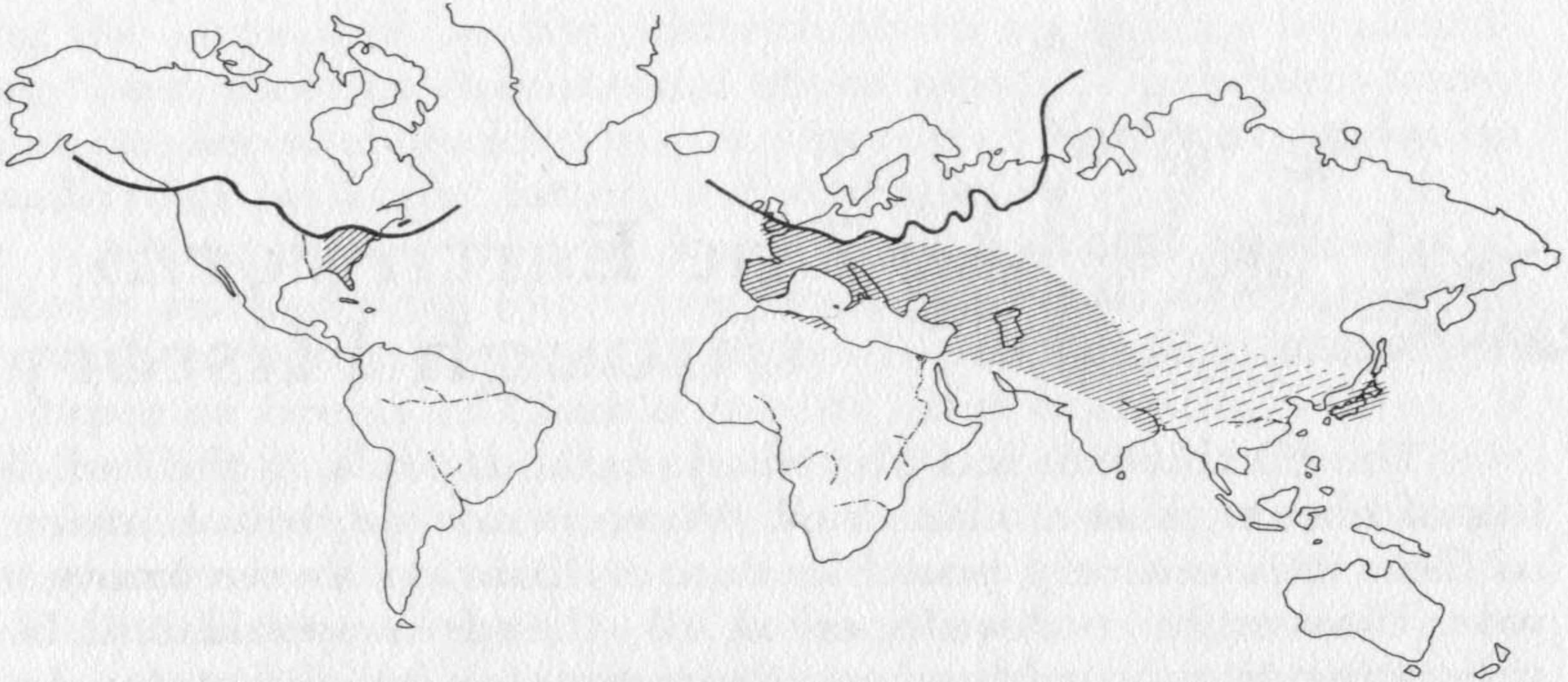


saddle-shaped cingulum

Diagram of types of clitellum.

Fundamental groupings

- **Lumbricidae** (N Hemisphere; some accidentally transported to SH)
- **Megascolecidae** (S Hemisphere - Gondwanan link; a few peregrine)



N.B. (1) The continuous line indicates the maximum advance of the Ice Age.
(2) The closeness of the cross-hatching indicates the degree of populatio[n] by endemic *Lumbricids*.

Figure 5 Distribution of Endemic *Lumbricidae* in the Ice Age (plotted on a present-day geographical map)

Source: Cernosvitov, L., Monographie der Tchechoslovakischen Lumbriciden (Monograph of Czechoslovakian Lumbricids), Prague (1935)

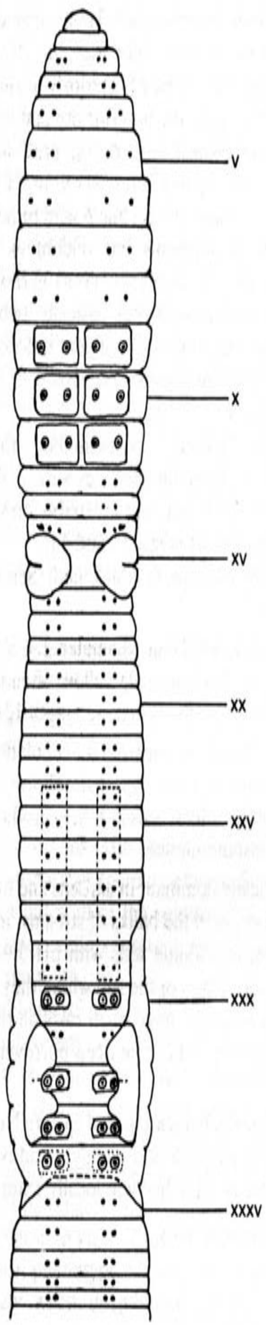


Fig. 14. *Aporrectodea caliginosa.* Ventral view of the anterior region.

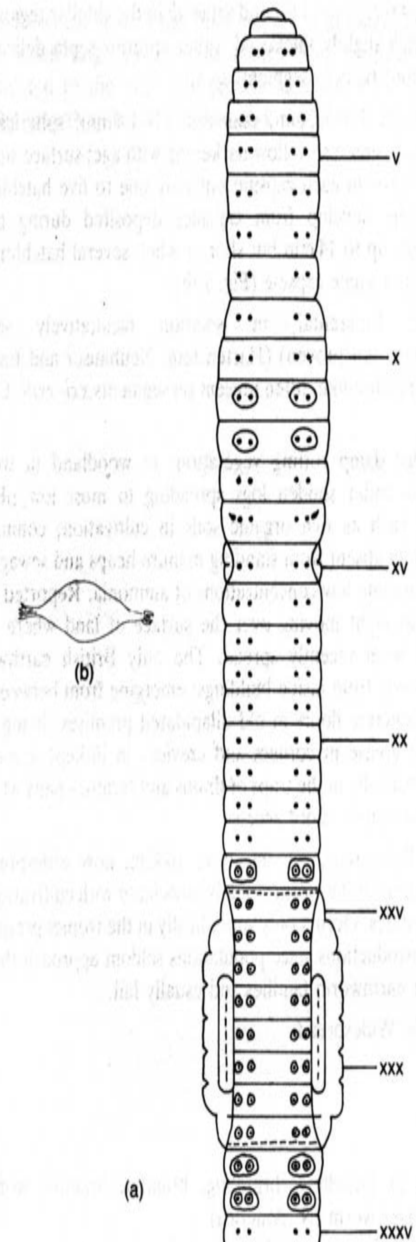


Fig. 26. *Eisenia fetida.* (*a*) ventral view of the anterior region and (*b*) egg capsule.

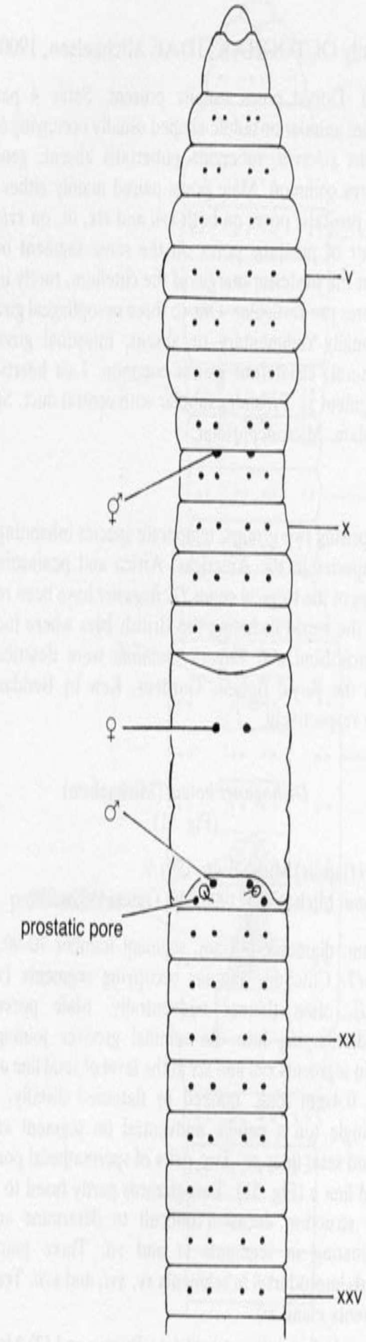


Fig. 50. *Microscolex phosphoreus.* Ventral view of the anterior region.

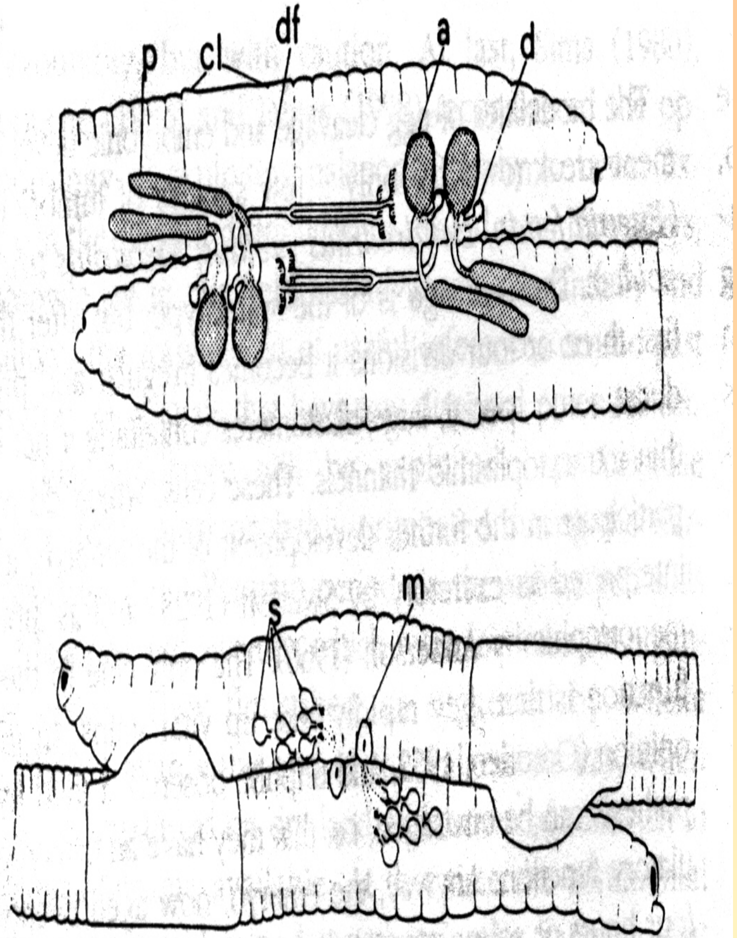


Fig. 3 - In the Lumbricoidea (bottom) only sperm is transferred into the small pyriform spermathecae. In the Megascolecoidea (top) sperm and albumen are transferred together: the albumen (dotted) is introduced in the spermathecal ampullae (a), whereas the sperm goes into the spermathecal diverticula (d). cl, clitellum; df, vas deferens; m, male pore; p prostate; spermathecae.

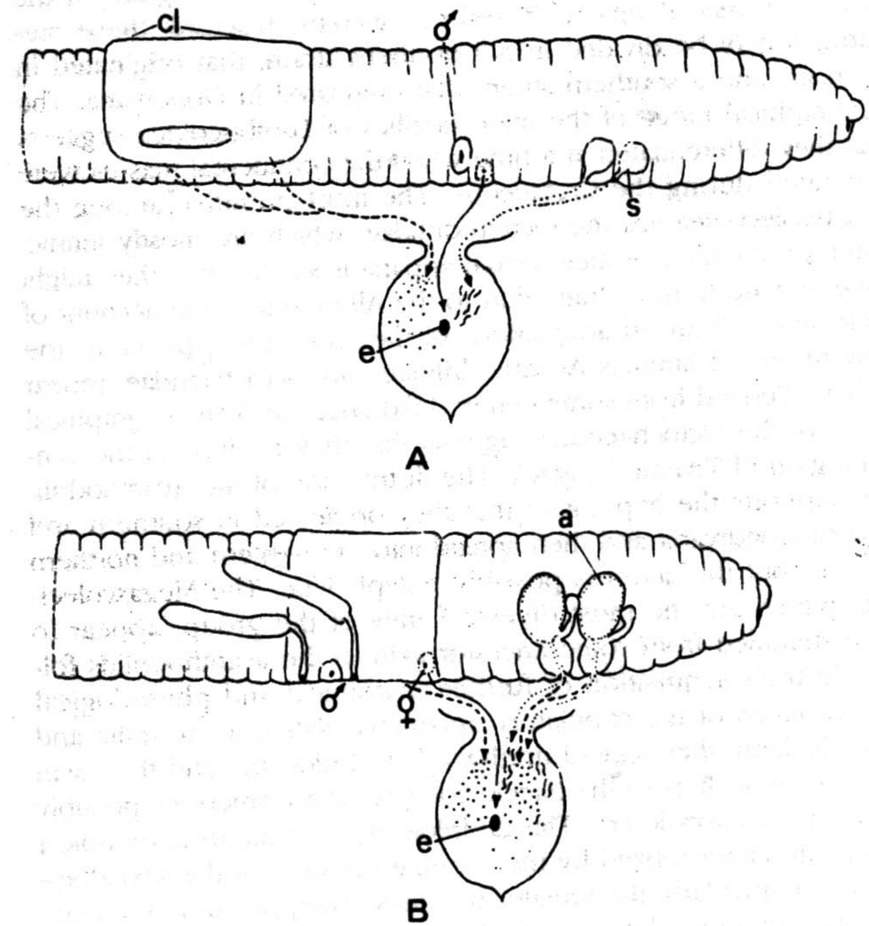
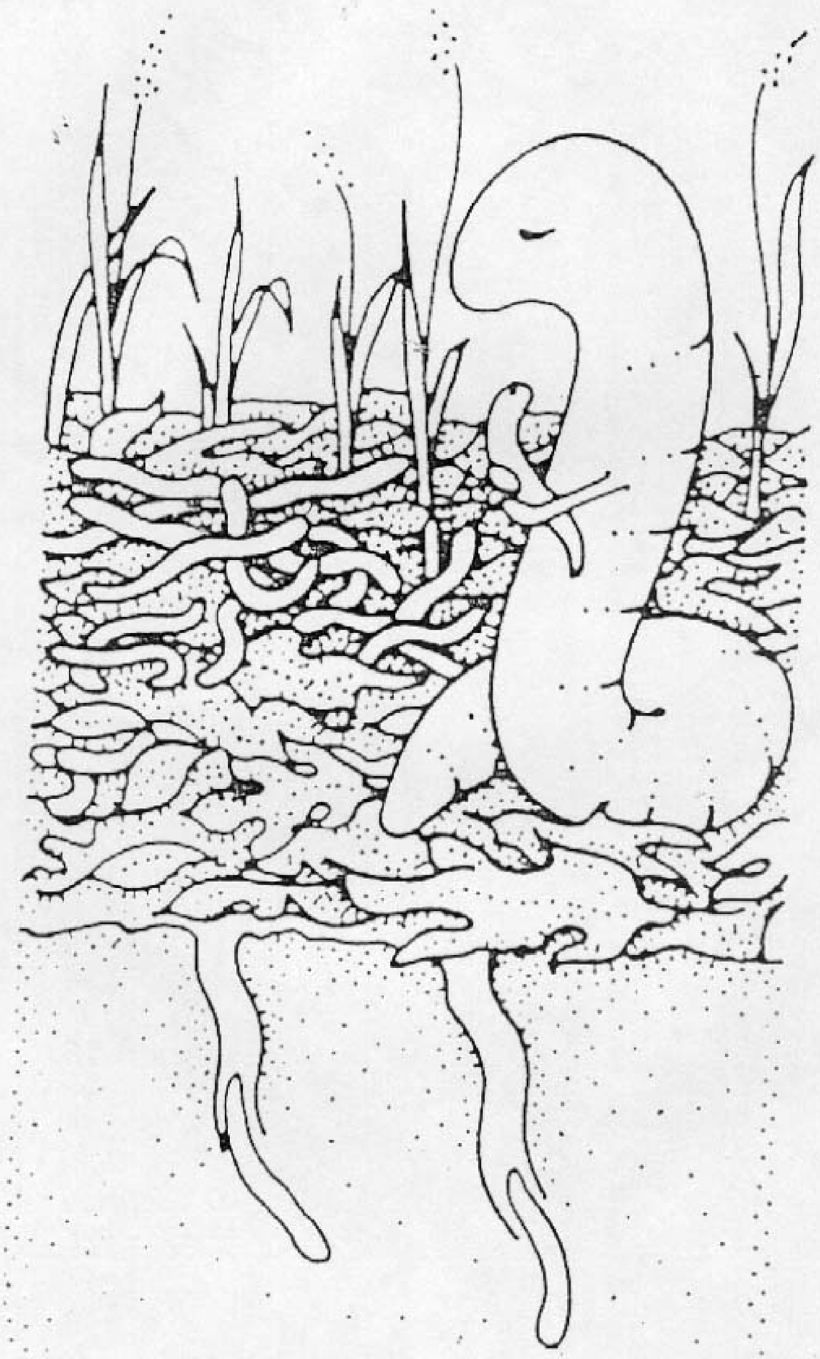


Fig. 1 - Cocoon formation in megadriles: **A**, in the Lumbricoidea, the albumen produced by the clitellum is transferred (dashed lines) into the cocoon along with the sperm stored in the spermathecae and the eggs; **B**, in the Megascolecoidea, the albumen produced by the clitellum together with that deposited in the spermathecal ampullae is introduced (dashed lines) in the cocoon with the egg(s) and the sperm contained in the spermathecal diverticula (dotted line). a, spermathecal ampulla; cl, clitellum; e, egg; s, spermatheca.



Earthworms affect all three components of soil fertility

Physical: improve soil structure

Chemical: increase incorporation of organic matter

Biological: redistribute spores of fungi (e.g. mycorrhizal fungi, plant pathogens)

Life cycle of earthworms:

- require moisture;
- organic matter (especially N);
- survive adverse conditions in surface as cocoons or aestivate at depth

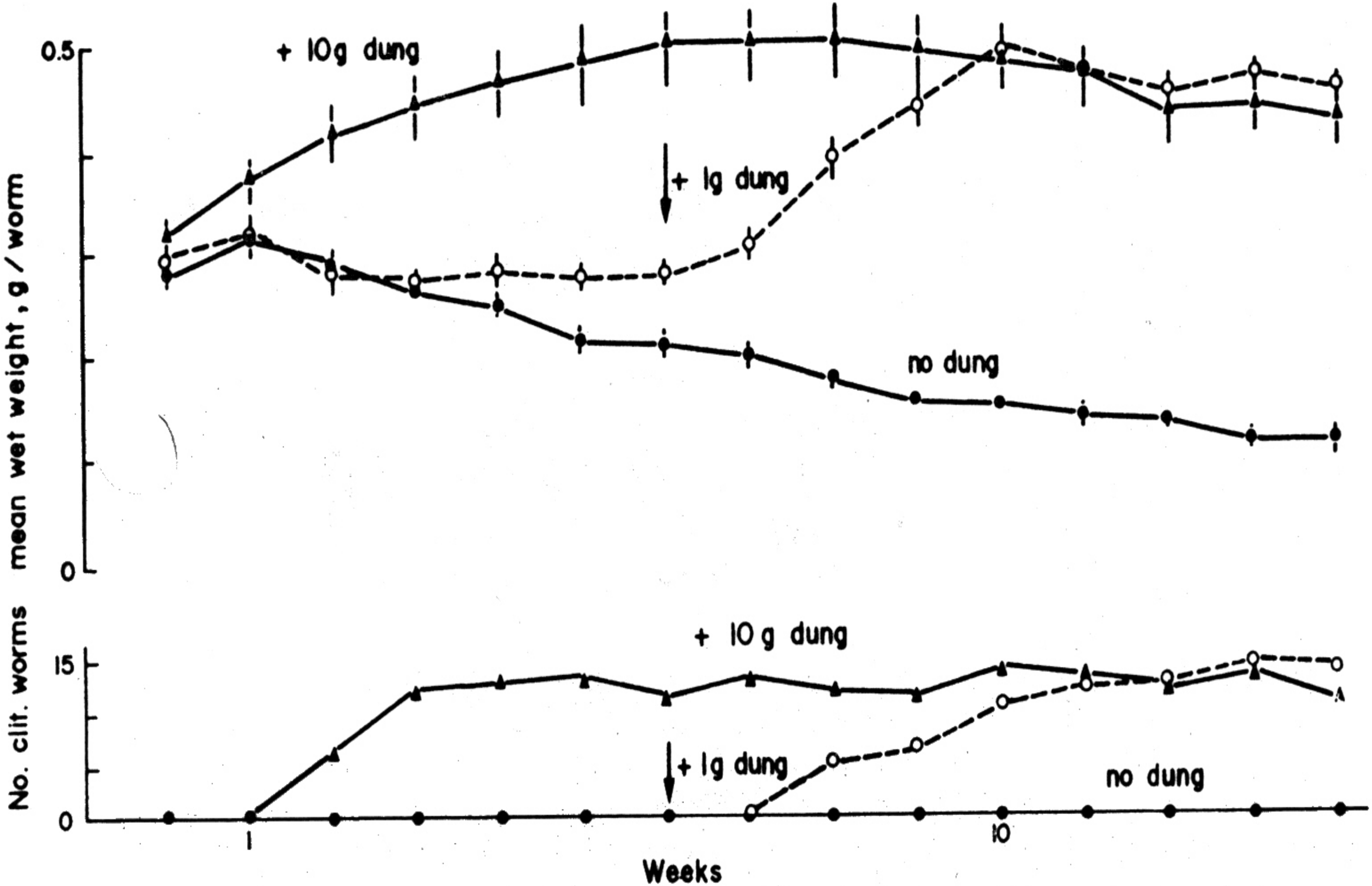


Fig. 1. Effect of food quantity on changes in body weight and reproductive condition of *Eisenia foetida*. Arrow indicates that 9 g of dung was added to the treatment with 1 g of dung at week 6. Standard errors of the means are shown as vertical bars.

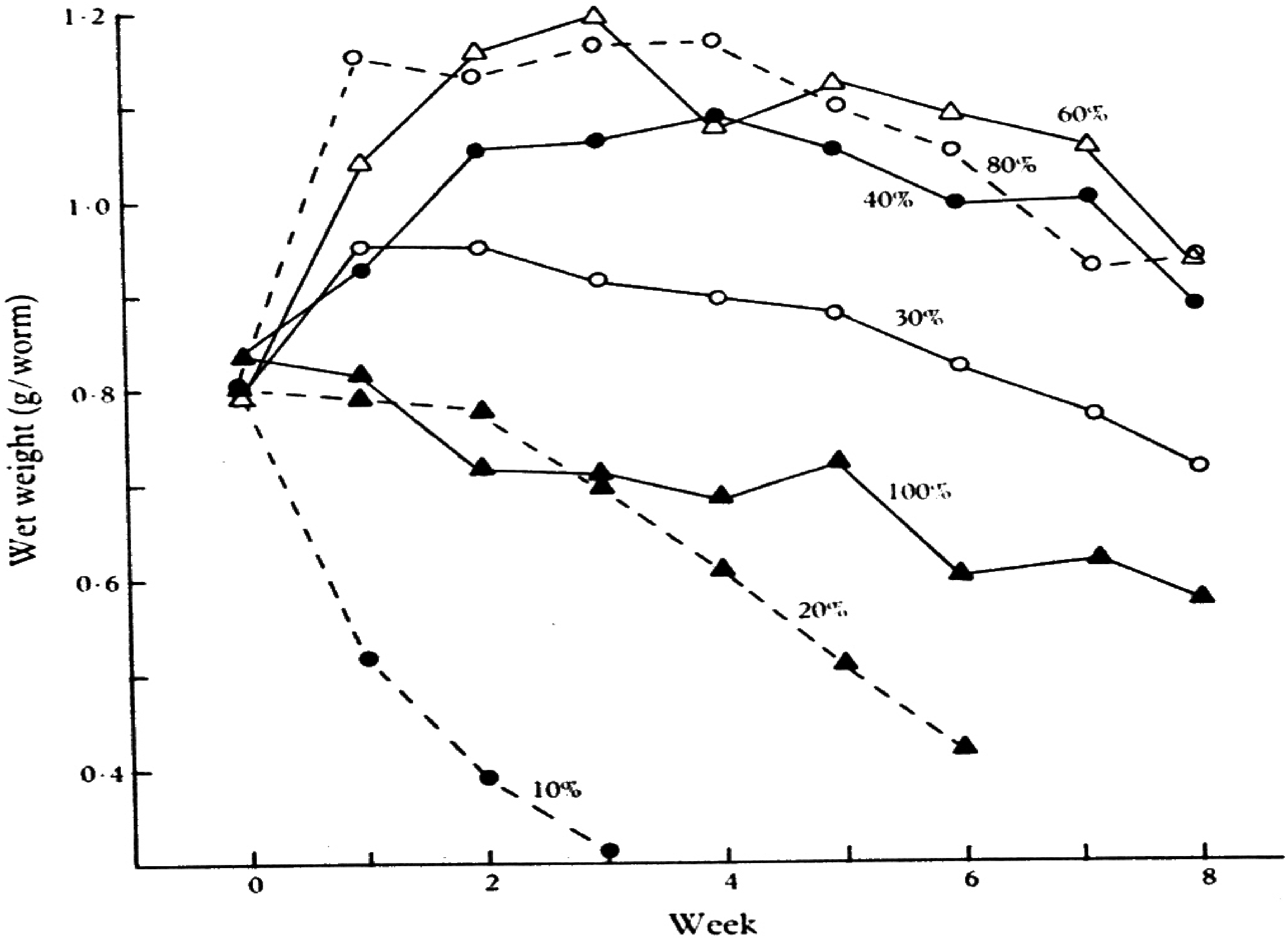


Fig. 5. Effect of soil moisture level on growth and survival of *Allolobophora trapezoides* in the same soil as in Fig. 4 (experiment 4).

Biological ploughs

- Earthworms can disturb soil
- Earthworms can be affected by processes that disturb soil

- seasonal changes in abundance
- burrows - distinctive for different species
- e/w have high requirement for nitrogen (i.e. require OM with high %N)
- e/w casts have higher nutrient status than bulk soil
- e/w increase soil aggregation & infiltration

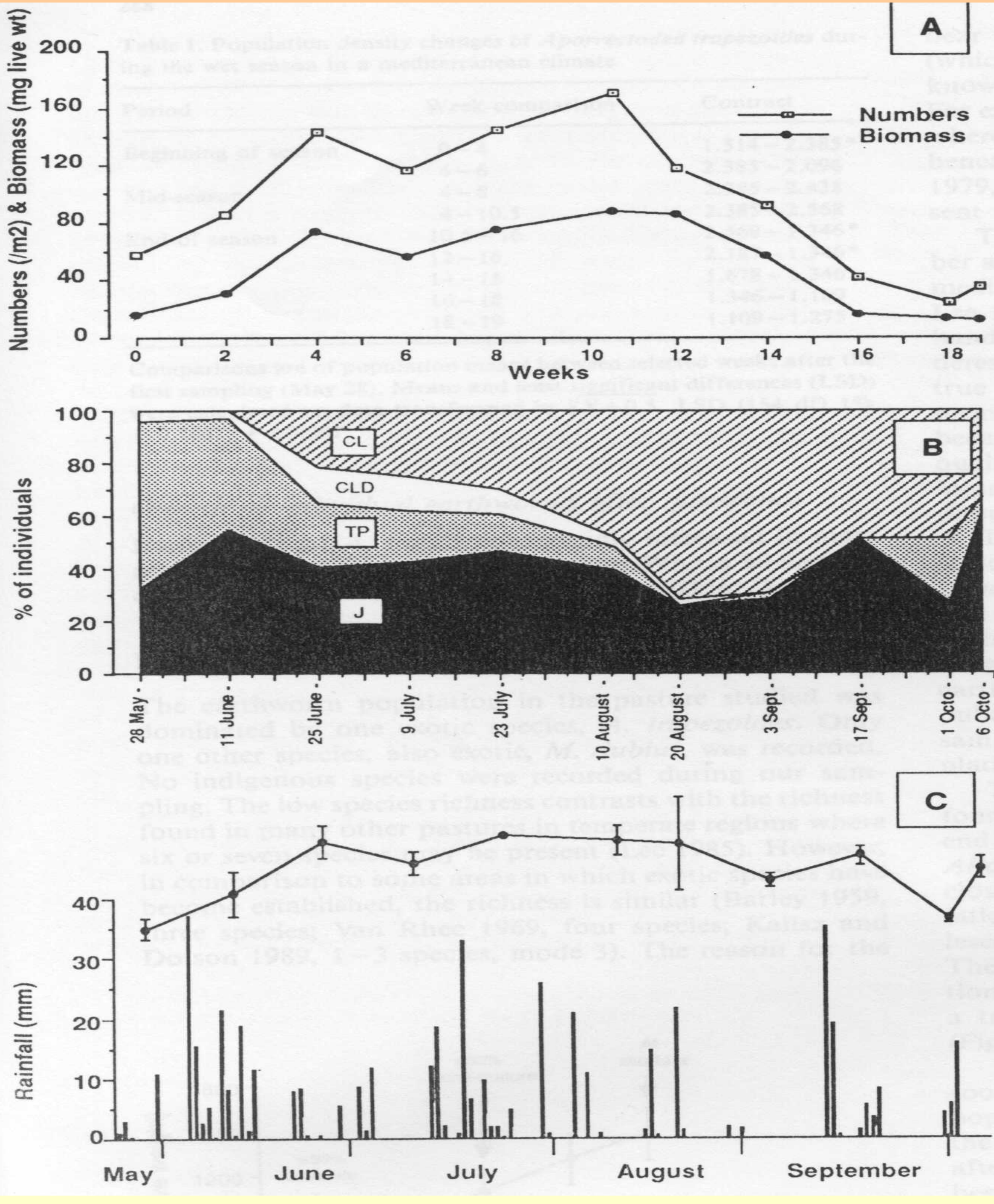
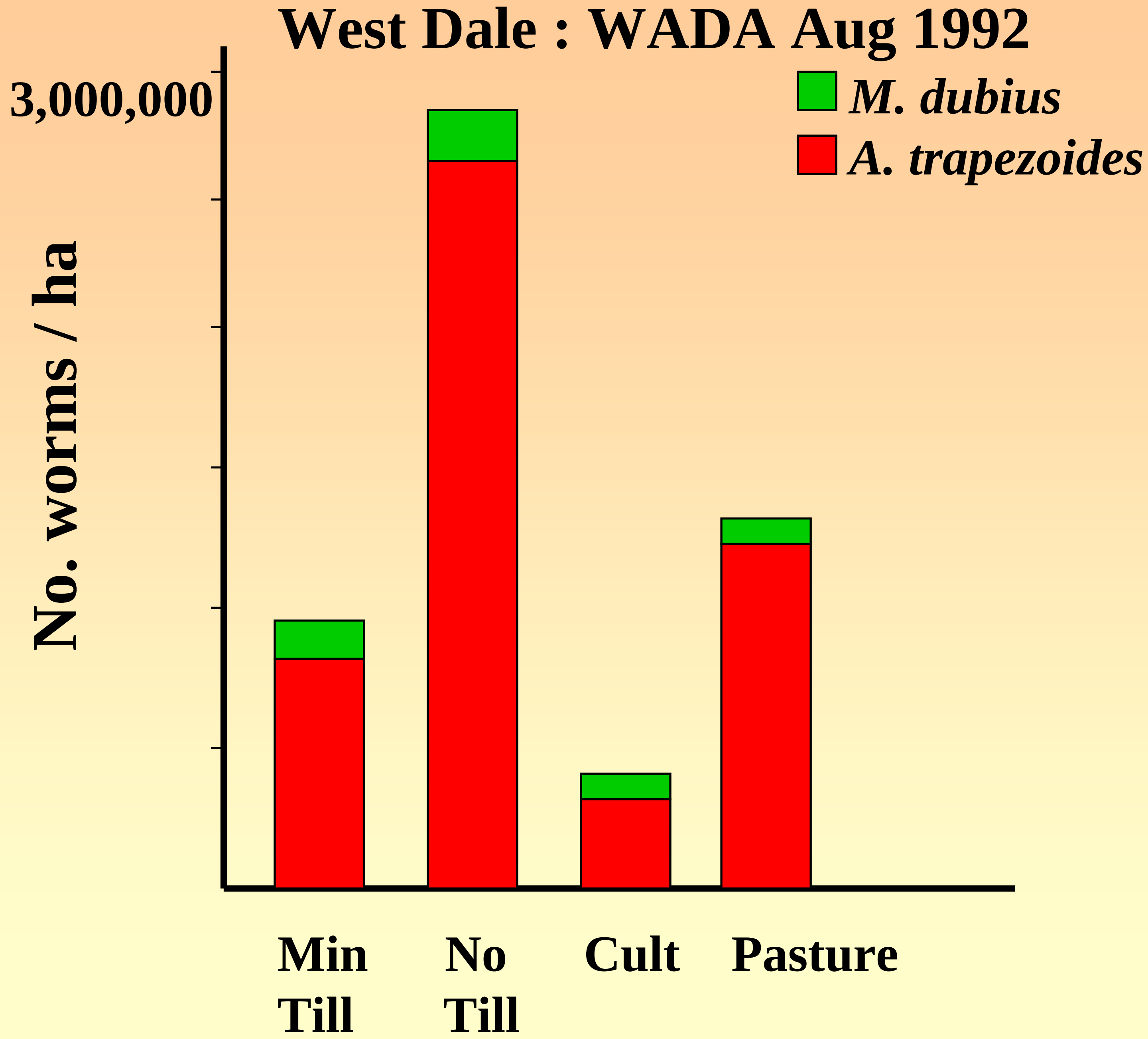


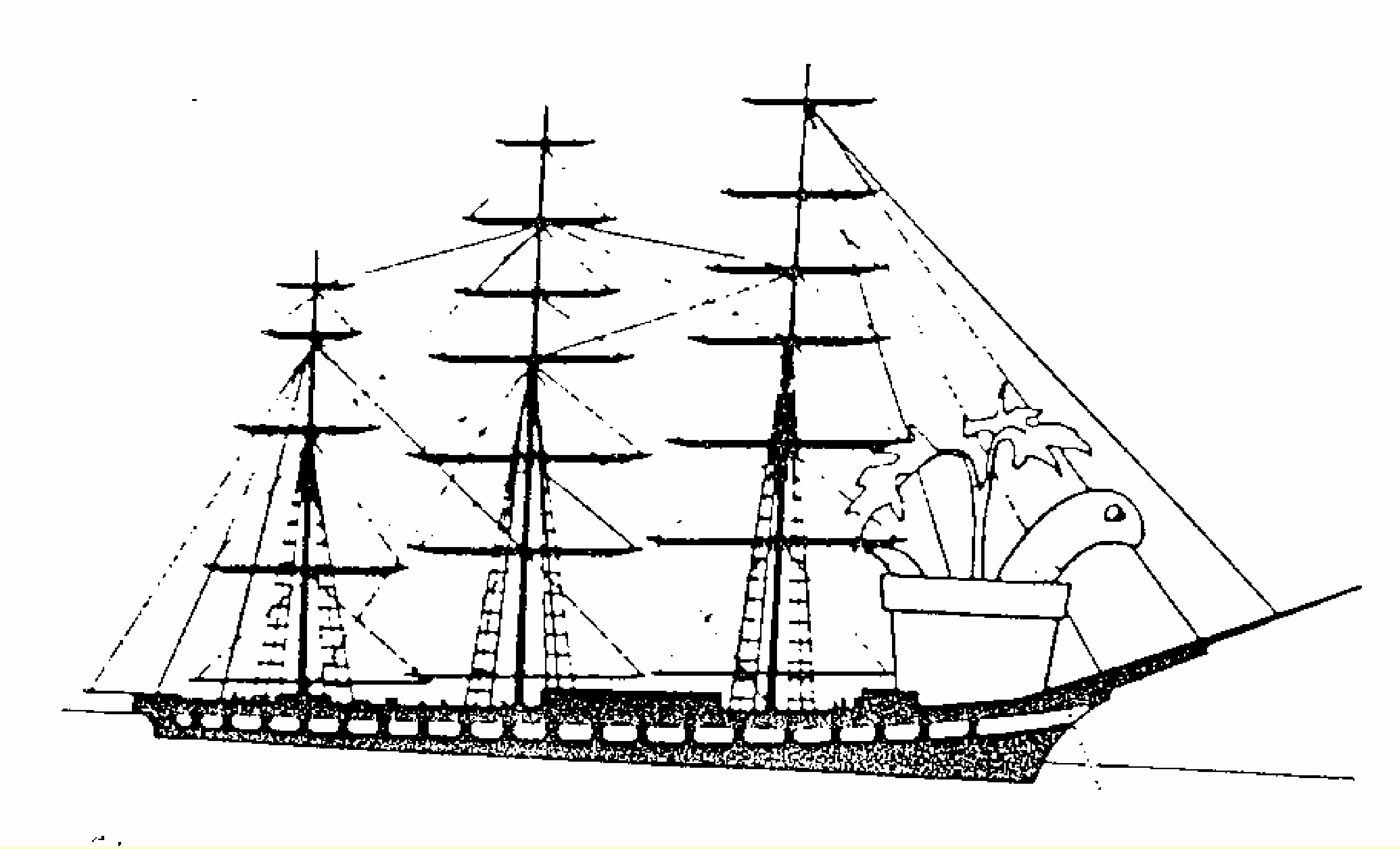
Fig. 1A–C. Changes in the population structure of *Aporrectodea trapezoides* throughout the wet season of a mediterranean climate. (A) Population size and biomass (see Table 1 for significance); (B) population age structure; *J*, juveniles; *TP*, tubercula pubertatis present; *CLD*, clitellum developing; *CL*, clitellum turgid; (C) rainfall (bars) and soil water (*bars* indicate standard errors)

Table 1. Presence/absence of earthworms in sites sampled in the Western Australian wheat-belt, August 1979

Site	No. of sites where earthworms Present	Absent	% occurrence by site
Pasture	29	25	54
Cultivated	6	28	18
Garden	18	0	100
Virgin	3	10	23


West Dale : WADA Aug 1992
3,000,000
No. worms / ha
M. dubius
A. trapezoides
Min Till
No Till
Cult
Pasture

Accidental importation of earthworms into Australia



Earthworms in SW WA

Main species present in agricultural soils:

Microscolex dubius
Aporrectodea trapezoides

Megascolex imparicystis (NATIVE species)

In undisturbed soils:

Generally small indigenous species present

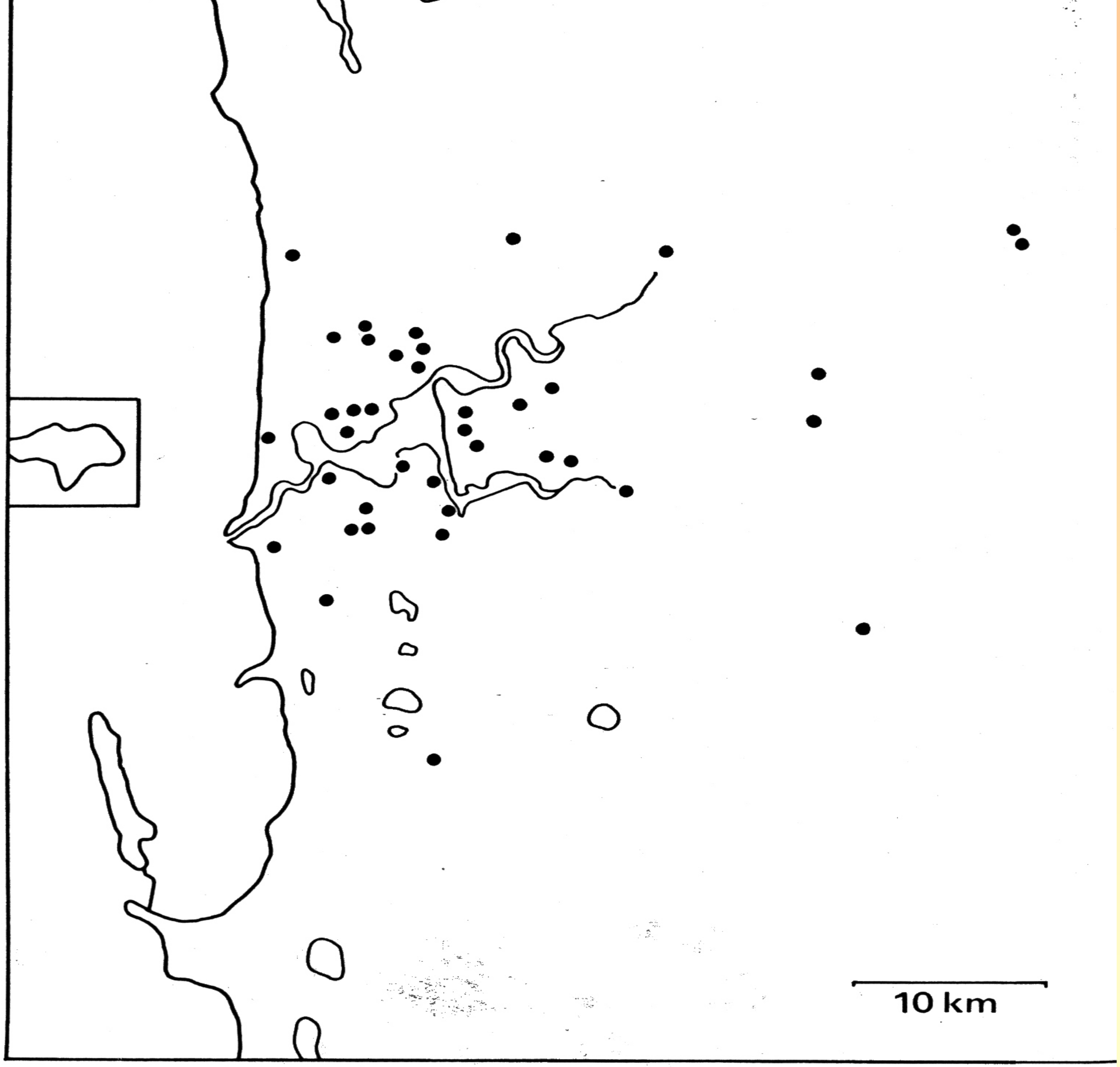


Figure 3 Known distribution in 1977-79 of *Eisenia fetida* in Perth metropolitan area.

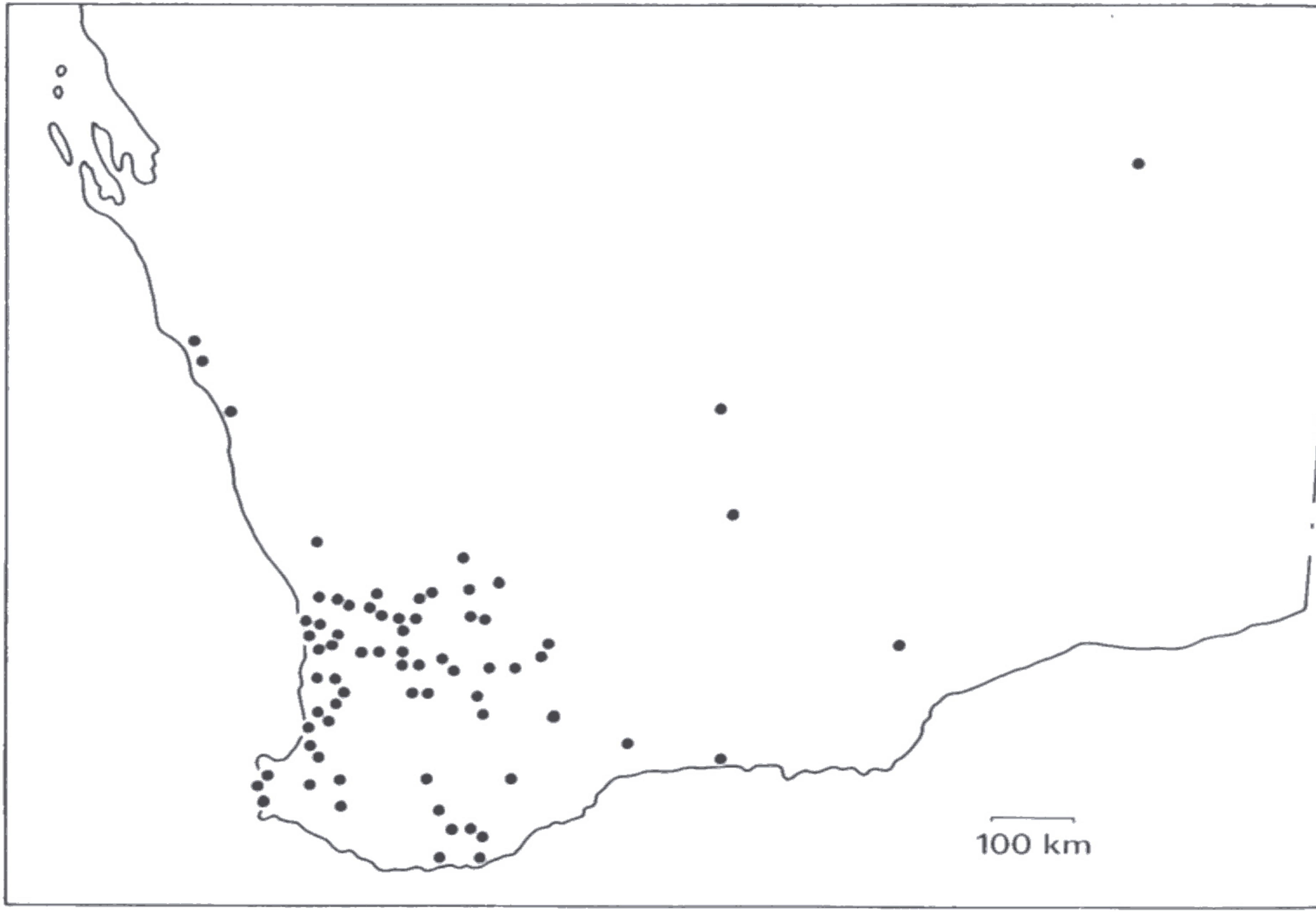


Figure 10 Known distribution of *Aporrectodea trapezoides* in temperate Western Australia (b
on all records available).

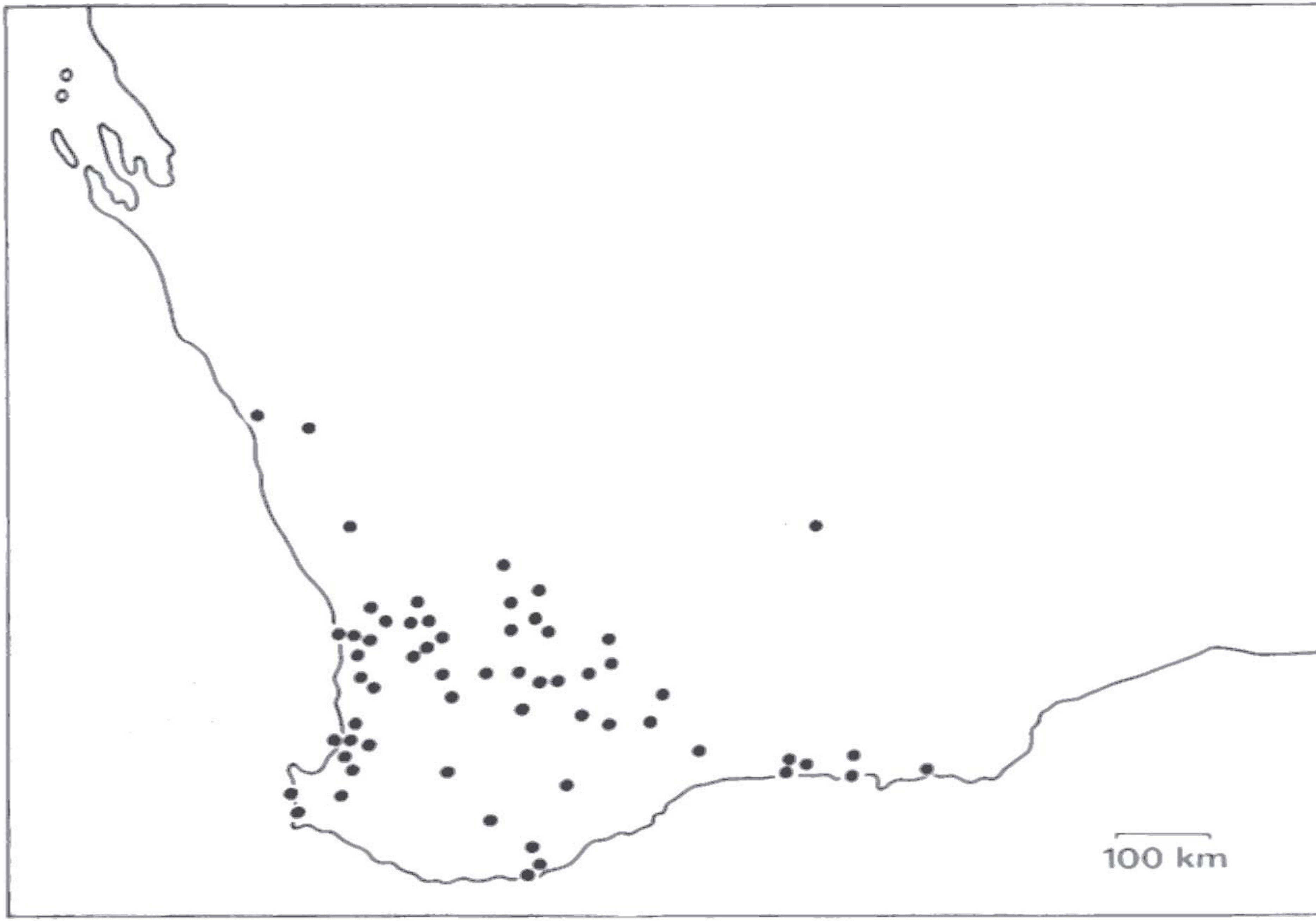


Figure 11 Known distribution of *Microscolex dubius* in temperate Western Australia
records available).

How many species of Oligochaeta?

- World: ?3000 spp
- Europe: 80 spp
- Australia: 350 native spp named
- Tasmania: 228 native + 23 exotic spp
- SW WA: 30 spp named
- Perth region: 21 native +7 exotic spp
- Porongurup Range: 11 native + 2 exotic spp

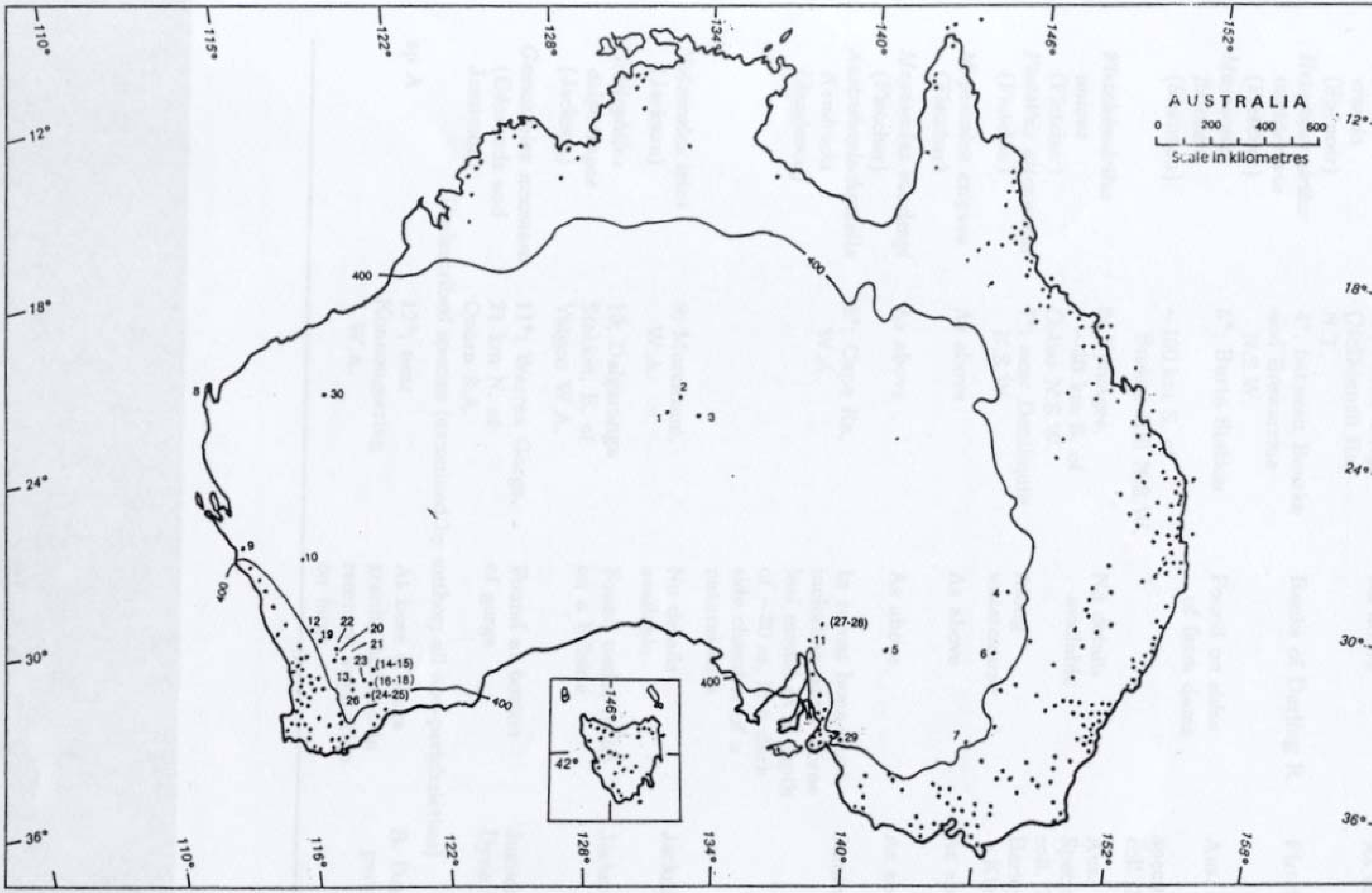
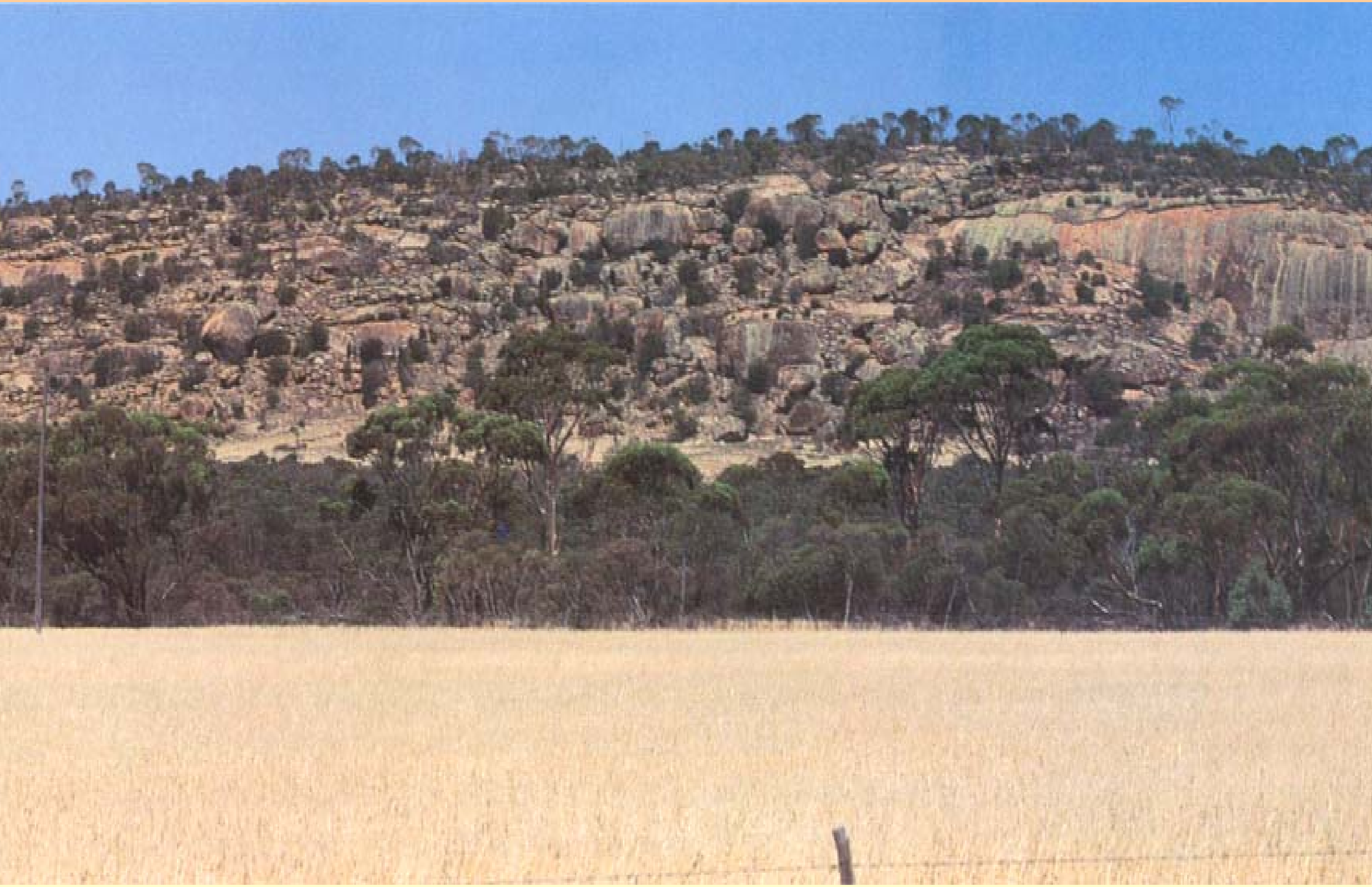


Fig. 1. Map of Australia showing the distribution of native earthworms. The position of the 400 mm median annual rainfall isoline is also shown. Localities numbered 1–30 are considered in more detail in Table 1.



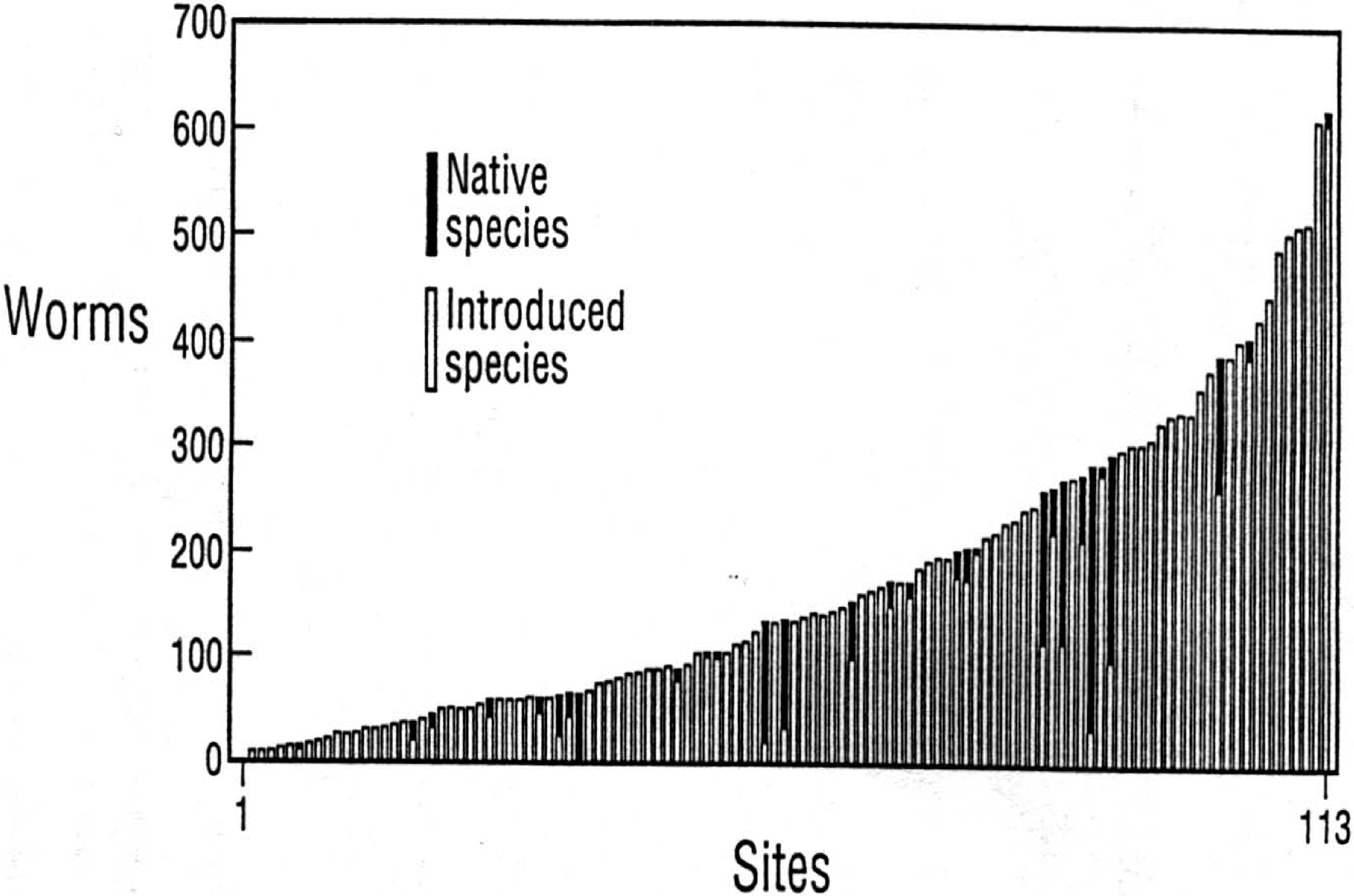


Fig. 2. Numbers of introduced (□) and native (■) earthworms (m^{-2}) recorded in 113 pastures in the Mount Lofty Ranges. The sites are ranked in order from those with least earthworms ($0\ m^{-2}$) to those with most ($608\ m^{-2}$).

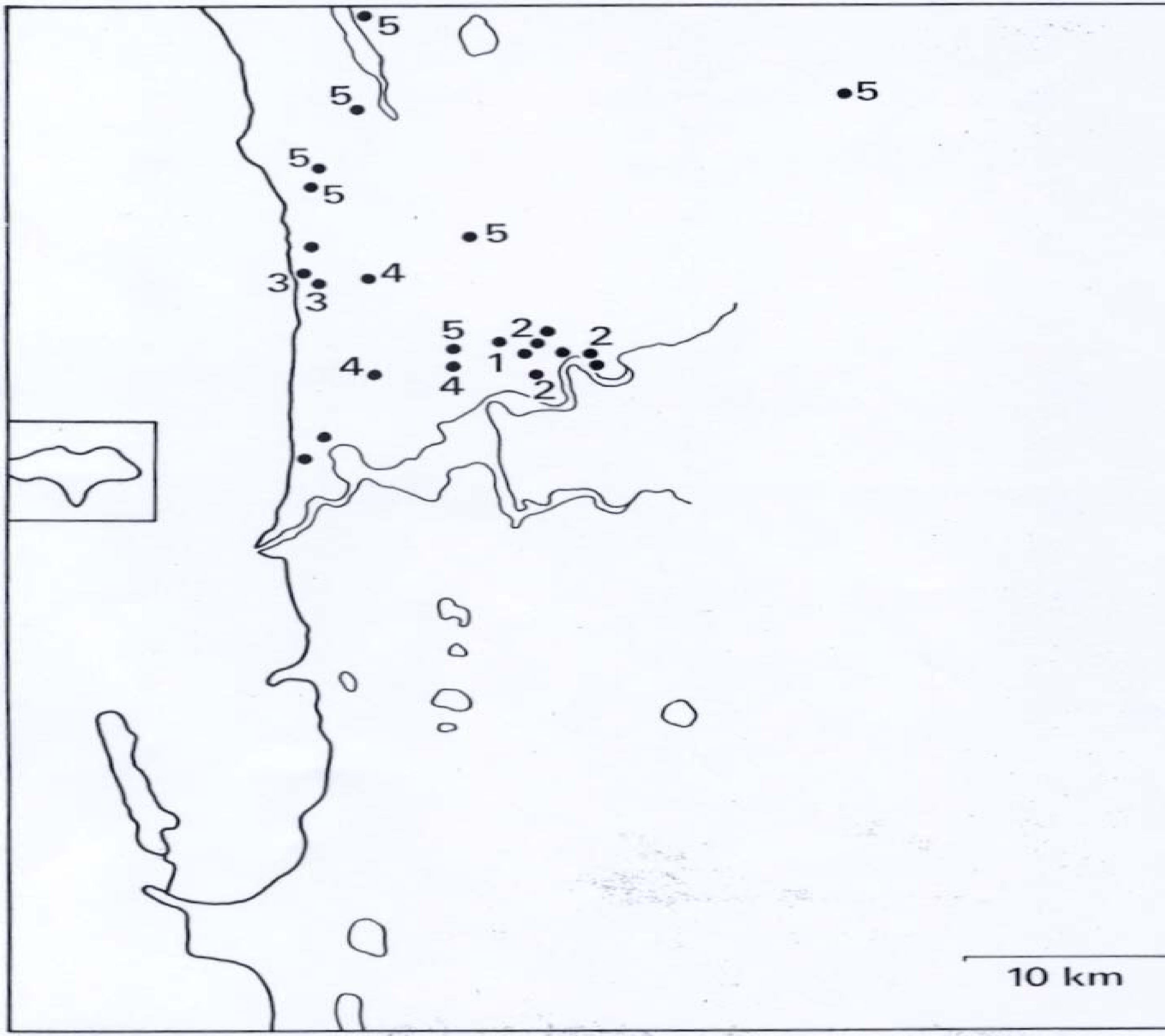


Figure 6 Known distribution of *Megascolex imparicystis*, coded by decades: 1 = 1920s, […] 3 = 1950s, 4 = 1960s, 5 = 1970s. (Most records from specimens in Western […] Museum.)

Megascolex imparicystis, Karakin

Land use	Biomass (kg ha^{-1})	
	1981	1982
Kwongan	0	0
Recently cleared	0	0
Pasture	410	670
Recently ploughed	360	130

Northern jarrah forest study - methods

- 23 stands sampled 1980-3
- 50 soil cubes searched (19 x 19 x 15 cm^3)
- 8 site characteristics recorded
- 12 soil properties measured
- 4 earthworm characteristics

Northern jarrah forest study - results

- No. of Spp = 0.006 AAR - 1.90 (R^2 = 0.75)
- Frequency = 0.07 AAR - 0.82 basal area - 4.31 years since fire - 14.17 (R^2 = 0.74)
- Biomass = 0.003 AAR + 0.13 (silt + clay) - 3.25 (R^2 = 0.78)
- Density = -22.22 pH + 0.03 AAR -1.17 coarse sand + 189.63 (R^2 = 0.82)

Northern jarrah forest study - results 2

When regression analyses repeated using only the 12 soil factors:

- No. spp: -K, -CS, -G (0.72)
- Frequency: -pH, -K, S+Cl, -CS, C (0.75)
- Biomass: -K, S+Cl (0.70)
- Density: -pH, -K, -CS, -FS (0.76)

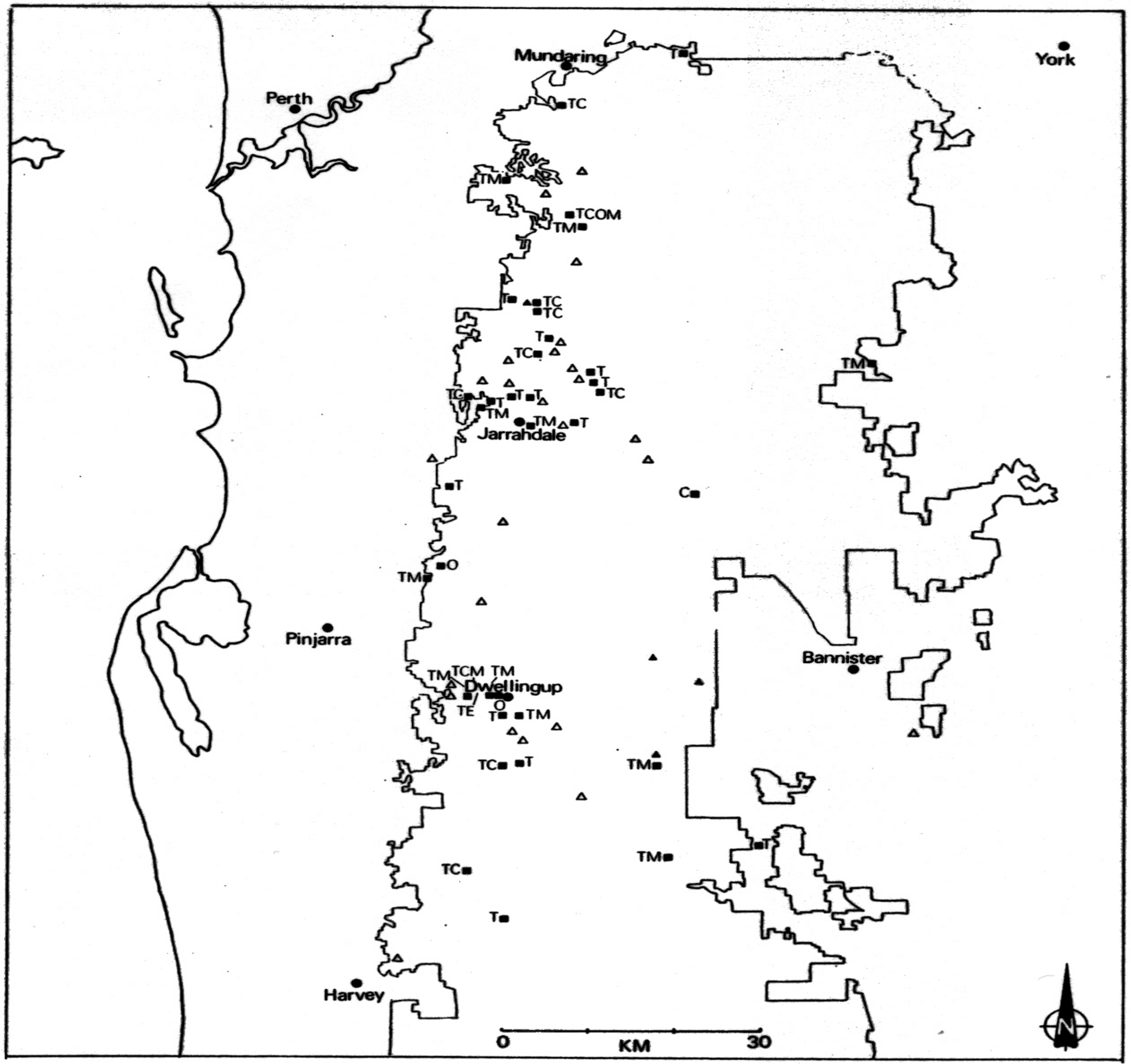


Fig. 1. Known occurrence of introduced species of earthworms in the northern jarrah forest. The location of all disturbed sites that were searched is shown.
KEY: ■T *Aporrectodea trapezoides*; ■M *Microscolex dubius*; ■C *A. caliginosa*; △ Indigenous species only; ■O *Octolasion cyaneum*; ▲ none collected; ■E *Eisenia fetida*.

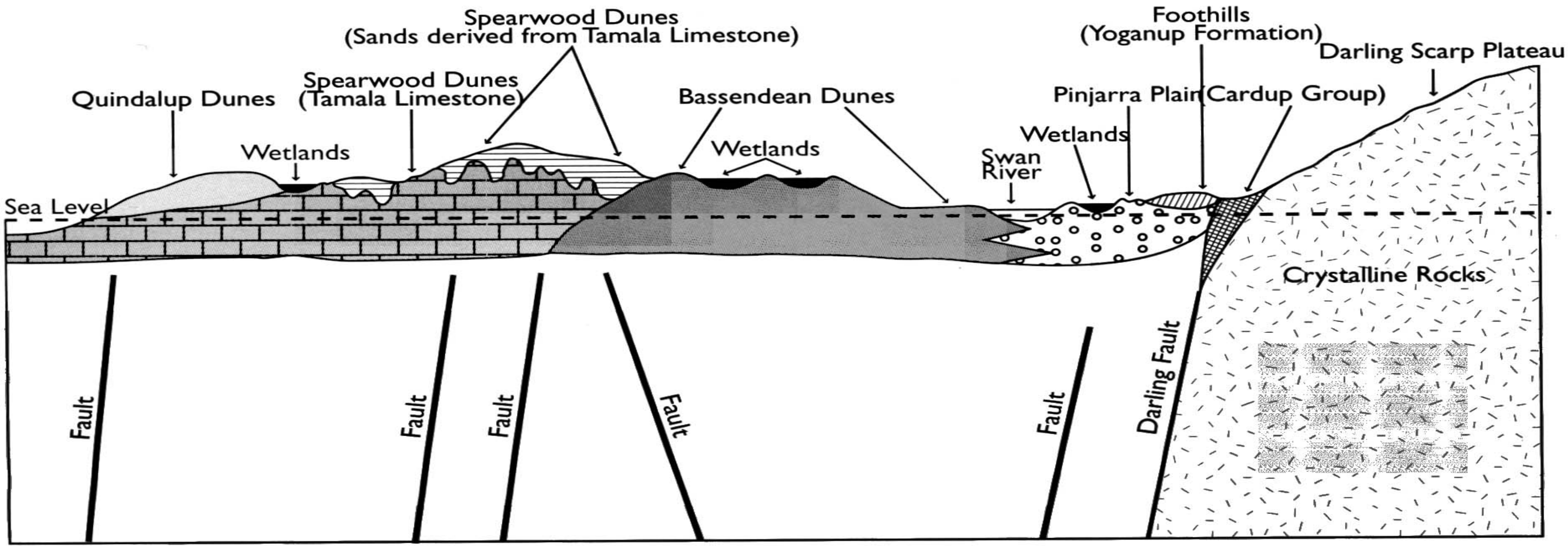


Figure 1: A cross section of the PMR showing the major landform elements

A 'typical' transect of the major geomorphological systems of the Swan Coastal Plain after McArthur and Bettenay (1960) followed by major geological systems after Playford et al. 1976

Foothills (Ridge Hill Shelf)

- Yoganup Formation
- Cardup Group

Bassendean Dunes

- Bassendean Sand

Pinjarra Plain

- Guildford Formation

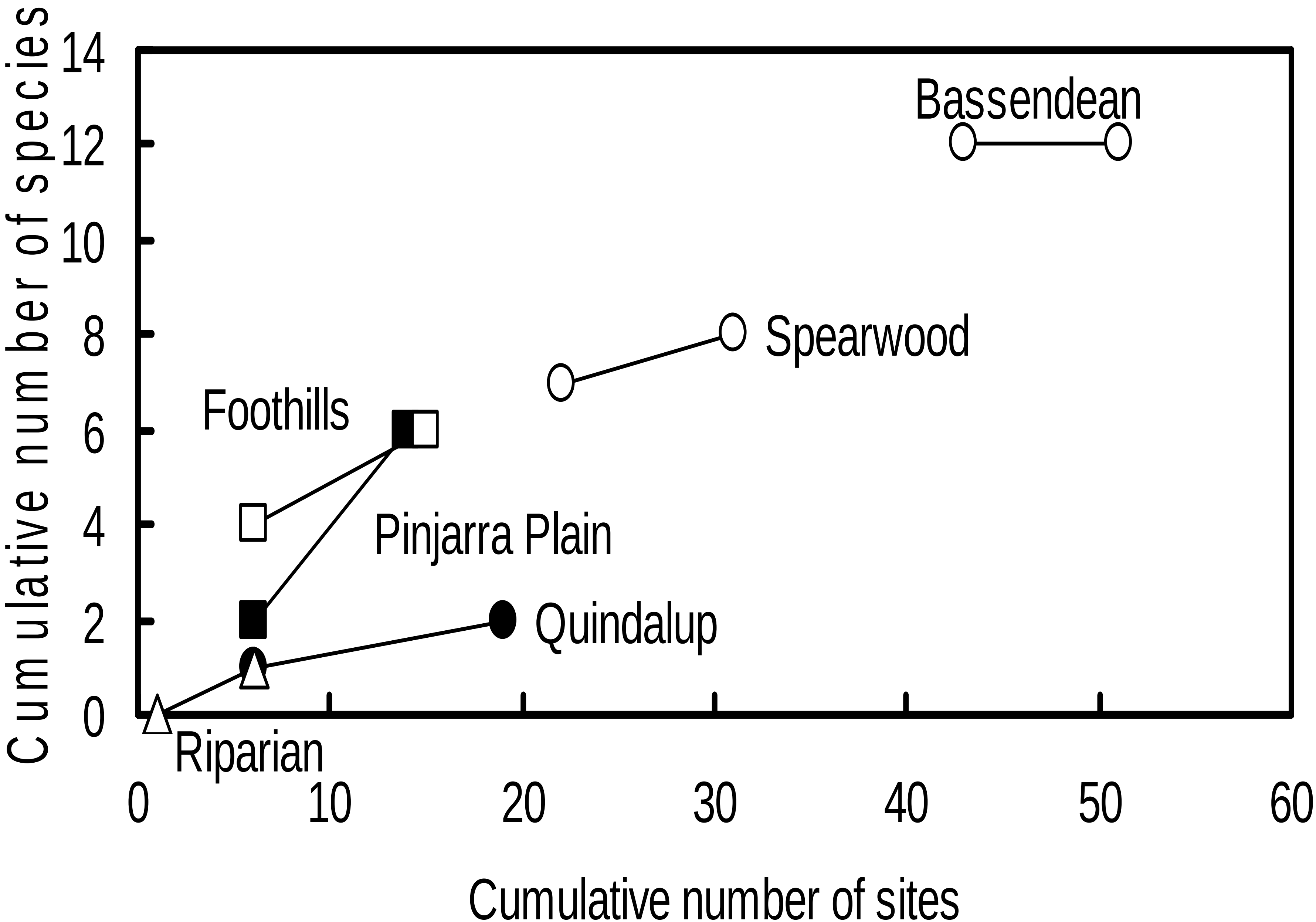
Spearwood Dunes

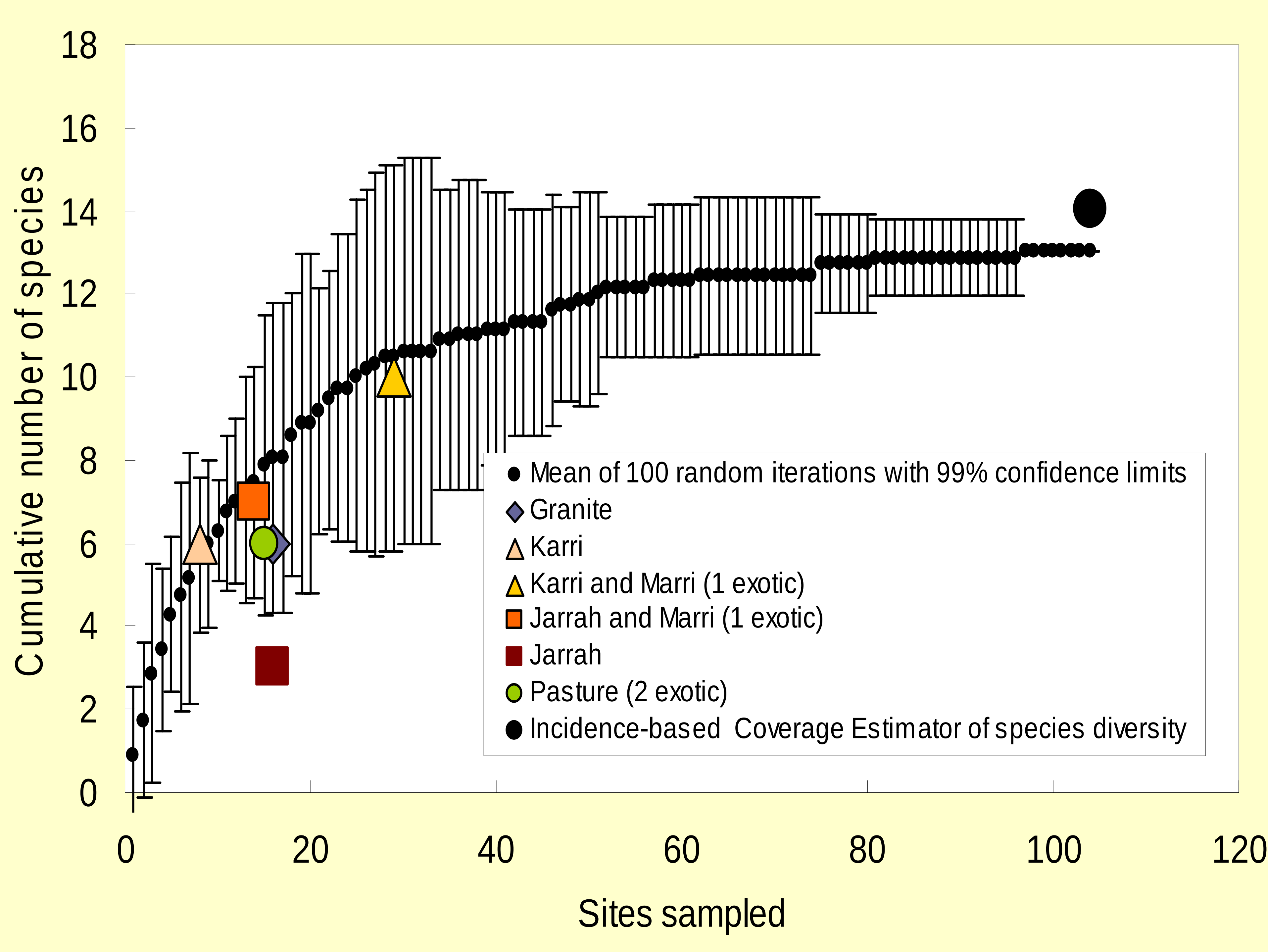
- Tamala Limestones
- Sands derived from Tamala Limestones

Quindalup Dunes

- Safety Bay Sands

Adapted with permission from Fact Sheet 15. The Geology of Perth.
Department of Minerals and Energy, Western Australia.


Cumulative number of species
14
12
10
8
6
4
2
0
Bassendean
Spearwood
Foothills
Pinjarra Plain
Quindalup
Riparian
0
10
20
30
40
50
60
Cumulative number of sites



18
16
14
12
10
8
6
4
2
0
Cumulative number of species
0
20
40
60
80
100
120
Sites sampled
Mean of 100 random iterations with 99% confidence limits
Granite
Karri
Karri and Marri (1 exotic)
Jarrah and Marri (1 exotic)
Jarrah
Pasture (2 exotic)
Incidence-based Coverage Estimator of species diversity

PUNCH'S ALMANACK FOR 1882. [December 6, 1881.

MAN · IS · BVT · A · WORM ·

Frontispiece Cartoon from *Punch*, December 6th, 1881