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Unraveling some Kinki worms (Annelida, Oligochaeta, Megadrili, Lumbricidae) – Part III

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Abstract

Eisenia anzac sp. nov., unearthed near the Commonwealth War Graves in Yokohama, raises the current Japanese Lumbricidae to 15 (sub-)species. Representing just 11% of Japans´s named earthworm fauna, most lumbricids are cosmopolitan exotics and only one – *Helodrilus hachiojii* Blakemore, 2007 – is thought wholly endemic to Japan. *Eisenia japonica* (Michaelsen, 1892) although native to the Far East has been questionably reported from Germany/Europe. Review is based on types and more recent specimens from rice paddy survey around Lake Biwa in the Kinki region plus ancillary collecting around Tokyo megalopolis. Both prior taxa are comparable (morphologically and via mtDNA COI barcode) to a potentially endemic species newly described herein.

Key words: lumbricid earthworms, Japan, types, taxonomy, rice paddy.

1. Introduction

Although ca. 166 Japanese earthworm species have been named, only half are considered valid taxa (Easton 1981, Blakemore 2003, 2004, 2007a, b, Blakemore et al. 2007) and addition of the present new species increases total Lumbricidae to just 15 (~11% of total).

The large holarctic family Lumbricidae comprises ~670 valid (sub-)species out of a total of some 1,150 nominal taxa [Blakemore (2005, 2008a, b); cf. Easton's (1983) checklist of ~386 valid lumbricids known at that time, just 25 years earlier]. As with some other earthworm families, its taxonomy is relatively complex and unstable even at the species level despite its long history of treatment by European and North American scholars. Gates (1982, p. 28) wrote: 'If the "unequalled chaos" of lumbricid taxonomy (Ljungström, 1972) is to be resolved, past reliance on invalid assumptions (Gates, 1972, p. 29, Nos. 1–11) must be abandoned'. Genetic DNA assessment, based on type-specimens of type-species, offers an objective solution to chronic problems of generic assignment and species identification (e.g. Blakemore et al. 2010). Such a problem is posed by the new species described herein that does not clearly fit into any existing generic definition: neither those of Michaelsen (1900), Sims & Gerard (1985), Qiu & Bouché (1998) nor Csuzdi & Zicsi (2003). Perhaps morphologically closest to

Eisenia Malm, 1877, to *Helodrilus* Hoffmeister, 1845 or, less likely, to *Prosellodrilus* Bouché, 1972, it is ascribed to the former genus.

Csuzdi & Zicsi (2003, p. 139) wrote that this genus *Eisenia* is heterogeneous and in need of further revision since many species of Caucasian or Far Eastern origin had been omitted from most recent treatments; moreover, several of these lack the supposed generically characteristic red pigmentation. This paper documents additional data on some such species, and provides a checklist of currently known Japanese lumbricids as part of a modest series updating Japanese earthworms (Blakemore & Kupriyanova 2010, Blakemore 2010; Blakemore et al. 2010).

2. Materials and methods

Classification follows the conventions, style and methodology of Blakemore (2000, 2008a) that complies with ICZN (1999). Familiar Arabic numerals are used, rather than contrived Latin numbers, as per Michaelsen (1900) and Blakemore (2000). Only partial synopses of the genera/species are given here. Full synonymies, diagnoses and distributions may be found elsewhere (e.g. Gates 1972, Easton 1983, Sims & Gerard 1985, Blakemore 2002, 2007a, 2008a) and checklists of all lumbricid species worldwide provided by Blakemore (2005, 2008a, b) may also be consulted.

Tissue samples were taken and submitted to the International Barcode of Life Secretariat under protocols of the working group WG1.9 program (see iBOL http://ibol.org, for details), where DNA extraction, amplification and mtDNA COI barcode sequencing will be attempted and, if successful, the resulting data will be added into their BOLD database and automatically uploaded to the GenBank online facility (http://www.ncbi.nlm.nih.gov/genbank).

3. Systematics results

Checklist of Japanese lumbricid species

Family **Lumbricidae** Rafinesque-Schmaltz, 1815

Distribution: Endemic to the Holarctic region, from Vancouver Island through North America and Eurasia to Japan; many species (ca. 35 lumbricids from a total of ca. 150 cosmopolitans, or ~23%) are found globally by introduction (Blakemore 2005, 2008a). In the following list, an asterisk (*) before an entry indicates exotic/introduced to Japan; a hash mark (#) is a native taxon and one with a question mark (?) is of uncertain origin.

Aporrectodea caliginosa species-group sensu Blakemore (2002):

*1. ***Aporrectodea caliginosa*** (Savigny, 1826).
*2. ***Aporrectodea trapezoides*** (Dugès, 1828).
*3. ***Aporrectodea tuberculata*** (Eisen, 1874).
*4. ***Aporrectodea rosea*** (Savigny, 1826).
*5. ***Bimastos parvus*** (Eisen, 1874).
?#6. ***Dendrobaena octaedra*** (Savigny, 1826). Details in Blakemore (2008a).
*7. ***Dendrobaena pygmaea*** (Savigny, 1826). See Blakemore (2004).

Dendrodrilus rubidus species-complex sensu Blakemore (2002):

*8. ***Dendrodrilus rubidus rubidus*** (Savigny, 1826) (inc. ***tenuis*** Eisen, 1874?).
*9. ***Dendrodrilus rubidus subrubicundus*** (Eisen, 1874).
?#/*10. ***Eisenia anzac*** Blakemore sp. nov.

Eisenia fetida species-complex sensu Blakemore (2002):

?*11. ***Eisenia andrei*** Bouché, 1972. Unconfirmed – see Blakemore (2003).

*12. ***Eisenia fetida*** (Savigny, 1826). Michaelsen (1891) and pers. obs.

?#13. ***Eisenia japonica*** (Michaelsen, 1892) (?synonyms *gigantica*, *minuta*).

*14. ***Eiseniella tetraedra*** (Savigny, 1826). See Blakemore et al. (2007).

#15. ***Helodrilus hachiojii*** Blakemore, 2007a.

Besides these, the single record of *Lumbricus* sp. from Japan in Easton (1981) is dismissed, not least because of many false reports around the world, now also including GenBank databases, of earthworm species specimens purported to be the 'Common Earthworm', *Lumbricus terrestris* Linnaeus, 1758 (see Blakemore 1997).

Species descriptions

Eisenia anzac Blakemore, **sp. nov.** [**Fig. 1**] [1]

Material Examined/Locality: Holotype: Hungary Natural History Museum, Budapest HNHM/15529. From under tree in park next to the Commonwealth War Graves Commission Cemetery in Hodogaya-ku (ca. 35° 27′ 36″ N 139° 35′ 46″ E), Yokohama-shi, Kanagawa-ken. Collected by author (RJB) and Yuko Hiramoto, 25.IV.2010. Anaesthesized in dilute alcohol and preserved in 80% ethanol (EtOH). A small non-essential tissue sample taken from posterior segments submitted to iBOL for DNA barcode analysis (Sept., 2010).

Diagnosis: Prostomium epilobous. First dorsal pore 3/4. Clitellum 22–30. Tubercula pubertatis mammilate on 26 only. Setae closely paired. Seminal vesicles in 9–12. Calciferous glands ½11–12. Spermathecae absent. Nephridial bladders sausage-shaped.

Etymology: Noun in apposition derived from Australian/New Zealand military acronym (ANZAC) reflecting the circumstances of collection on Anzac Day from a park adjacent to the Military Cemetery, and near to a stand of *Eucalyptus* gum trees of Australian origin.

Distribution: Hodogaya Ward of Yokohama city, central Japan. Despite its location near a garden of introduced plants, there is however no implication that the current species is a direct introduction from the Australasian region as lumbricids are not considered endemic there, except questionably for enigmatic *Eophila eti* Blakemore, 2008 from Tasmania.

Behaviour: Fairly passive, lacking the 'body lashing' response seen for many pheretimoids.

External features: Length 50 mm. Segments 139. Body yellowy unpigmented, but with darker, violet mid-dorsal line; clitellum buff. Body cylindrical but posterior end tapering and flattened. Prostomium open epilobous. First dorsal pore minute in 3/4, others open from 4/5. Neither spermathecal pores nor spermatophores found. Clitellum saddle-shaped in 22–30. Tubercula pubertatis as paired 'nipples' just lateral of b lines centred in 26 and encroaching into both 25 and 27 (Fig. 1). Setae closely paired (ratio on Fig. 1). Setal tumescences not pronounced. Nephropores not located (ventral and minute?). Female pores minute just lateral of b setae on 14. Male pores small in mid-bc line of 15 with faintly darker seminal groove extending longitudinally to start of clitellum.

Internal morphology: Pharyngeal mass extending from 3–4/5. Septa not especially thickened except perhaps 13/14. Dorsal blood vessel single, hearts in 7–11. Calciferous

1 After manuscript submission, a second mature specimen identified as *Eisenia anzac* was collected by RJB & MJG on 2nd February (Groundhog Day), 2011 under trees in the garden of Shingu-jinja shrine near Lake Biwa, Shiga-ken – somewhat extending this species' range. Currently accessioned under combined LBM Misc. Inverts. FY2011-22 it is to be further described by the senior author in due course, hopefully with pending mtDNA COI barcode results.

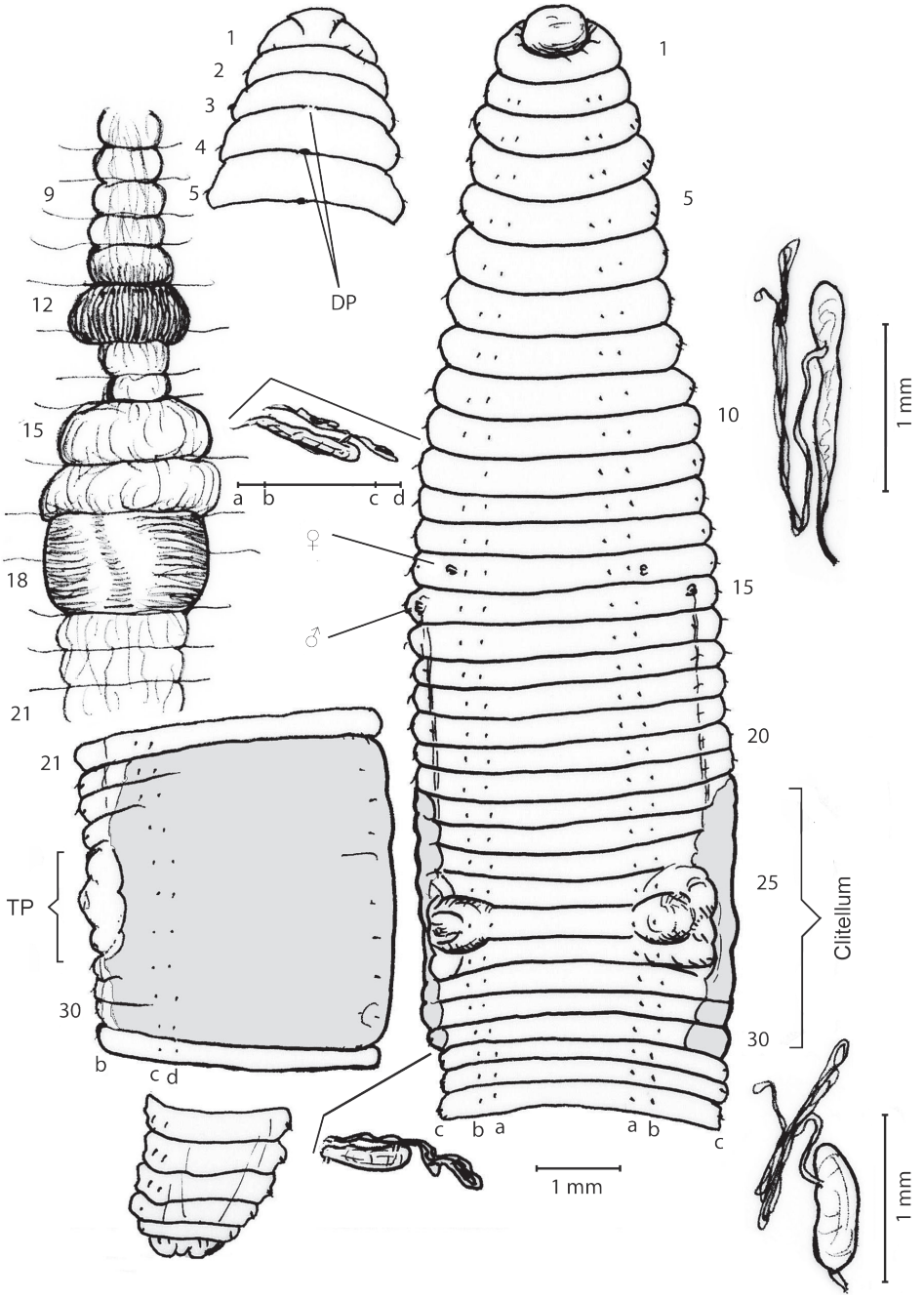

Fig. 1 *Eisenia anzac* Holotype showing anterior with prostomium and pygidium, side view (clitellum shaded) and nephridia in 10rhs and 30rhs plus enlargements. Section of intestinal tract figured in situ. DP – dorsal pores; TP – tuberculum pubertatis.

gland showing annular dilation and composed of numerous lamellae, mainly in 12 but some oesophageal modification in posterior half of 11 and superficially vascularized in 10. Crop in 15–16; gizzard large, muscular in 17–18, followed by dilated intestine; dorsal typhlosole thin, lamellar from about segment 30. Nephridia holoic, with elongate, sausage-shaped bladders exiting near ab lines. Male organs comprising large, iridescent testes free on anterior of septa 10/11 and 11/12, with vasa deferentia ducting to body wall in 12/13. Seminal vesicles paired, small and vestigial on anterior of septum 9/10, small on anterior of 10/11, larger on posterior of septum 10/11, largest on posterior of 11/12. Ovaries small in 13, with large oviducts. Ovisacs small and vestigial on posterior of 13/14. Small tumid glands sessile in 25–27, corresponding to sites of tubercula pubertatis. Gut contained organic soil attesting to its superficial soil layer habitat.

Remarks: Genetic placement of this new species is difficult, but on balance it most likely belongs in *Eisenia* following the composite keys to genera in Sims & Gerard (1985), Csuzdi & Zicsi (2003) and Blakemore (2008a) inasmuch as it has an epilobous prostomium, closely paired setae, sausage-shaped nephridial vesicles and intramural calciferous glands (these last in ½11–12). As Table 1 shows, closest congeners *Eisenia japonica* (Michaelsen, 1892) and *E. koreana* Zicsi, 1972 differ, not least, in locations of their clitella (on 23,24–30,31 in *E. japonica* and 25–31 in *E. koreana*) and tubercula pubertatis (on 27–29 in *E. japonica* and 27–28 in *E. koreana*). Only a single specimen of *E. anzac* is available, so no assessment of its morphological variability is currently possible neither is funding available to undertake further study.

Lack of spermathecae (or spermatophores) suggests parthenogenesis that is more characteristic of *Bimastos* species, with *B. tumidus* (Eisen, 1874) being particularly similar but differing on its tubercula pubertatis paired and slightly raised on 27 and 28 (according to Michaelsen, 1900) or lacking (in its *gieseleri* synonyms after Gates, 1972). *Helodrilus* species, in contrast to the present new species, display reduced development of nephiridial bladders (cf. *H. hachiojii* Blakemore, 2007 redescribed below).

Another possible accommodation is in *Prosellodrilus* Bouché, 1972 as several species described by Qiu & Bouché (1998, p. 37) appear similar on superficial inspection. In particular, the French species *Prosellodrilus calcicola*, *P. arenicola*, and *P. milo*, all newly described by Qiu & Bouché (1998), as diagnosed for comparison in Tab. 1.

Tab. 1 Characters of *Eisenia anzac* and closely similar species

Species / Characters	***E. anzac***	***E. japonica***	***E. koreana***	***P. calcicola/ arenicola/matoi***
1st Dorsal pore	3/4,4/5	4/5	present	6/7–9/10
Clitellum	22–30	23,24–30,31	25–31	(20)21–30(31)
Tubercula pubertatis	26 (½25–½27)	27 or 27 and 29	27–28	(22)23–27(28)
Neph bladders	sausage-like	sausage-like	present	hairpin/'digitoid'
Ca Glands	½11–12	11–12	present	11–14
Spermathecae	none found	9 and 10	?	multiple in 14–15
Distribution	Japan only (?)	East Asia	Korea only	France

Neph – Nephridial; Ca – Calciferous.

Since no precise match of any previous description has yet been found, this species from Yokohama is taken to be new to science as well as a new record for Japan. Insufficient information is available to determine whether it is native or an introduced species and, if the latter case, its provenance. A guess would be a European origin, possibly incidentally introduced with plants indirectly from Canada, India, or Australia/ New Zealand within the last 60 yrs to the landscaped gardens of *Eucalyptus*, teatree (*Melaleuca* sp.) and a kauri (*Agathis* sp.) around a cemetery that the Japanese call the '*Eirenpo Senshisha Bochi*'.

Eisenia japonica (Michaelsen, 1892) [**Figs 2–5**]

Allolobophora japonica Michaelsen [1891, p. 6]; 1892, p. 230. [Type localities '*Enosima*' = Enoshima near Yokohama plus Hakodate Hokkaido, Japan. Types Berlin Nr. 2115 and 2117 plus Hamburg V119–122 as described below].
Allolobophora (*Allolobophora*) *japonica*: Rosa 1893, p. 424, 449.
Helodrilus (*Allolobophora*) *japonicus*: Michaelsen 1900, p. 481; 1910, p. 62.
Allolobophora japonica f. *typica* Oishi 1934, p. 134.
Allolobophora japonica f. *gigantica* Oishi 1934, p. 134. [Tomakomai. Types ?].
Allolobophora japonica f. *minuta* Oishi 1934, p. 134 [Morioka, Asamushi. Types?].
Eisenia japonica: Gates 1975: 1; Easton 1981, p. 43 (syn. *gigantica, minuta*); Easton 1983, p. 480; Blakemore 2003, 2005, 2008a, b.

Nomenclatural note: In 1892 Michaelsen provided a full description of *Allolobophora japonica*, but authorship and initial date are often erroneously given as 'Michaelsen 1891, p. 6', e.g. by Michaelsen (1900, p. 481), Gates (1975), Hartwich & Kilias (1989, p. 268) and by Reynolds & Cook (1976, p. 120). Michaelsen (1900, p. 481) also listed '1892, p. 230' and Easton (1981, p. 43) regarded this as the authorship publication date. Dr Andreas Schmidt-Rhaesa (pers. comm. to RJB, 31.VIII.2010) writes: 'Concerning *Allobophora japonica*, 1892 is indeed the exact citation for the name. In the 1891 paper („Die Terricolenfauna der Azoren" in „Abhandlungen aus dem Gebiete der Naturwissenschaften" Vol. 11, pp. 3–8) Michaelsen writes (translated from German): The japanese material of *Terricola* shows many representatives of lumbricids. I found until now *Allolobophora foetida* Sav. and a new *Allolobophora* species, which is probably characteristic for the entire Japanese islands, as it was collected with a number of specimens from two distant regions, namely Hakodate on the island Jesso [Hokkaido] and Enosima near Tokyo. I think this must be what he later called *japonica*.' Correct ICZN (1999) citation is thus: (Michaelsen 1892, p. 230).

Type-series: Michaelsen (1892, p. 232) inspected material in the Zoological Museum, Berlin: Nr. 2117 from Enoshima (ca. 35° 17′ 59″ N 139° 28′ 49″ E) collected by Hilgendorf on 29.III.1875, and larger but less well preserved specimens from Hakodate (ca. 41° 46′ N 140° 44′ E) Nr. 2115 which were a part of the 'Fischerei-Ausstellung' (a German exhibition to promote consumption of fish, as held in Berlin in 1880 and again later in 1896?) with Spec. Kat. Nr. 469. These same Berlin lots were listed by Hartwich & Kilias (1989, p. 268) as 2115 from Hakodate (with all syntypes lost, one after an exchange with Dr D. Rosa in the Turin Museum on 16.I.1893), and 2117 from Enoshima (8 syntypes). Reynolds & Cook (1976, p. 120) additionally listed types in Hamburg (V119–122) together with those remaining in Berlin (No. 2117), probably from Gates' records. Berlin types No. 2117 and Hamburg types V119–122 were loaned and are described below. Interestingly, although three of the Berlin No. 2117 syntypes from Enoshima are macerated with two broken in half, the other five are solid and slightly coiled, but none have been previously dissected (RJB pers. obs.), one with

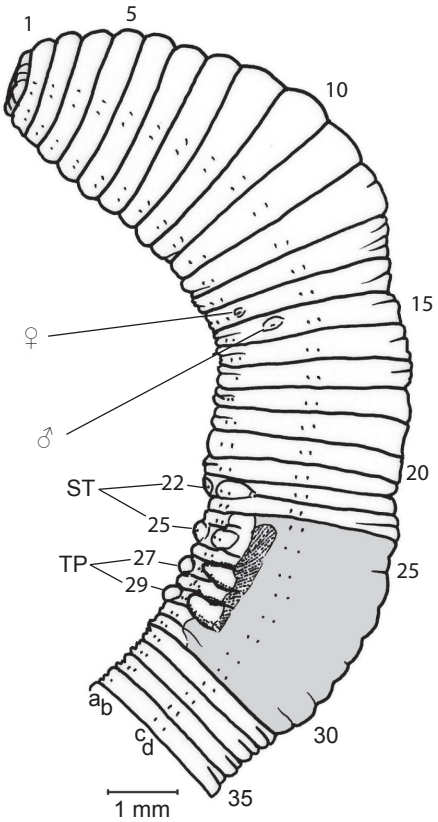

Fig. 2 *Eisenia japonica*, a syntype from Enoshima (Berlin Nr. 2117). ST – setal tumescence; TP – tubercula pubertatis.

slight damage at its hind end and with soil attached, here it is sketched and figured (Fig. 2) and a sample of loose tissue taken from the damaged area for DNA analysis.

Material Examined/Localities: Syntypes: Berlin with non-original label stating 'Kat. No. 2117 *Allolobophora japonica* Michlsn. 8 Syntypen! Enosima Hilgendorf', one damaged specimen herein sketched. [Note: a stout red hair was found in the No. 2117 sample jar, is possibly Michaelsen's eyelash!]. Hamburg V119–122 with non-original label stating '*Allolobophora japonica* Type material', comprising V119 – a specimen lacking anterior (removed by Michaelsen?) and a complete specimen (sketched); V120 – two curled and complete specimens that superficially agree with V119; V121 – two large, macerated matures (l~145–150 mm, both sketched as possibly the Hokkaido syntypes – see Fig. 3); V122 – one macerated mature (l~60 mm) plus an anterior part of another specimen. None of the Hamburg 'syntypes' had been dissected altough Michaelsen remarked that his larger Hokkaido specimens were too poorly preserved for this, thus V121, at least, may represent the missing Berlin 2115 syntypes with others of the V119–122 series questionably from Enoshima.

Topotypic specimens from Enoshima type-locality from around Okutsunomiya shrine, several collected by RJB, 8.X.2002 and, significantly, 16 specimens (NMST An417) collected on

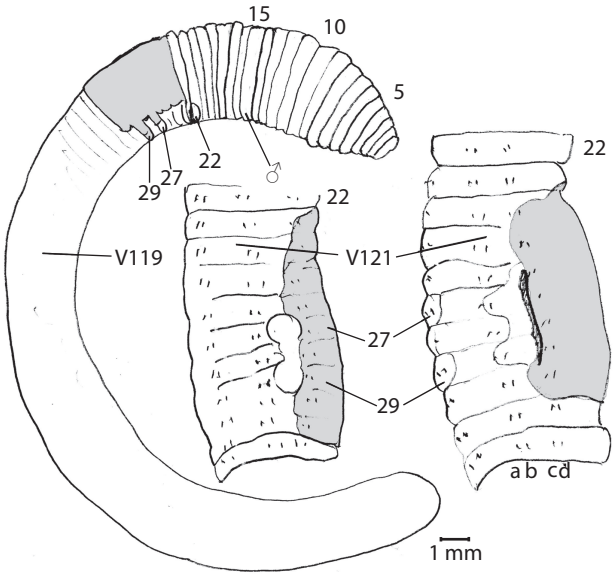

Fig. 3 *Eisenia japonica*, 'types' (Hamburg, V119, and midriffs of both V121 specimens).

29.III.2010 (exactly 135 years after F. Hilgendorf's visit) plus 11 specimens (NMST An418) from same locality on 18.IV.2010; from these batches two mature specimens each were sent to Hungary Natural History Museum, Budapest (HNHM/15530) and Senckenberg Museum für Naturkunde, Goerlitz (catalog no. 1790). Also from Kyorin University, Miyashita-cho, Hachioji-shi, Tokyo (e.g. sample Id.20000705 ident. RJB 3.VII.2001); Kamakura (coll. RJB 17/22.X.2002); Yamanashi-ken (ident. RJB 8.I.2003); Okutama-yama (collected RJB, VII.2001 and 26.V.2003); Yokohama National University (YNU) Wadamachi Campus, Tokiwadai, Yokohama (coll. RJB 5.III.2004); Tomakomai, Hokkaido (YNU specimens 18–21.IX.2001 ident. RJB 8.V.2003) plus specimens collected from same site by RJB on 4.X.2006; 'Buna' beech forest on summit of Mt. Oyama, Tanzawa Range, Kanagawa-ken coll. RJB 26.IV.2004; specimens from bank of Fudogawa stream, Ojiyamakoen Park (coll. RJB 2.II.2007), four specimens from fallow ricefield in Haguri 1-chome, Kurosatsu (coll. RJB & MJG 17.VI.2009) all in Otsu-shi near Lake Biwa, Shiga-ken [Lake Biwa Museum (LBM) collection LBM1380000019, -106 and -107 respectively]; single mature from Hodogaya park next to Commonwealth Graves Commission Cemetery (coll. RJB 25.IV.2010 NMST An415) and this specimen sketched (Fig. 4) and tissue taken for its DNA; from shrine gardens at Shuzenji, Izu-hanto, Shizuoka-ken (coll. RJB + YH 7.V.2010 but specimens not retained).

Easton (1981, p. 43) was uncertain which 'Enosima' Michaelsen referred to, but almost certainly it is Enoshima, Kanagawa-ken, the site of the first marine biological laboratory in Asia that Mr Edward Sylvester Morse founded in 1877, only two years after F. Hilgendorf had visited the island yet, as he left Japan in 1876, the two men never met.

Diagnosis: First dorsal pore 4/5. Spermathecal pores in 9/10/11 in c or cd lines. Clitellum 23,24–30,31. Tubercula pubertatis on 24,25–29 with raised papillae on 27 or 27 & 29; tumescences around ab of some of 22, 25, 26 and 32, at least. Setae closely paired. Holandric, seminal vesicles in 9–12. Spermathecae small in 9 and 10. Holoic, vesciculate.

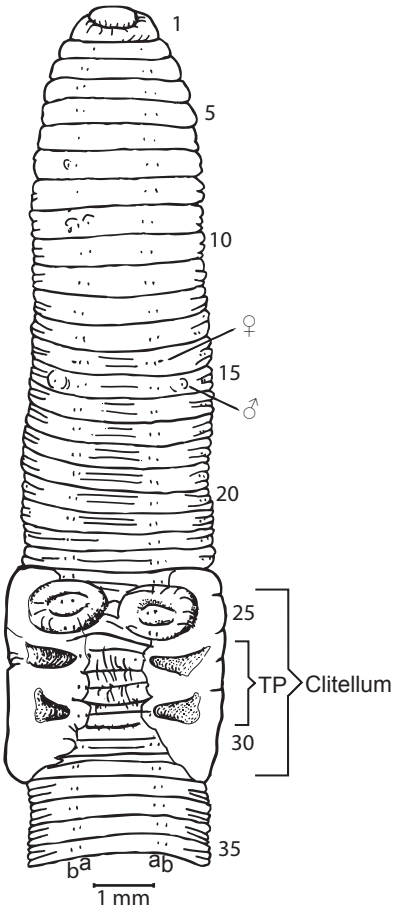

Fig. 4 *Eisenia japonica*, distinct specimen from Hodogaya-ku, Yokohama (NSMT An415).

Distribution: Considered endemic to Japan (Hokkaido to Kyushu but excluding Ryukus), Korea and possibly China [e.g. from 'Sansei' by Ohfuchi (1951, p. 62)], also listed in the Red Data Book of the Russian Federation (Anon 1997) from Sakhalin Island, north of Hokkaido (Perel 1979, p. 78). Claimed from Germany [Graff (1954) perhaps after cited 'Wilcke (1940)' report from garden soil] and a probable mistake from Slovakia in their 'Databank of Slovak Fauna' (http://zoology.fns.uniba.sk/checklist/interface/results_page.asp?binomen=EiseniaIII.2007); cf. EDDA 2007 and GENRES 2010 where it is listed as '*Eisenia japonica* (Michaelsen 1891) [FaEu 178405] – Japanese Red Worm' are all unconfirmed reports.

Habitat: From woodland soils, under litter and logs, paddy.

Behaviour: Docile to touch; handling or placing in water produces similar and distinctive odour to *Eisenia fetida* (pers. obs.), perhaps indicative of close phylogenetic relationship. When disturbed the anterior end retracts and then the prostomium protudes and probes looking somewhat like toothpaste initially squeezed from a tube.

External features: Size variable, 20–175 mm by 2–5.5 mm. Michaelsen (1892) wrote that

Enoshima specimens were small, up to 42 mm by 3 mm, whereas his poorly preserved Hokkaido specimens ranged up to 130 mm by 5½ mm. Enoshima syntypes (No. 2117) varied from 45–90 mm with 123–125 segments; Hamburg specimens (V119–120, 122) were 45–60 mm, and (V121) both were 150 mm with ca. 145 segments. The current Enoshima specimens are about 50 mm and those from Tomakomai in Hokkaido vary from 20–150 mm. Body cylindrical. Segments range 96–155. Colour is pinkish but rather transparent in life so that blood vessels and ingesta show through. Live specimens from Enoshima, both adults and immatures, often had distinct, bright yellow coelomocytes showing through at the tip of tail and, interestingly, anteriorly. Preserved specimens lose this yellow feature and are whitish grey or dark reddish brown. Clitellum pale buff in life and when preserved.

Note: red pigment, sometimes definitive of genus *Eisenia*, is not present. Prostomium, open epilobous, sometimes falsely appearing tanylobous (as with *E. fetida*). First dorsal pore small in 3/4, open from 4/5 (in syntypes and other specimens). Setae 8 per segment closely paired; (7/ratio quoted as aa:ab:bc:cd:dd:U = ca. 10:1:5:1:30:0.5 cf. Fig. 2). Nephropores inconspicuous, alternating irregularly on each side above b and d lines.

Clitellum saddle-shaped, 23,24–30,31,32. Male pores small, equatorial slits confined to 15 in mid-bc lines. Female pores minute, just lateral to b in 14. Spermathecal pores small, paired in 9/10/11 in c lines (or cd according to Michaelsen 1892), not found in syntypes. Genital markings comprise tubercula pubertatis in form of paired longitudinal ridges on ½24, 25–29 in mid-bc (seen in almost all syntypes and new specimens from Enoshima), usually with more discrete raised papillae situated more ventrally on 27 and 29; tumescences around ab, variably, of 16, 21, 22, 25, 26, 30 and 32 (and elsewhere?), especially in 22 and 25 but this may sometimes be unilateral. Specimens collected from Otsu-shi, Lake Biwa (by RJB 1.II.2007) had some variation in genital papillae, e.g. one having paired papillae in 29 on one side and a single papillae on 27 on the other. In the specimen from Hodogaya (An415) the ventral setae on 25 were most noticeably surrounded by distinctive tumescences but none were around setae of segment 22 (possible variety).

Internal morphology: Septa, none appear especially thickened. Hearts in 7–11. Gizzard in 17–18. Calciferous glands without sacs, intramural, annular in 11–12 (opening behind 10/11). Intestinal origin and typhlosole not noted. Nephridia holoic, sausage-shaped or digitiform bladders present. Male organs with testes/funnels holandric, iridescent in 10 and 11; seminal vesicles paired and small in 9–10, larger in 11, largest in 12. Ovaries small in 13. Spermathecae as two small pairs in 9 and 10 (or sometimes posterior to septa and thus in 10 and 11), with spherical ampullae, adiverticulate (not sought in undissected syntypes). Gut contains mostly fine soil and some organic material in dissected specimens.

Economic importance: Assumed to have contribution to soil fertility and involvement in ecological food webs, as typical with other earthworms, although an unconfirmed report has an ‘outbreak’ causing slumping of rice in irrigated rice fields in Kanagawa-ken (Japanese regional newspaper article, October, 2005). A Korean fishing website (accessed 17.VIII.2010) list among its bait worms: ‘*eunnaksijireongyi* (*Allolobophora japonica gingantica*) [sic = *gigantica*], *soenaksijireongyi* (*Allolobophora japonica minuta*)’.

Taxonomic notes: Gates (1975) provided a detailed account of this species. Although ‘varieties’ were recognized as *E. japonica gigantica* and *E. japonica minuta* by Oishi (1934, p. 134), these were considered dubious and combined by Easton (1981, p. 43) and by Easton (1983, p. 480) – a conclusion with which Blakemore (2003) concurred. Nevertheless, the marker characters for morphs of *E. japonica* – that appear to be mere intergrades – as used

by Oishi (1934) and later by Easton (1981, Tab. 2), are given in Tab. 2 herein. Compare also to *Helodrilus hachiojii* Blakemore, 2007 (found sympatrically at Lake Biwako) as briefly summarized below.

Tab. 2 Characters of *Eisenia japonica* morphs after Oishi (1934) [cf. Easton, 1981]

	E. j. minuta	***E. j. typica* [*japonica*]**	***E. j. gigantica***
Length (mm)	42–55 [24–55]	60–102 [42–102]	139–175
Diameter (mm)	1.75–2.0 [1.75–2.80]	3.5–5.0 [2.5–5.0]	5.2–7.2 [3.5–7.2]
Segment number	110 [85–110]	102–140 [96–140]	125–151
Colour	Uniformly whitish grey	Anterior pink, posterior whitish grey	Dark reddish brown
Shape of TP	Round	Triangular	Intermediate

TP – tubercula pubertatis.

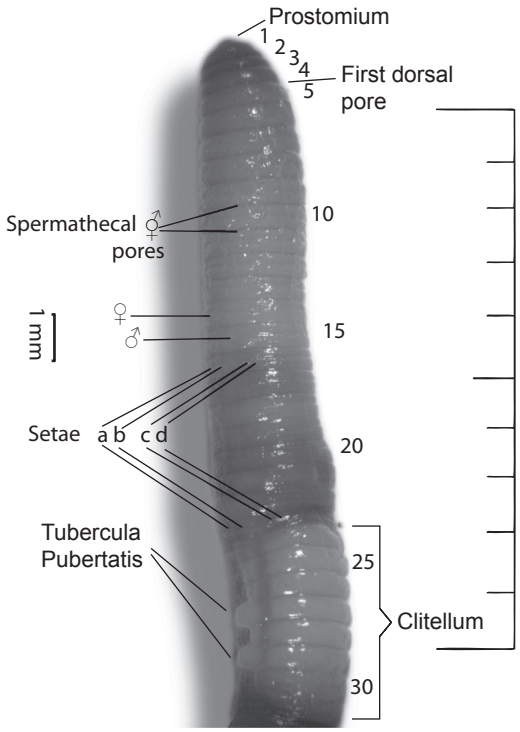

Fig. 5 *Eisenia japonica* from Hachioji, western Tokyo – labeled photograph clearly showing the tubercula pubertatis on 27 and 29 but not the details possible with inked Figs.

Helodrilus hachiojii Blakemore, 2007

Helodrilus hachiojii Blakemore, 2007a: 17, Fig. 1; 2008a, b; 2010. [From Hachioji-shi. Types in Tokyo NSMT An371 (H), 372-3, 374-6 (Ps)].

Diagnosis: Length 50–70 mm. Pinkish with lightly pigmented brown dorsum. Anterior body cylindrical, posterior flattened rectangular. Prostomium epilobous. First dorsal pore at 4/5. Setae closely paired, in anterior part at least. Spermathecal pores not found. Male pores confined to 15. Clitellum saddle-shaped, in 23–31. Tubercula pubertatis in form of paired papillae on 29 lateral of setae b. Calciferous glands in 11–12 (and 13–14). Nephridia holoic, bladders (mostly) lacking. Spermathecae (and spermatophores) lacking.

Material Examined/Localities: Types NSMT-An 371 – Holotype (H) clitellate mature, dissected and sketched; Paratypes (Ps): An 372-3 – P1-2, two sub-adults, dissected; An 374-6 – P3-5, one aclitellate juvenile and two immatures, all lacking tubercula pubertatis, inspected. All from Komiya Park, Hachioji, western Tokyo (ca. 35° 40‘ N 139° 19‘ E) collected by RJB and Yuko Hiramoto 22.X.2004); same location and collectors six years later on 5.IX.2010: Hungary Natural History Museum, Budapest (HNHM/15531) and Senckenberg Museum für Naturkunde, Goerlitz (catalog no. 1789) – two mature specimens each. Specimens LBM: 1380000005 ex Accession Batch Number FY2007–11 – one mature from north of the Lake Biwako (ca. 35° 20′ N 136° 10′ E) collected by RJB and Eiso Inoue on 4.X.2007 from moist mud of harvested rice paddy opposite konbeni store at Takatsuki en route to Saugura at Shiotsuhama, Nishiazai-cho; undissected but externally it complies with *H. hachiojii*; LBM1380000089 – one specimen from Kaideima-cho, Hikone-shi, Shiga-ken (coll. RJB, MJG and Univ. of Shiga Prefecture party 18.VI.2009); LBM 1380000105 – three specimens, one of them dissected from Shinme 2-chome, Otsu-shi, Shiga-ken (coll. RJB and MJG 17.VI.2009).

Habitat: In mud beside creek draining spring-fed moat of Otanibenzaiten shrine, Hachioji. A later 2009 Lake Biwa trip found several specimens in moist soil of rice paddy (at Hikone) and under water in drain near an old walled farmhouse (at Shinme).

Behaviour: Docile, i.e., no lashing as in pheretimoids; handling elicits distinctive odour as for *Eisenia fetida* and as noted for *E. japonica* above.

Species associations: From type-locality – small microdriles (tubificids?) and large pheretimoid megadriles e.g. members of the *Amynthas corticis* (Kinberg, 1867) species-complex. Lake Biwa sites had pheretimoids, lumbricids, moniligastrid *Drawida*, and ocnerodrilid *Eukkeria* present plus leeches (details in Blakemore 2007b, 2008a, 2010 and in prep.).

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5. References

[For brevity, not all historical taxonomic authorities are presented here; for earlier taxonomic references see Michaelsen (1900), Easton (1981) or Sims & Gerard (1985)]

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