DANCES WITH WORMS - Biology, ecology, taxonomy and Worm Species Suitable for Vermicomposting

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"*All the fertile areas of this planet have at least once passed through thebodies of earthworms*." - Charles Darwin

Basic biology (see Biology texts and eg. Gates, 1972; Lee, 1985; Sims & Gerard, 1985; Edwards & Bohlen, 1996). Earthworms are promiscuous, polygamous, hermaphrodites. Their reproductive strategy involves mate recognition, mutual exchange of sperm, and shedding of eggs within a protective and nutritive **cocoon**. Some families have direct fertilization and others exchange sperm-packets (**spermatophores**), but for most species, mating, or **amphimixis**, is by two individuals going head to tail with the male pores of one lining up, successively, with the spermathecal pores of another. Sperm from the concopulant is stored in the **spermatheca** (plural **spermathecae**). The **clitellum** (plural **clitella**), a girdle-like thickening of the body wall formed in the middle to fore-region, detaches and moves forward along the body, receiving eggs (from the female pores) that are fertilized by a partner's sperm (from the spermathecae) to form embryos within the shed cocoon. Development and hatching of the young worms is remote from the adults, without a larval stage. Some species are **parthenogenic**, producing viable offspring without mating, but these still retain their reproductive anatomy, or at least the rudiments.

The design of an earthworm is a tube, the digestive system, within a tube, the muscular body. The space between these two tubes is the **coelom**, filled with fluid that acts as a **hydrostatic skeleton**. The body is **annular**, compartmentalized into segments that are most specialized in the anterior, forming rings externally where divided internally by the **septum** (plural **septa**). Due to the earthworm's subterranean habitat and its need to build and maintain burrows, there are no external appendages and only subtle differences in body form prevail. Externally, apart from variations in size and position of superficial pores, clitella, and **genital markings**, most worms look alike. It is essential in most cases therefore to dissect specimens so that the nature of their internal organization can be revealed. Only then can they be recognized by relating internal anatomy to consistent external features.

Characters used to differentiate species are: **Setae** (sing. **seta**), the 'bristles' for locomotion and defence, are **lumbricine** (8 per segment), **anisochaetine*** (uneven, eg. 8 increasing further back), or **perichaetine** (>8). The **prostomium** (the flap over the mouth) is **prolobous**, **epilobous**, or **tanylobous**.(see figures). Female pores are invariably on segment 14 (unless anterior segments are deleted) from the **ovaries** in 13; male pores may be on 13, 15, or around segment 18 (in different families) with ducts from the **testes** in 10 and 11. **Prostate** glands (where present) send ducts to 17 and/or 18 and come in three flavours: tubular, tubuloracemose, or racemose (like a bunch of grapes). **Nephridia** (excretory tubules) are either **holoic** (one pair per segment) or **meroic** (more than one pair per segment). **Gizzards** for munching food can be single or multiple, either (o)esophageal or intestinal, or both. The (o)esophagus may have **calciferous glands** with various functions, and the intestine **caeca** (sing. **caecum**) to culture microbial gut symbionts. **Dorsal pores** secrete moisture for lubrication and respiration. Worms have hearts and nerves, but no lungs nor eyes, and only tiny brains.
Size is not so important as worms are soft bodied and can stretch, however the smallest species are about an inch (2.5 cm) the largest up to 7 feet (3 m) long, but some (unconfirmed) reports are of 21 feet (7 m). Colo(u)r can sometimes be useful indicator of identity and ecology – i.e., whether unpigmented or vivid, and some worms glow in the dark. Because worms are part of the **cryptofauna**, we know little of their behaviour patterns.

Ecology 101

Worms eat dirt. They are **detritivorous** where they feed on decaying organic matter and **geophageous** where they feed mainly in the soil mineral layers. Lee (1959, 1985, 1987) categorized worms into three **broad ecological strategies** (these precede, supercede, and are mostly equivalent to French terms currently in use in some quarters):

1. **Litter species** – living and feeding in the surface mulch layers, from these come the **vericomposting** species.
2. **Topsoil species** – burrow into the soil but feed at the surface where they produce **casts**.
3. **Subsoil species** – mostly dwell deep in the soil feeding in the lower root zones.

Buckerfield (1994) has simplified classification of common earthworms as either "**composters**" or "**fieldworkers**" - vermicomposting species that can be readily cultured do not survive well in the field, and are not the same as the most beneficial of field worms, and vice versa.

Ecological requirements (eg. moisture, temperature, food supply), and rates of reproduction and growth for several vermicomposting species can be found elsewhere in texts and papers (eg. Lee, 1985; Edwards & Bohlen, 1996). An interesting finding by Miles (1963) was that when *Eisenia fetida* was cultured in sterile soil to which soil fungi and bacteria were added, specimens failed to grow, but when soil protozoa were added, the worms grew to maturity.

Earthworms have many, many predators (eg. grizzly bears, foxes, moles, platypuses, birds, snakes, frogs, fishes, insects, ants, leeches, planarian flatworms, and there is even a cannibalistic earthworm in Africa); and parasites (eg. carnivorous flies, helminths, nematodes, protozoans, bacteria, viruses). Earthworms are the intermediate hosts of

certain parasites of higher animals, and have been implicated in the distribution of both pathogenic and beneficial plant microbes.

Regeneration of damaged heads and/or tails is possible in many species (see Blakemore, 1999a).

Taxonomy in a nutshell

Governed by codes of ICZN (1999), authors give species scientific names to avoid linguistic and regional confusion with vernacular names. Classification is heirarchical and phylogenetic: Species->Genus->Family->Order->Class->Phylum->Kingdom. Genus name always starts with a CAPITAL and may be abbreviated, putting a capital before a species name is a **flogging offence**. The authority follows the species name (and is in braces only if the species has been subsequently transferred to a different genus), eg. *Lumbricus terrestris* Linnaeus, 1758.

Vermicomposting species

Of a worldwide total of almost 4,000 described megadrile earthworm species, detailed ecological studies have been made on fewer than 20 of these (Reynolds, 1998, Blakemore, 1999b). (Approx. regional species totals are: UK and Ireland - 45; Japan – 78; North America – 160; NZ – 192; Tasmania – 260; India – 350; Australia – 350+). Those species used in vermiculture around the world are mainly "Litter" species that include, but are not limited to:

Eisenia fetida (Savigny, 1826) "Tiger Worm" and its sibling species *E. andrei* Bouché, 1972 "Red Tiger Worm";

Perionyx excavatus Perrier, 1872 "Indian Blue";

Eudrilus eugeniae (Kinberg, 1867) "African Nightcrawler";
Amynthas corticis (Kinberg, 1867) and *A. gracilis* (Kinberg, 1867) "Pheretimas" (formerly known a *P. hawayana*);
Eisenia hortensis (Michaelsen, 1890) and *Eisenia (=Dendrobaena) veneta* (Rosa, 1886) "European Nightcrawlers";
Lampito mauritii Kingerg, 1867 "Mauritius Worm".
Additional species used in Australia are *Anisochaeta buckerfieldi* (Blakemore, 1997), *Anisochaeta* spp. and *Dichogaster* spp.
Claimed use of *Lumbricus rubellus* Hoffmeister, 1843 "Red Worm" and *Polypheretima elongata* (Perrier, 1872) are probably misidentifications. With tongue-in-cheek, John Buckerfield has pledged to eat a specimen of *Lumbricus rubellus* actually found in a commercial vermiculture operation, any wormgrower who claims their "Red worms" are *L. rubellus* should have the similar conviction to eat them if they aren't…

Different species are used regionally for bioremediation and land rehabilitation and for fishing bait markets, eg. *Lumbricus terrestris* Linneaus, 1758 "Canadian Nightcrawler" which is sold at a premium in North America.

Earthworm **hybrids** are possible for some species, but have not been confirmed for *E. fetida* (see Gates, 1972: 103).

Other worm species involved in *vermi*composting are of Family Enchytraeidae (enchytraeid or pot worms), microdriles (small 'aquatic' worms), free-living nematodes (roundworms), and, if you are really unlucky, predatory planarians (flatworms) and leeches.

(Mis)quoting the Clown in Shakespear's Anthony and Cleopatra, *"I wish you all joy of the worm."*

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 *The term "anisochaetine" is newly introduced in this paper.