Alien earthworms in the Asia/Pacific region with a checklist of species and the first records of *Eukerria saltensis* (Oligochaeta : Ocnerodrilidae) and *Eiseniella tetraedra* (Lumbricidae) from Japan, and *Pontoscolex corethrurus* (Glossoscolecidae) from Okinawa

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Abstract Of the 80 or so earthworms in Japan (including Ryukyus) approximately 50% are alien species that were most likely introduced inadvertently by human activities. This diversity compares with about 93 species found in Korea (25% alien), 71 species in Taiwan (38% alien), and 152 from mainland China (26% alien). In comparison, 715 species are known from Australia (ca. 10% alien) including 230 from Tasmania (ca. 11% alien), and New Zealand has 199 species (ca. 14% alien). Australia, Tasmania and New Zealand have relatively low numbers of aliens; the latter two regions are especially similar with 60-67% of their aliens being Lumbricidae of direct or indirect European/Middle-eastern origin. Mainland Japan and the Ryukyus, Taiwan, Southeast Asia and southern China are similar with most of the ca. 26-65% aliens due to exchanges of Oriental pheretimoids (species ex *Pheretima* auct.). North America is intermediate yet more varied: one third of its 180 species are non-native of which about half are Lumbricidae. Biodiversity differences for natives are accounted for by geological histories (e.g. plate tectonics, volcanism, glaciation) and by topographic and climatic factors, whereas distribution of the aliens echo patterns of human migration and trade and, overall, appreciation of both groups is determined by the intensity of taxonomic treatment. Newly reported from Japan are the semi-aquatic *Eiseniella tetraedra* (Savigny, 1826) and *Eukerria saltensis* (Beddard, 1895), and from Okinawa the circum-tropical *Pontoscolex corethrurus* (Müller, 1856). Both latter species originate from South America. *Eukerria saltensis* is considered a pest in Australian rice paddies but despite discovery in drains at Kamakura and a river in Tokyo, it is not known under Japanese rice and its risk here is as yet unquantified.

Keywords: Australasia; America; exotic species diversity; *Pheretima*; lumbricids.

SPECIES COMPOSITIONS

Earthworms are an ancient group with generally weak means of dispersal, thus Family origins are partly determined by plate tectonics (e.g. Michaelsen 1922, from Lee 1994) (see Tab. 1 and Appendix 1). The degree of endemism depends on the geological history and current climate of the region as well as the intensity of glaciations and/or volcanism, whereas the present-day distribution of aliens is strongly influenced by recent, historical and pre-historical human trade and migrations before quarantine barriers were implemented (Stephenson 1930, Gates 1972, Easton 1981, Lee 1987, Blakemore 1999). The adult worms, or their cocoons, can be easily transported in soil of potted-plants (Gates 1972). Australia and New Zealand, due to their remoteness and isolation from major world trade except in the last 200 years of recorded history, provide useful information on the capability and speed of spread of alien species. Reflecting their European settlement this region tends to have more Lumbricidae compared to the Asian countries where both native and alien species are more often Megascolecidae or Moniligastridae. Korea and northern China appear exceptions as cooler climates allow a relatively greater (natural?) abundance of Lumbricidae. However, several Oriental species are now widely distributed, for example, there are reports of components of the *Metaphire hilgendorfi* species-complex that possibly originated in Japan, viz. *Metaphire agrestis*, *M. hilgendorfi* and *Amynthas tokioensis*, from North America (Hendrix and Bohlen 2002, Blakemore 2003, 2005). A summary of the relative proportions of Lumbricidae - including *Eisenia japonica* supposedly native to Korea and Japan, and Megascolecidae - mainly pheretimoids, is shown in Tab. 2.

From a total earthworm fauna of ca. 5,500 described species, the Holarctic lumbricids comprise about 600, whereas roughly 900 Oriental pheretimoids

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Table 1 Alien earthwarms in Australis (Aust.), Tasmania (Tas.), New Zealand, Japan, Ryu-kyu Islands, Korea, Taiwan, China, South East Asia, U.S.A. and Canada (based on Appendix 1).

	Aust. (excl. Tas.)	Tas.	N.Z.	Japan (excl. Ryuku)	Ryu-kyu Isls.	Korea (inc. Cheju)	Taiwan	China (incl. Hainan)	SE Asia	U.S.A. and Canada
Approx. No. of aliens in region (A)	63	27	27	33	18	23	27	40	50+	60
Approx. No. of natives in region (N)	450	203	172	38	10	70	44	112	?	120
Approx. TOTAL spp. (A+N)	513	230	199	71	28	93	71	152	?	180
Aliens [A/(A+N)] x 100 %	12.3	11.7	13.6	46.5	64.3	24.7	38.0	26.3	?	30.0

are known (Easton 1983, Sims, 1983, Sims and Easton 1972, Blakemore 2004b, 2004c, 2005), and these two groups each contribute about a third to the 110 most common alien species now found around the world (Blakemore 2002). The remaining third of 'cosmopolitan species' have diverse origins (Tab. 1 and Appendix 1). Although wide environmental tolerance is often characteristic of aliens, their ability to survive in a new region once introduced is influenced by the local climate and ecology (Lee 1985, 1987).

Apart from determining new natives, one of the challenges in ecological taxonomy is distinguishing the aliens from the natives and assessing the diversity and distribution of both. Regional comparisons help us appreciate mechanisms of initial introduction and to chart the relative rates of dispersal and differentiation.

BIOGEOGRAPHY AND COMPARATIVE SPECIES DIVERSITY

The 3,000 islands of Japan extend almost 3,000 km from subarctic Hokkaido in the northeast to subtropical Okinawa to the southwest, occupying 378,000km^2 similar in total area to Britain and Ireland, just smaller than California, but just larger than New Zealand or the Korean peninsula. Between 56,000 to 10,000 years ago during the glacial Pleistocene, Japan was connected to Korea, and the southernmost Ryukyu chain of islands were united with Taiwan which itself was periodically connected to China (Tsai *et al.* 2000a) facilitating natural exchange of fauna. The Ryukyu archipelago stretches across nearly 1,000km of ocean and includes the main islands of Okinawa, Miyako, Ishigaki and Iriomote. Ten Okinawan native worms are known, with all but two species also recorded from the main islands of Japan, although none are in common with the Taiwan fauna.

A checklist of Japanese earthworms by Easton (1981) reported 70 species, the majority pheretimoids (i.e., species ex *Pheretima* auct.) that frequently have parthenogenetic morphs. About 60 new names were proposed in Ishizuka (2001) but most were polymorphic synonyms, giving a new total of just 80 valid names with another dozen retained as *species incertae sedis*; of these 80 taxa, about 40 are presumed natives, 33 are known aliens, and the remaining species are of uncertain origin (Blakemore 2003, 2004a). The Japan/Ryukus diversity is very similar to that of the Korean peninsula including volcanic Cheju (= Quelpart) Island that has 93 known species (70 native); and these totals compare (Tab.1 and Appendix 1) with 71 species from Taiwan (44 native); 152 from China (112 native composed of about 90 from the mainland and 22 from Hainan). The totals are modified slightly from Shih *et al.* (1999) and from Tsai *et al.* (2000a) to include recently described *Amynthas* species from Korea (some being synonyms) e.g. by Hong and James (2001) and several new, mainly pheretimoid species from subtropical Taiwan as listed by Blakemore (2005) and Blakemore *et al.* (in press).

The diversity of earthworms differs considerably in non-Asian countries. The British Isles, for example, have 48 taxa which are mostly composed of common Lumbricidae (re-)introduced from continental Europe since the last Ice Age (Sims and Gerard 1999) with ca. 30 of these same species now in Australasia and the Americas (Blakemore 2002). Currently about 180 taxa (ca. 120 natives) are to be found in North America, the

Table 2 Relative proportions of Lumbricidae (originally from temperate Eurasia or North America) and Megascolecidae (mainly from subtropical Asia/Australasia).

	Aust. (excl. Tas.)	Tas.	N.Z.	Japan (excl. Ryuku)	Ryu-kyu Isls.	Korea (inc. Cheju)	Taiwan	China (incl. Hainan)	SE Asia	U.S.A. and Canada
Approx. No. Lumbricidae as % total aliens	35%	60%	67%	39%	0	57%	22%	23%	6%	50%
Approx. No. Megascolecidae as % total aliens	37%	18%	22%	46%	77%	39%	66%	55%	48%	30%

northern parts of which were similarly glaciated, and the volcanic Hawaiian Islands have 50 taxa listed, probably only 33 being reasonably valid names and all presumed to be post-Columbian introduced species (Hendrix 1995, Anon. 2003, Blakemore 2005). New Zealand's North and South islands have 199 species (172 natives), while ca. 715 (ca. 650 natives) are known from Australia, including ca. 203 natives from the cool temperate island state of Tasmania that is roughly the same size as Ireland, Hispaniola, or Hokkaido (Lee 1959, Blakemore 1999, 2000, 2002, 2005). If neoendemics (as defined by Blakemore 1999) and taxa that are native to the region but believed also introduced outside of their natural range within the region were included with the ca. 65 aliens (<10% of total with just 3% lumbricids), then Australian and Tasmania would have a combined total of nearly 80 non-wholly native taxa. These figures are remarkably high compared to diversities in Europe, Asia or the Americas, especially considering the relatively brief exposure to international trade and communication with Australia since 1788 and somewhat delayed start to eco-taxonomic surveys.

ECOLOGICAL/ECONOMIC RISK OF ALIEN SPECIES

The beneficial and deleterious effects of invasive alien earthworms in North America are presented in a summary by Hendrix and Bohlen (2002). Alien species for which there are reports of some adverse effects include *Pontoscolex corethrurus* (Müller. 1856) that often dominates newly colonised tropical lowlands (e.g. Tsai *et al.* 2000b). It has yet to be confirmed in mainland Japan although it is newly reported here in Yona, northern Okinawa [collected by R.J.B. on 20.xi.2005 from soil by storm-drain in *Castanopsis sieboldii* (Makino) forested hills above Ryukyu University Forestry Research Centre]. Gates (1972: 183) noted that *Pontoscolex corethrurus* along with a lesser population of *Polypheretima elongata* (Perrier, 1872) were implicated in rendering a South Indian soil cloddy and unproductive. Similarly, seepage from taro patches in Kauai, Hawaii, from rice paddies in Taiwan, and from 2,000-year-old mountain rice terraces in Ifugao, Philippines were all attributed to excessive burrowing by *Polypheretima elongata* morphs by Gates (1972).

Dichogaster annae (Horst, 1893), reported as its probable junior synonym *D. curgensis* Michaelsen, 1921, has been indicted as a serious pest of rice terraces in the Philippine Cordilleras (Barrion and Listinger, 1997). Although known from Africa, India, Southeast Asia, South America and recently recorded from Australia (Blakemore 1999, 2002), it is not yet reported from Japan.

The semi-aquatic South American *Eukerria saltensis* is a new species record in Japan (Appendix 2). It is considered a pest in aerially-sown rice in Australian paddies with crop failures from up-rootings usually occurring between tillering and harvest, caused by increased water turbidity and reduced soil compaction attributed to the worms' activities (Stevens and Warren 2000). These authors also found an indirect affect on the rice due to the worms attracting ibis (*Threskiornis* spp.) and other waterbirds that trample the young plants as they hunt for prey. Rotations with dryland crops such as winter cereals appeared effective in controlling both these worm problems (Stevens 2003; see also *http://www.ogtr.gov.au/rtf/ir/biologyrice1.rtf* February, 2005). To what extent this species presents a threat to Japanese rice production, if at all, is currently unknown.

Furthermore, the alien lumbricid *Eiseniella tetraedra* (Savigny, 1826) is newly recorded from a riverbank in Toyama-ken central Honshu, Japan (identified by R.J.B. from a specimen delivered to M.T. Ito, December, 2005) and from running water of Chichawan Stream on Wuling Farm, Shei-Pa National Park, northeastern Taiwan (several specimens from Dr. J.-H. Chen, February, 2004). This limicolous species is probably native to the western Palaearctic but is now widespread in mainly temperate regions in both hemispheres of the world. It is not known to present any environmental risks (Blakemore 2002, Csuzdi & Zicsi 2003).

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APPENDIX 1

Records of alien earthworms from Australasian and Oriental regions compared to continental North America.
(Family classification after Blakemore 2000; full synonymies listed in Blakemore 2002).

Families (origins) and Species from Regions	**Aust. (excl. Tas.)**	**Tas.**	**N.Z.**	**Japan (excl. Ryuku)**	**Ryu-kyu Isls.**	**Korea (inc. Cheju)**	**Taiwan**	**China (incl. Hainan)**	**SE Asia**	**U.S.A. and Canada**
MONILIGASTRIDAE (Oriental & Indian)										
Desmogaster sinensis Gates, 1930								+		
Drawida barwelli (Beddard, 1886)	*							*(H)	+	
Drawida japonica (Michaelsen, 1892)				+		+	+		+	
Drawida longatria longatria Gates, 1925									+	
Drawida nepalensis Michaelsen, 1907									+	
GLOSSOSCOLECIDAE (Neotropical)										
Pontoscolex corethrurus (Müller, 1856)	+		+	+(BI)	*		+	+	+	+
ALMIDAE (Circum-tropical)										
Glyphidrilus papillatus (Rosa, 1890)								+(H)		
CRIODRILIDAE (Southwestern palaearctic)										
Criodrilus lactuum Hoffmeister, 1845										+
HORMOGASTRIDAE (Mediterranean)										
Hormogaster redii Rosa, 1887										+
LUMBRICIDAE (Holarctic)										
Allolobophora chlorotica (Savigny, 1826)		+	+							+
Allolobophoridella eiseni (Levinsen, 1884)		*	+							+
Aporrectodea caliginosa (Savigny, 1826)	+	+	+	+		+	+?	+		+
Aporrectodea icterica (Savigny, 1826)										+
Aporrectodea limicola (Michaelsen, 1890)	B+									+
Aporrectodea longa (Ude, 1885)	+	+	+							+
Aporrectodea rosea (Savigny, 1826)	+	+	+	+		+		+		+
Aporrectodea trapezoides (Dugès, 1828)	+	+	+	+		+	+	+	+	+
Aporrectodea tuberculata (Eisen, 1874)	+		+	+?		+?	+?	+?		+
Bimastos parvus (Eisen, 1874)	+		+?	+		+	+	+	+	+?
Dendrobaena attemsi (Michaelsen, 1902)	?	?								+
Dendrobaena hortensis (Michaelsen, 1890)	B+	*								+
Dendrobaena octaedra (Savigny, 1826)				+						+
Dendrobaena pygmaea (Savigny, 1826)				*						+
Dendrobaena veneta (Rosa, 1886)	B+		*							+
Dendrodrilus rubidus rubidus (Savigny, 1826)	+	*	+	+		+		+		+
D. rubidus subrubicundus (Eisen, 1874)	+									+?
D. rubidus tenuis (Eisen, 1874)	+(HI)	+(MI)		+		+				+?
Eisenia andrei Bouché, 1972	+?		+?	+?		+?				+?
Eisenia fetida (Savigny, 1826)	+	*	+	+		+	*	+	+	+
Eisenia japonica (Michaelsen, 1892)				+?		+?				
Eisenia nordenskioeldi (Eisen, 1879) sub-spp.						+?		+		
Eiseniella tetraedra (Savigny, 1826)	+	+	+	*			*			+
Lumbricus castaneus (Savigny, 1826)	*	*	+							+
Lumbricus festivus (Savigny, 1826)	+?									+
Lumbricus friendi Cognetti, 1904										+
Lumbricus rubellus Hoffmeister, 1843	+	+	+			+?				+
Lumbricus terrestris Linnaeus, 1758		*	+			+?				+
Murchieona minuscula (Rosa, 1906)										+
Octolasion cyaneum (Savigny, 1826)	+	+	+							+
Octolasion tyrtaeum lacteum (Örley, 1881)	*?		+					+		
O. tyrtaeum tyrtaeum (Savigny, 1826)	+									+
Satchellius mammalis (Savigny, 1826)										+

(APPENDIX 1 continued)

FAMILIES (ORIGINS) AND SPECIES FROM REGIONS	Aust. (excl. Tas.)	Tas.	N.Z.	Japan (excl. Ryuku)	Ryu-kyu Isls.	Korea (inc. Cheju)	Taiwan	China (incl. Hainan)	SE Asia	U.S.A. and Canada
OCNERODRILIDAE										
(Tropical America & Africa)										
Gordiodrilus elegans Beddard, 1892	*								+	+
Nematogenia panamaensis (Eisen, 1900)									+	
Ocnerodrilus occidentalis Eisen, 1878	*	*		+	+			+	+	+
Eukerria kuekenthali (Michaelsen, 1908)	+(CI)								+	
Eukerria saltensis (Beddard, 1895)	+	*?		*					+	+
Malabaria levis (Chen, 1938)								+(H)	+	
Thatonia exilis Gates, 1945									+	
Thatonia gracilis Gates, 1942									+	
ACANTHODRILIDAE (Pangean?)										
Microscolex dubius (Fletcher, 1887)	+	*	+							+
Microscolex kerguelarum (Grube, 1877)	+(HI)									
Microscolex macquariensis (Beddard, 1896)		+(MI)								
Microscolex phosphoreus (Dugès, 1837)	+	*	+	+						+
Rhododrilus kermadecensis Benham, 1905	B+?	*								
Rhododrilus queenslandicus Michaelsen, 1916	+									
OCTOCHAETIDAE										
(Circumtropical, Australasian)										
Dichogaster affinis (Michaelsen, 1890)	*							+(H)	+	+
Dichogaster annae (Horst, 1893)	*								+	
Dichogaster bolaui (Michaelsen, 1891)	+				+		+	+(H)	+	+
Dichogaster corticis (Michaelsen, 1899)									+?	
Dichogaster modiglianii (Rosa, 1896)									+	+
Dichogaster saliens (Beddard, 1893)	*				+				+	+
Dichogaster sp. nov?	*									
Lennogaster pusillus (Stephenson, 1920)									+	
Octochaetona beatrix (Beddard, 1902)	*								+	
Octochaetona surensis Michaelsen, 1910									+	
Ramiella bishambari (Stephenson, 1914)	+(CI)							+	+	
MEGASCOLECIDAE (mostly Indo-Australasia)										
Argilophilus marmoratus Eisen, 1893	?									
Pontodrilus litoralis (Grube, 1855)	+		+	+				+(H)	+	+
Perionyx excavatus Perrier, 1872	*	*	*	+		+	+		+	+
Amynthas aspergillum (Perrier, 1872)							+	+		
Amynthas carnosus (Goto & Hatai, 1899)						+?	+?	+?	+?	
Amynthas corticis (Kinberg, 1867)	+	*	+	+	+	+	+	+	+	+
Amynthas glabrus (Gates, 1932)				+	+				+	
Amynthas gracilis (Kinberg, 1867)	+		+	+	+		+	+?	+	+
Amynthas hupeiensis (Michaelsen, 1895)	+(T)?		?+	+	+	+	+	+	+	+
Amynthas incongruus (Chen, 1933)							+	+		
Amynthas lautus (Horst, 1883)					+?		+?	+?		
Amynthas loveridgei (Gates, 1968)										+
Amynthas minimus (Horst, 1893)	+			+	+		+	+	+	+
Amynthas morrisi (Beddard, 1892)	+			+	+		+	+	+	+
Am. morrisi group sp. nov.?	*									
Amynthas papulosus (Rosa, 1896)				+	+		+	+	+	
Amynthas robustus (Perrier, 1872)				+	+	+	+	+	+	
Amynthas rodericensis (Grube, 1879)	+							+?	+	+
Amynthas taipeiensis (Tsai, 1964)							+?	+?		
Amynthas tokioensis (Beddard, 1892)						+?				+
Anisochaeta dorsalis (Fletcher, 1887)		+								
Anisochaeta gracilis (Fletcher, 1886)		+?								
Anisochaeta sebastiana (Blakemore, 1997)		+								
Begemius queenslandicus (Fletcher, 1886)	+									
Didymogaster sylvatica Fletcher, 1886			+							
Lampito mauritii Kinberg, 1866	+(CI)							+	+	
Metaphire agrestis (Goto & Hatai, 1899)						+?				+
Metaphire bahli (Gates, 1945)	+								+?	
Metaphire californica (Kinberg, 1867)	+			+	+		+	+	+	+
Metaphire hilgendorfi (Michaelsen, 1892)						+?				+
Metaphire houlleti (Perrier, 1872)	+							+	+	+
Metaphire javanica (Kinberg, 1867)	+?							+?	+?	
Metaphire peguana (Rosa, 1890)					+?				+	
Metaphire posthuma (Vaillant, 1868)	+(CI)						+	+	+	+
Metaphire schmardae macrochaeta (Mich., 1899)				+				+?		
Metaphire schmardae schmardae (Horst, 1883)				+?	+		+	+	+	

(APPENDIX 1 continued)

FAMILIES (ORIGINS) AND SPECIES FROM REGIONS	Aust. (excl. Tas.)	Tas.	N.Z.	Japan (excl. Ryuku)	Ryu-kyu Isls.	Korea (inc. Cheju)	Taiwan	China (incl. Hainan)	SE Asia	U.S.A. and Canada
Metaphire soulensis (Kobayashi, 1938)				+?		+?		+?		
Pheretima darnleiensis (Fletcher, 1886)	+(T,CI)								+	
Pheretima montana Kinberg, 1867									+	
Pithemera bicincta (Perrier, 1875)	+			+	+		+		+	+
Polypheretima brevis (Rosa, 1898)	+(CI)									
Polypheretima elongata (Perrier, 1872)	+				+		+		+	+?
Polypheretima taprobanae (Beddard, 1892)	+									
EUDRILIDAE (West African)										
Eudrilus eugeniae (Kinberg, 1867)	*									+

Aust – Mainland Australia; Tas. – Tasmania; N.Z. – New Zealand. **+ -** present as an alien species; ***** - first records from principal author's (R.J. Blakemore) studies; ? - indicates some ambiguity of taxonomic description, endemicity, or veracity of report; B – J. C. Buckerfield of Adelaide pers. comm.; (BI) Bonin Island; (CI) Christmas Island; (H) Hainan; (HI) Heard Island; (MI) Macquarie Island; (T) Torres Straits Islands.

Notes: The above table is adapted from Blakemore (1999, 2000, 2002, 2005) and various other sources as noted there within. Rosa's *constricta*, once part of *Bimastos parvus* (syn. *beddardi*) is now included in *D. rubidus*. *Rhododrilus kermadecensis* is probably endemic to Kermadec. *Anisochaeta spp.* and *Didymogaster* are endemic to Australia. *Amynthas indicus* (Horst, 1883) listed from Christmas Island (and Torres Straits?) was said by Sims and Easton (1972: 263) to be *Pheretima darnleiensis*. It was though by Easton (1981) that *Amynthas lautus* was a synonym of *A. robustus*, but Tsai *et al.* (2000a: 286) disagree. *Metaphire javanica* is possibly synonymous with *M. californica* that has page priority (pers. obs.) whereas *Pithemera bicincta* may comprise more than one taxon (pers. obs.) as its synonym *Pithemera violacea* (Beddard, 1895) perhaps merits specific status.

APPENDIX 2

Eco-taxonomic description of *Eukerria saltensis* (Oligochaeta : Ocnerodrilidae). *Eukerria saltensis* (Beddard, 1895)

Kerria saltensis Beddard, 1895: 225. [Type locality Valparaiso, Salto, Chile. Types in US National Museum (21025) and British Museum (1904:10:5:928)]; Michaelsen, 1900: 371; Michaelsen, 1907: 23 (syn. *sydneyensis*).

Acanthodrilus sydneyensis Sweet, 1900: 124. [From Sydney, Australia. Types?]

Kerria gunningi Michaelsen, 1913: 1. [From tropical or subtropical Africa? Types in Hamburg: 7490].

Kerria nichollsi Jackson, 1931: 121, Pl. XVI, figs. 5,8,9,11. [From WA. Types?].

Eukerria saltensis: Michaelsen, 1935: 40 (syns. *nichollsi*, *sydneyensis*); Gates, 1942: 67 (syn. *gunningi*); Gates, 1972: 270; Blakemore, 2002 (syn. *sydneyensis, gunningi, nichollsi*).

Taxonomic note: Often misdated as "Beddard, 1892" when other *Eukerria* species were described by that author, e.g. the morphologically similar *Eu. halophila* (Beddard, 1892: 357).

Distribution: South America and spread worldwide by human and other agencies: Spain (e.g. Valencia), USA [e.g., Oregon, Texas, Georgia, Florida, and North Carolina by Gates (1972: 270)], Chile (Salto, Valparaiso, Coquimbo, Quillota, also mid-Pacific Easter Island and the Iles San Fernandez: Robinson Crusoe Island, Santa Clara Island, and Alexander Selkirk Island), Argentina (Bella Vista, Cordoba), Brazil (e.g. Minas Gerais and from Sao Paulo), Myanmar (Pyinmana, Mandalay, Lower Chindwin), Vietnam (Thai, 2000), South Africa (Cape Province, Natal, Transvaal), New Caledonia. In Australia previously reported from NSW (Sydney including Sydney Harbour, Paramatta and Blue Mtns.) and Victoria, WA, now confirmed from Qld, and possibly also present in Tasmania (museum specimens). In Japan: from Kamakura and Machida, Tokyo. These are the first records from the Far East.

Locality of Examined Material: Samford (e.g. ANIC: RB.95.4.6), Closeburn, CSIRO Narayen (collector R.J.B. as detailed in Blakemore, 1994) all in Qld; Whitton near Griffiths (collector J. Blackwell); Woodburn Island/Maclean (e.g. ANIC: RB.95.13.1), Lismore, Whitton and Deniliquin (ANIC: RB.95.2.1-2 collected 7.xii.1994 by M. Stephens), NSW; in QVM collection, Tasmania - new Australian records. From drain at Kuzuharagaoka Shrine, (founded 1333) at Kamakura, collected 13.vi.2004 by R.J.B., Amanda Reid and Yuko Hiramoto; also besides Sakaigawa creek east of Hashimoto station, Machida-ku, Tokyo, the boundary between Tokyo and Kanagawa-ken, collected 18.viii.2004 by R.J.B. - new Asian records. (For details of ANIC Canberra, ACT, Australia collection, see Blakemore, 2005).

Habitat: limicolous, generally in irrigated or sodden soil, besides water courses or in drains, under rice, sugarcane, and pasture soil. Can survive in clay soils (Blakemore, 1994).

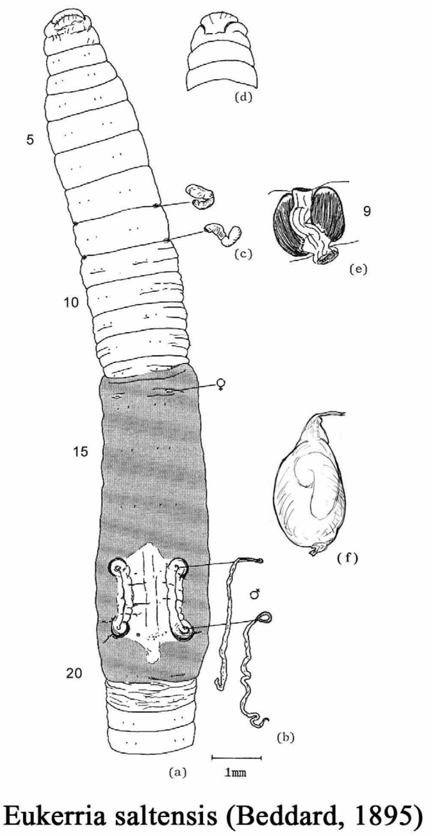

Figure 1 *Eukerria saltensis* Qld specimen, (a) anterior view with (b) prostates and (c) spermatheca *in situ*, (d) prostomium, (e) laterally paired ocnerodrilid diverticula in 9, (f) cocoon with embryo visible. (After Blakemore 2002, fig. 1.7).

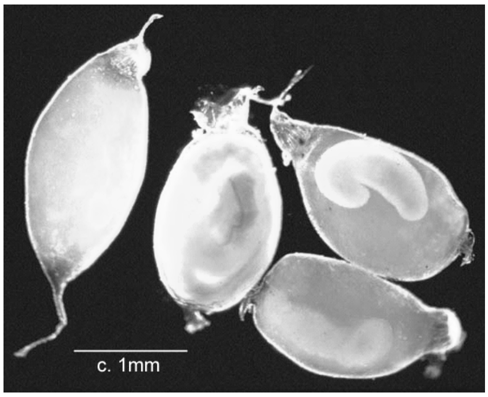

Figure 2 *E. saltensis* cocoons, lengths 2mm (photo courtesy Dr Mark Stevens, NSW Agriculture from adult specimens identified by R.J.B.).

Registration No.: Japanese specimens to be deposited in National Science Museum, Tokyo.
Length: 30-95mm.
Width: generally ca. 1mm.
Segments: 97-131.
Colour: unpigmented but red from blood and dark from soil in gut; anterior faint, with brilliant, blue iridescence, some worms may appear white from coelomocytes in body cavity. Clitellum yellowy or pale.
Behaviour: fairly docile although white prostomium probes inquisitively; body readily extends and is easily broken; when in water specimens aggregate in coiled masses; specimens coil on preservation and produce much mucus.
Prostomium: epilobous, closed or open.
First dorsal pore: none (consistent with aquatic habitat).
Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment, **ab** absent on 17, **b** absent on 18-19. (3:1:3:1:10:0.44).
Nephropores: not visible (in **ab** lines?).
Clitellum: 13½, 14-20; mostly annular but thin or absent near male field.
Male pores: acanthodriline, on 18 in slightly inwardly bowed seminal grooves between pairs of prostates equatorial in **ab** in 17 and 19.
Female pores: 14, variously: paired longitudinal slits anterior to setae **a** almost at 13/14; longitudinal slits just anterior to **b**; only a single pore found in two Qld specimens just anterior to **b** line on right hand side.
Spermathecal pores: inconspicuous in 7/8 and 8/9 lateral between **b** and **c** lines, often closer to **c**.
Genital markings: none.
Septa: 5/6-11/12 present and thick.
Dorsal blood vessel: single, continuous onto pharynx.
Hearts: 9, 10 and 11; supraoesophageal vessel with commissurals in 10 and 11.
Gizzard: weakly muscular barrel or pear-shaped gizzard in 7.
Calciferous glands or diverticula: paired in 9, ventro-laterally discharging into oesophagus at 9/10, (glands are supplied by small capillaries and have thick walls and central lumen in cross section).
Intestine origin: commences between 11-13 (caeca, typhlosole absent).
Nephridia: holoic, commencing from around 7, avesiculate (consistent with aquatic habitat).
Testis/sperm funnels: free and iridescent in 10; paired seminal vesicles in 9 or 9 and 11 [or funnels in 11, seminal vesicles in ?11 and 12].
Ovaries: large pair palmate in 13.
Prostates: two pairs of thin elongate tubular prostates with short muscular ducts in 17 and 19, intercoiled and extending back several segments.
Spermathecae: two pairs in 8 and 9; moderately small; ampullae may be bent at right angles to longer duct; adiverticulate; non iridescent.
Gut contents: fine soil and colloidal organic matter (consistent with habitat).
Reproduction: Gates (1972) provides data that shows this species to have both biparental and parthenogenetic reproduction; there is some evidence to suggest (internal?) self-fertilisation of some isolated specimens in laboratory experiments.

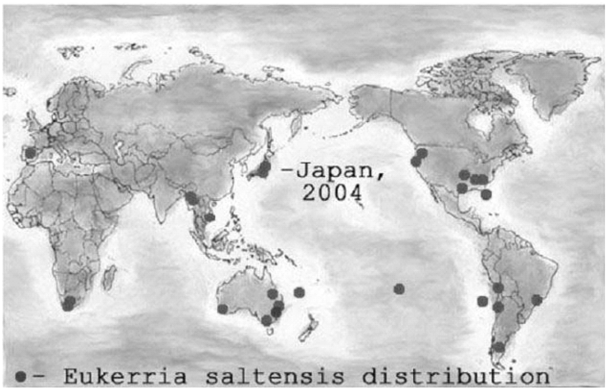

Figure 3 *E. saltensis* known World distribution (original).

Genetic profiles: not yet known to have been sequenced.

Notes: collected in relatively large numbers at CSIRO Narayen, Qld from sodden soil beside a water tank, where they were difficult to extract since they produced a viscous, "gummy" exudate that adhered to their bodies which snapped in two when stretched. From Samford, they were found in very moist clay soil, coiled at 5-10cm depth or active in the root zone in two locations and in association with several other earthworm species, including *Aporrectodea trapezoides*. Maclean specimens were collected form the delta of Clarance River in irrigated alluvial soil under sugarcane, found in association with *Zacharius zacharyi* Blakemore, 1997. Specimens of *Eu. saltensis* from Whitton and Deniliquin were collected from rice paddies where they were abundant and thought to be rather problematic as they attracted wading birds such as ibis (*Threskiornis* spp.) which muddied the water (M. Stevens *pers. comm.* 1994, and see Stevens & Warren, 2000; Stevens, 2003). In Japan, several specimens were collected from a drainage channel beside a shrine at Kamakura and a riverbank at Machida (similar specimens collected from Kochi, Shikoku Island by R.J.B. in 2004 were too damaged to reliably identify to species). It is not known if their spread into Japanese rice fields is likely to be problematic or not, as Japanese rice is generally transplanted, unlike in Australia where it is sown.

In moist habitats, this species may be easily confused with chironomid larvae (Diptera: Chironomidae) or aquatic microdriles such as tubificids that are called "bloodworms"; although of similar size, these larvae and microdriles have body appendages unlike true 'earthworms' and can be more serious pests of rice paddies (e.g. *http://www.rirdc.gov.au/reports/RIC/99_141.doc*).

This species was deliberately introduced along with lumbricids into cultivated soils in NSW, but failed to clearly demonstrate beneficial effects although air permeability of the red-brown earth soil was reportedly increased (Blackwell & Blackwell, 1989). In a series of laboratory and glasshouse trials on studies of about 30 native and alien species by Blakemore (1994; 1997), they were found to have slight to negligible effect on mesocosm plant yield and soil structure, and their small size and susceptibility to injury made them difficult to handle. They also seem to require high moisture for survival. Although found to be of negligible benefit in these plant growth studies, like many other peregrine species, the ubiquity and range of distribution of *Eukerria saltensis* in Australia, and now Asia, from a supposed South American origin is quite remarkable.

Key to alien/peregrine *Eukerria* species originating from South America

Spermathecal pores in setal ab lines
.... *E. kuekenthali* (Michaelsen, 1908)
Spermathecal pores slightly median to setal c lines
.... *E. saltensis* (Beddard, 1895)