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## Journal of Natural History

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/tnah20>

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Published online: 21 Feb 2007.

To cite this article: Emilia Rota & O. Schmidt (2006) *Dichogaster bolau* (Oligochaeta: Octochaetidae), an unusual invader in a swimming pool in Ireland, *Journal of Natural History*, 40:3-4, 161-167, DOI: [10.1080/00222930600630875](https://doi.org/10.1080/00222930600630875)

To link to this article: <http://dx.doi.org/10.1080/00222930600630875>

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## ***Dichogaster bolau* (Oligochaeta: Octochaetidae), an unusual invader in a swimming pool in Ireland**

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(Accepted 7 February 2006)

### **Abstract**

The exotic octochaetid earthworm *Dichogaster bolau* (Michaelsen, 1891) is reported from a heated indoor swimming pool in Cork, Ireland. The worms were noticed to emerge from drains in shower rooms and gaps between floor tiles almost daily for over a year. This is the first record of the species from Ireland or Britain. In the last two decades, this pantropical “tramp” native to central Africa has been in the limelight because of its ability to thrive and spread within the plumbing systems of urban buildings in Fennoscandia. It appears that a buffered microclimate and constant food supply (biofilm, organic residues) such as those found in domestic/sanitary sewers allow these worms to be active year-round and prolific even at high latitudes. We also speculate that the prominent vascularization of the body wall and inner organs may facilitate their survival and spreading under flooded conditions. Earthworms are not known to act as vectors of human parasites or pathogens. However, control of indoor earthworm populations in households and public amenity buildings is desirable because of the loss of aesthetic value and perceived lack of neatness caused by their presence. In the present case, *D. bolau* was controlled by repeated applications of concentrated salt solutions into drains and on to floor tiles and manual collection of the emerging worms.

**Keywords:** *Dichogaster bolau*, invasive species, Ireland, new record, octochaetid, tropical earthworm

### **Introduction**

About 3% of all known species of earthworms are widely distributed in regions isolated from their apparent native range (“peregrine species”) and are presumed to have been transported across otherwise impassable barriers by humans (Lee 1987). Such long-distance anthropochorous dispersal has probably occurred since the beginning of human travel and trade, but in the last five centuries, and expanding exponentially in the last 100 years, faster and bigger transport has kept up and multiplied sources, pathways, modes, and circumstances for dispersal (National Research Council 2002). Plant importations for horticulture, the fishing bait trade, and soil used as ships’ ballast account for the majority of earthworm introductions (Lee 1987). Gates (1982), collaborating with the US Bureau of

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Published 26 April 2006

ISSN 0022-2933 print/ISSN 1464-5262 online © 2006 Taylor & Francis

DOI: 10.1080/00222930600630875

Quarantine during 1950–1982, identified 50 different species of earthworms intercepted at US ports with plant material arriving in cargos, by mail, or with passengers' baggage.

If only due to climatic constraints, most exotic imports have low chances of surviving and spontaneously establishing viable populations in the new area: generally, earthworm species from higher latitudes are poor colonizers in tropical and mediterranean environments and vice versa. Thus, exotic lumbricids are restricted to areas which are within the climatic range of the native northern temperate zone (Edwards and Lofty 1977). For instance, *Dendrobaena octaedra* (Savigny, 1826), parthenogenetic and eurytopic in the northern Palaearctic (Terhivuo 1988), is recorded from few southern countries and only at high altitude (Fragoso et al. 1999; and personal observations); *Eisenia fetida* (Savigny, 1826), which in the temperate Holarctic thrives in natural and anthropogenic accumulations of plant residues, manure, and other organic materials, and which has been exported around the world for vermiculture, occurs only sporadically in tropical countries (Gates 1972).

For many introduced species, association with human-made habitats is the key for survival in the new area. They may remain confined indoors, such as in culture beds of worm farms, nurseries of exotic plants, greenhouses and botanical gardens; or, provided the climate, soil, and biotic conditions are suitable, they can take advantage of human disturbance of the outdoor environment. Peregrine species with wide habitat tolerances, living in temporary burrows and with geophagous habits, do indeed benefit from soil cultivation, due to an enhanced food supply, and have become the dominant earthworms of agricultural lands and gardens in temperate and tropical regions of the world (Lee 1985; Lavelle et al. 1998).

More and more instances are reported, however, of exotic earthworms being able to sustain populations outside human influence and/or, to various degrees, beyond their expected climatic and habitat tolerance, proving that these species not only have high ecological plasticity but may have undergone some local adaptation and selection. For instance, some pheretimoid megascolecids native to tropical eastern Asian and traded worldwide as fishing bait are capable of penetrating natural or semi-natural North American forests even under subtropical or temperate climates, and are seen as a threat to indigenous biodiversity, through their impacts on habitats and ecosystems (Burtelow et al. 1998; Callaham et al. 2003). Of a more temperate origin (southern South America, according to Gates 1972), the acanthodrilids *Microscolex dubius* (Fletcher, 1887) and *M. phosphoreus* (Dugès, 1837) are now widely represented in anthropogenic habitats throughout regions with mediterranean climate and can survive outdoors even in continental Europe (Csuzdi 1986; Sims and Gerard 1999). None of these peregrine species, however, have succeeded in forming spontaneous populations at higher latitudes, in spite of recurring introductions via plant importation.

In the last two decades, the pantropical octochaetids *Dichogaster bolau*i and *D. saliens* (Beddard, 1893), native to central Africa, have come to notice because of their ability to thrive and spread within the plumbing systems of urban buildings in Fennoscandia (Terhivuo 1991; Erséus et al. 1994; Erséus 1995). Once colonized, possibly by escapees from ornamental potted plants (Terhivuo 1991), the urban sewer system, which is constantly wet or humid, rich in organic matter, and sheltered from the rigours of the outdoor climate, can act as a secondary dispersal source for these tropical faunal elements, allowing them to proliferate in cities as far north as Oulu in Finland. More recent findings of *D. bolau*i in the same type of habitat in Hungary (Csuzdi et al. 2004) and the present record from a swimming pool in Ireland demonstrate that the same process of colonization may be under way in other parts of Europe.

Here, we outline the morphological and physiological features of *D. bolau*, we discuss briefly possible pathways for the introduction and spread of this species to Ireland and we evaluate its potential as an invasive species and the risks associated with the occurrence of earthworms in the domestic environment.

## Methods

One of the authors (O.S.) was contacted by an Environmental Consultant regarding a “worm infestation” in a swimming pool in the city of Cork, Ireland. This heated (water temperature about 32°C) indoor pool is part of a health club in a hotel complex. Patrons and management were alarmed by the emergence of brightly red coloured, lively and mobile worms primarily from drains in shower rooms and also, less frequently, from cracks in the grouting between and cavities beneath the floor tiles next to the pool. Live worms were seen almost daily over a period of about 12–18 months.

Specimens were obtained on 14 and 28 May 2002 by flooding the tiled floor surface next to the pool with (chlorinated) pool water and collecting the worms emerging from gaps between the tiles. Specimens (15 juveniles, five adults) were preserved in formaldehyde (8%) and identified using Sims and Gerard (1999). The material is kept in E.R.’s personal collection.

## Results

The adults were determined to be exotic octochaetid earthworms, *Dichogaster bolau* (Michaelsen, 1891). [The monophyly of the classical family Octochaetidae is not supported by molecular data (Jamieson et al. 2002), which rather suggests to regard *Dichogaster* as a specialized member within Megascolecidae.] This is the first confirmed record of this species from Ireland or Britain.

### *Description of worms*

Adult body size 20.7–25.2 by 1.4 mm. Segment number 66–86. All (fixed) individuals coiled into a back bend. Segments VII–XII triannulate, from XXI on pluriannulated. Clitellum over XIII–XX, with intersegmental furrows generally obliterated dorsally except at 13/14. Somatic chaetae in close ventral and ventrolateral pairs, conspicuous throughout. First dorsal pore in 5/6. Female pore single, midventral in XIV. Male pores paired in XVIII. Genital chaetae *ab* associated with prostatic pores in XVII and XIX, one chaeta long, toothed, the other shorter, scalpel- or spoon-shaped. Inner side of body wall and walls of inner organs richly vascularized. Spermathecae two pairs, opening laterally to chaeta *a* in 7/8, 8/9, each endowed at mid-length with a small, spherical, long-stalked diverticulum filled with sperm. Ovaries fan-shaped, paired in XIII; egg receptacles in XIV, nearly as conspicuous as ovaries due to large size of oocytes.

## Discussion

*Dichogaster bolau* was originally described from specimens collected in Bergedorf, a town near Hamburg in Germany, and was immediately recognized as an introduction from the tropics (Michaelsen 1891). Four years later, the species already appeared as “almost

worldwide in its distribution" (Beddard 1895, p 559). According to Fragoso et al. (1999) it has by now been recorded from five continents and 43 countries.

*Dichogaster bolau* is a small epigeic species. The substrate in which it was first discovered was fermenting bark of a German tannery (Michaelsen 1891). Curiously, in those same years (1891–1894) it was collected "in Poliporen" (mushrooms growing on wood) in Togo, a former German colony in West Africa (Michaelsen 1897). Tropical Africa appears indeed to be the worm's homeland (Omodeo 1958), with records from litter and decaying logs in native gallery forests (Omodeo 1973) and from the trunk and crown humus of endemic palm trees (Wasawo and Omodeo 1963). The species is not found in old tropical forests outside Africa, unless there is a high level of human disturbance (e.g. Lavelle and Lapid 2003).

In the tropics, *D. bolau* is commonly found in a variety of managed ecosystems such as croplands, pastures, tree plantations, fallows, and organic wastes (Fragoso et al. 1999). In India it was also found in the plumbing of a bathtub and in ditches draining waste effluents from human habitations (Gates 1972). Likewise, it was collected near sewage drains and cesspools in the yards of old houses in urban areas of the eastern side of Tenerife (Talavera 1992). Thus, this species, like the epigeic lumbricids *Eisenia fetida*, *Dendrobaena hortensis* (Michaelsen, 1890), and others (Judas and Büchner 1989; Sims and Gerard 1999), is naturally attracted to, and can establish permanent populations in, domestic sewerage systems.

*Dichogaster bolau* is indeed one of the most adaptable tropical earthworms, both at regional and local levels, with wide climatic and edaphic tolerances: it can stand wide ranges of temperature (18–30°C), precipitation (800–4725 mm), and pH (5.0–8.2), and is tolerant to very low levels of nutrients and organic matter (Fragoso et al. 1999).

The species has a propensity to live in soil around the roots of potted plants and under the bark of trees (Omodeo 1958; Gates 1972; Terhivuo 1991), habitats where, well protected, it can survive long trips and is easily transported. In fact, overseas distribution may perhaps always be ascribed to human-mediated transportation of tropical crops and ornamentals: Gates (1982) cited interceptions in soil with *Anthurium*, arum, banana, orchids, *Dicentra*, *Gloxinia*, bromeliads arriving to various ports of entry to the USA, from Brazil, Cape Verde Island, China, Costa Rica, Hawaii, Mexico, the Netherlands, the Philippines, Puerto Rico, and Venezuela. In many warm countries, human agency must also mainly be responsible for subsequent local and regional dispersal, via secondary releases from botanic gardens, horticultural trade centres, and householders.

Although introduced repeatedly to North America, records of *D. bolau* there have so far been largely confined to greenhouses (as far north as Ontario and New Brunswick; Reynolds and Wetzel 2004); outdoor reports are only from man-made habitats in the southernmost USA (Texas, Florida, Georgia) (Gates 1982; Csuzdi 1997). By contrast, in northern Europe, invading the urban sewer system has given the species an opportunity for active dispersal in a vacant niche, each infected site being potentially an effective dispersal source via the water drains.

What makes the urban sewer system a favourable habitat for colonization by *D. bolau*? For epigeic "tropical tramps" (see Lee 1985) such as *D. bolau*, local dispersal is most efficient in warm humid regions, where they can be active year-round and reproduce uninterruptedly, and seasonal floods can assist in the spreading of the species. In *D. bolau*, the prominent vascularization of the body wall and inner organs facilitates an occasional amphibiotic lifestyle. The species' activity and breeding are year-round when conditions permit, e.g. in northern India and the Congo basin (Gates 1972; Omodeo 1973).

Continual activity seems also possible in the urban sewer system, a habitat with a buffered microclimate that remains wet even in the summer and warm even during the winter, and where highly nutritious food is always available in the form of biofilm. In addition, warm water, paper tissue, hair, fats, faecal matter, and other organic debris generally washed down sanitary drains or flushed down the toilet are harmless or nourishing for earthworms.

Barois et al. (1999) provide a detailed report on the reproductive biology of a population of *D. bolau* from Sambalpur, India: generation time was 3 months; worms produced large (each 6.5 mg fresh weight, i.e. 8% of adult weight) and numerous cocoons (46.6 cocoons per adult per year, each yielding two hatchlings); incubation time was 8.5 days. According to Senapati and Sahu (1993), the incubation time in India can be as short as 7 days. Judging from the rapid succession of the Scandinavian records (Terhivuo 1991), once established, the rapidity with which the species can spread in urban sewerage appears also rather high.

Both in Finland and Sweden, "bathroom worms" were first discovered in the act of crawling along the wall of sanitary ware. What makes the worms emerge, sometimes in high numbers (Terhivuo 1991; Erséus et al. 1994; Erséus 1995) from the drains? Seasonal outbreaks of the populations would seem to be an unlikely explanation, since records occurred all year round in both Nordic countries. It is possible rather that worms were escaping exposure to irritant cleaning agents. (*D. bolau* has also relatively little tolerance of low pH situations).

Oral accounts of frequent observations over one year or more in the present case suggest that populations of *D. bolau* were established successfully and lastingly in this heated indoor swimming pool on a Western European island. The source of infestation is unknown. A possible source was potted ornamental plants which had been placed in the pool room after a refurbishment and which were believed to have been imported, but no details are available (E. Hogan, personal communication). The importation of plants into the European Union is regulated in detail by European plant-health legislation, aimed at preventing the introduction and spread of "harmful organisms", which in the case of Animalia is restricted to insects, mites, and nematodes (Council of the European Union 2000). Importation of soil is prohibited from most non-member countries, while importation of soil attached to or associated with plants from such countries is subject to appropriate measures, including inspection and treatment to ensure that it is "found free from insects and harmful nematodes" (Council of the European Union 2000, p 38, 55). It is therefore likely that earthworms are frequently introduced with potted plants.

A number of invertebrate animals can be uninvited visitors to outdoor swimming pools, usually simply by falling into the water (Rachesky 1973; Stachecki and De Haan 1997). Anecdotal evidence suggests that this is a common, albeit undocumented, problem with earthworms, especially during times of surface migrations. The present case is the first report of an established, reproducing population in the anthropogenic environment of an indoor health club. Earthworms are not known to cause allergic reactions in humans or to act as vectors of human parasites or pathogens, in fact they can reduce the pathogen load in sewage sludge, for example (Edwards and Lofty 1977). While swimming pools can pose significant public health risks chiefly through microbial and viral infections (Dadswell 1996), the potential of earthworms to mediate or enhance these risks (e.g. by transporting sewage-derived pathogens on to floor tiles) is likely to be negligible because of their restricted mobility. This is in contrast to some other, scavenging and highly mobile invertebrate pests in similar indoor situations such as cockroaches which, in addition to

being vectors of pathogens, produce allergens associated with asthma (Rivault et al. 1994; Miller and Peters 2004).

Some patrons of the Cork swimming pool reacted with alarm and disgust to the worm infestation, and a few even demanded a refund of their fee for membership of the health club. Even though they are unlikely to have public health implications, control of indoor earthworm populations in households and public amenity buildings is desirable because of the loss of aesthetic value and perceived lack of neatness associated with their presence. In the present case, *D. bolau* was controlled in the swimming pool by repeated applications of concentrated salt solutions into drains and on to floor tiles and manual collection of the emerging worms: a simple and non-disruptive method to avoid economic losses from this benign, unusual invader.

## Acknowledgements

We thank Mr Eamonn Hogan, Cork, for bringing this record to our attention and for collecting specimens.

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