New and little-known earthworm species from the Ivory Coast (Oligochaeta: Acanthodrilidae: Benhamiinae and Eudrilidae)

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Abstract
In the framework of the international project called “Conservation and Sustainable Management of Below-Ground Biodiversity”, soil macrofauna collections were carried out in the Centre-West Ivory Coast. Altogether, 13 earthworm species were recorded, of which four belonged to the family Eudrilidae and nine to the family Acanthodrilidae. From the species collected, two, Dichogaster (Dichogaster) eburnea sp. nov. and Dichogaster (Dichogaster) mamillata sp. nov., proved to be new to science. To accommodate the enigmatic eudrilid earthworm species Scolecillus compositus Omodeo, 1958, a new genus, Lavellea gen. nov., is proposed.

Keywords: Benhamiinae, Earthworms, Eudrilidae, Ivory Coast, new species

Introduction
The earthworm fauna of Ivory Coast is one of the most well known in Africa. Since the beginning of the 1950s, several taxonomic and many more ecological papers have been devoted to the earthworm research carried out in this West African country (e.g. Sciacchitano 1952; Omodeo 1955a, 1955b, 1958; Omodeo and Vaillaud 1967; Lavelle 1971, 1973, 1978, 1981; Tondoh 2006). This ongoing activity resulted in the recording of 58 earthworm species belonging to the families Acanthodrilidae and Eudrilidae (Table I). Nevertheless, our knowledge of the earthworm fauna of the Ivory Coast is far from complete. This is clearly seen if we take into account that this species number, recorded for a territory of 322,462 km², is the same as that for Hungary with a territory of 93,000 km². The reason for this is twofold. Firstly, most of the samples are mainly from two regions, the Lamto Natural Reserve and the Mount Nimba Reserve. Secondly, most of the samples were taken with quantitative sampling methods to answer ecological questions and not to explore the
| Family            | Species                                      | References                                      |
|-------------------|----------------------------------------------|-------------------------------------------------|
| Acanthodrilidae   | Agastrodrilus dominicae Lavelle, 1981        | Lavelle 1981, p 254; Csuzdi 2000, p 52          |
|                   | Agastrodrilus multivesiculatus Omodeo and Vaillaud, 1967 | Omodeo and Vaillaud 1967, p 927; Lavelle 1973, p 79 |
|                   | Agastrodrilus opisthognus Omodeo and Vaillaud, 1967 | Omodeo and Vaillaud 1967, p 926; Lavelle 1973, p 79; Csuzdi 2000, p 53 |
| Acanthodrilidae   | Benhamiona balantina (Omodeo, 1958)          | Omodeo 1958, p 46                               |
| Acanthodrilidae   | Benhamiona capilliseta (Omodeo, 1958)        | Omodeo 1958, p 57                               |
| Acanthodrilidae   | Benhamiona guineana (Omodeo, 1958)          | Omodeo 1958, p 39                               |
| Acanthodrilidae   | Benhamiona murrithae Csuzdi and Zicsi, 1994 | Csuzdi and Zicsi 1994, p 222                     |
| Acanthodrilidae   | Benhamiona ornata (Sciacchitano, 1952)       | Sciacchitano 1952, p 482                         |
| Acanthodrilidae   | Benhamiona pylaerti Csuzdi and Zicsi, 1994  | Omodeo 1958, p 41 (as B. robertiana var?)        |
| Acanthodrilidae   | Dichogaster (D.) arcifera Omodeo, 1958       | Omodeo 1958, p 68; Csuzdi 1997, p 36; Csuzdi 2000, p 55 |
| Acanthodrilidae   | Dichogaster (D.) baeri Sciacchitano, 1952    | Sciacchitano 1952, p 477; Omodeo 1955a, p 225; Csuzdi 2000, p 55; Tondoh et al. 2007, p 587 |
| Acanthodrilidae   | Dichogaster (D.) candida Omodeo, 1958        | Omodeo 1958, p 70                               |
| Acanthodrilidae   | Dichogaster (D.) eburnea sp. nov.           | Csuzdi 2000, p 55; Tondoh et al. 2007, p 587    |
| Acanthodrilidae   | Dichogaster (D.) enchytraeus Omodeo, 1958    | Omodeo 1958, p 84                               |
| Acanthodrilidae   | Dichogaster (D.) insularis (Michaelsen, 1895) | Omodeo 1958, p 67 (as D. montis-toi)             |
| Acanthodrilidae   | Dichogaster (D.) lamottee Omodeo, 1958       | Omodeo 1958, p 69                               |
| Acanthodrilidae   | Dichogaster (D.) leroyi Omodeo, 1958         | Omodeo 1958, p 65                               |
| Acanthodrilidae   | Dichogaster (D.) mamillata sp. nov.         | Omodeo 1958, p 76                               |
| Acanthodrilidae   | Dichogaster (D.) nematochaeta Omodeo, 1958   | Omodeo 1958, p 74                               |
| Acanthodrilidae   | Dichogaster (D.) papillosa Omodeo, 1958      | Omodeo 1958, p 85                               |
| Acanthodrilidae   | Dichogaster (D.) penigera Omodeo, 1958       | Omodeo 1958, p 72                               |
| Acanthodrilidae   | Dichogaster (D.) proandra Omodeo, 1958       | Omodeo 1958, p 78                               |
| Acanthodrilidae   | Dichogaster (D.) septemdecim Omodeo, 1958    | Omodeo 1958, p 82                               |
| Acanthodrilidae   | Dichogaster (D.) sexdecim Omodeo, 1958       | Omodeo 1958, p 81                               |
| Acanthodrilidae   | Dichogaster (D.) singula Omodeo, 1958        | Omodeo 1958, p 75                               |
| Acanthodrilidae   | Dichogaster (D.) terraenigræ Omodeo and Vaillaud, 1967 | Omodeo and Vaillaud 1967, p 934; Lavelle 1973, p 79; Tondoh 2006, p 336 |
| Acanthodrilidae   | Dichogaster (D.) tuzeti Omodeo, 1955         | Omodeo 1955, p 227                              |
| Acanthodrilidae   | Dichogaster (D.) undecim Omodeo, 1958        | Omodeo 1958, p 79                               |
| Acanthodrilidae   | Dichogaster (D.) wenkei (Michaelsen, 1931)   | Omodeo and Vaillaud 1967, p 936; Lavelle 1973, p 79; Tondoh 2006, p 336 (all as D. agilis) |
| Acanthodrilidae   | Dichogaster (Dt.) saliens (Beddard, 1893)    | Tondoh et al. 2007, p 587                        |
| Acanthodrilidae   | Guineoscolex coronatus (Omodeo, 1958)        | Omodeo 1958, p 56                               |
| Acanthodrilidae   | Guineoscolex inaequalis (Michaelsen, 1914)   | Omodeo 1958, p 48                               |
| Acanthodrilidae   | Guineoscolex mamillatus (Omodeo, 1958)       | Omodeo 1958, p 52                               |
| Acanthodrilidae   | Guineoscolex microscolecinus (Omodeo, 1958)  | Omodeo 1958, p 54                               |
| Acanthodrilidae   | Guineoscolex minusculus (Omodeo, 1958)       | Omodeo 1958, p 55                               |
| Acanthodrilidae   | Millsonia bouna Csuzdi, 2006                 | Csuzdi 2006, p 41                               |
| Acanthodrilidae   | Millsonia brevicepingulata Sims, 1986        | Sims 1986, p 283                                |
total earthworm diversity of the region investigated. Therefore, it is not surprising that a
survey of a previously unexplored territory reveals several undescribed species.

Most of the samples presented here were collected in the framework of the international
project “Conservation and Sustainable Management of Below-Ground Biodiversity” in the
Centre-West Ivory Coast. This project is being undertaken simultaneously in seven
countries and aims, in the first phase, to assess the impact of land management on soil
organisms across a gradient of forest disturbance.

Altogether 13 earthworm species were recorded, of which four belonged to the family
Acanthodrilidae and nine (including two undescribed species) to the family Eudrilidae.

| Family          | Species                        | References                                                                 |
|-----------------|--------------------------------|---------------------------------------------------------------------------|
| Acanthodrilidae | *Millsonia guttata* (Michaelsen, 1913) | Omodeo 1955a, p 221                                                        |
| Acanthodrilidae | *Millsonia lantioiana* Omodeo and Vailaud, 1967 | Omodeo and Vaillaud 1967, p 932; Lavelle 1973, p 79; Csuzdi 2006, p 39; Tondoh et al. 2007, p 587 |
| Acanthodrilidae | *Millsonia pumilia* Sims, 1965 | Sims 1986, p 306                                                            |
| Acanthodrilidae | *Millsonia schlegeli* (Horst, 1884) | Omodeo 1958, p 60                                                            |
| Acanthodrilidae | *Monothecodrilus monothecus* (Omodeo, 1958) | Omodeo 1958, p 50                                                            |
| Acanthodrilidae | *Pickfordia (Omodeoscolex) africana* (Omodeo, 1955) | Omodeo 1955b, p 8; Omodeo 1958, p 24                                           |
| Acanthodrilidae | *Pickfordia (Omodeoscolex) cisatlantica* (Omodeo, 1955) | Omodeo 1955b, p 12; Omodeo 1958, p 25                                           |
| Acanthodrilidae | *Pickfordia (Pickfordia) diatheca* Omodeo, 1958 | Omodeo 1958, p 34                                                            |
| Acanthodrilidae | *Pickfordia (Pickfordia) hemibalantina* Omodeo, 1958 | Omodeo 1958, p 36                                                            |
| Acanthodrilidae | *Pickfordia (Pickfordia) magnisetosa* Omodeo, 1958 | Omodeo 1958, p 30                                                            |
| Acanthodrilidae | *Pickfordia (Pickfordia) pseudoplanaria* Omodeo, 1958 | Omodeo 1958, p 33                                                            |
| Acanthodrilidae | *Reginaldia (P.) anomal a* (Omodeo, 1955) | Omodeo 1955a, p 219; Lavelle 1973, p 79; Tondoh 2006, p 336                    |
| Acanthodrilidae | *Reginaldia (P.) omodeoi* (Sims, 1986) | Omodeo 1955b, p 2; Omodeo 1958, p 27                                             |
| Acanthodrilidae | *Reginaldia (R.) ghanensis* (Sims, 1986) | Sims 1986, p 287; Lavelle 1973, p 79; Tondoh 2006, p 336                       |
| Acanthodrilidae | *Wegeneriella monothe ca* Omodeo, 1955 | Omodeo 1955b, p 2; Omodeo 1958, p 27                                             |
| Eudrilidae      | *Eudrilus eugeniae* (Kinberg, 1867) | Omodeo 1955a, p 213                                                            |
| Eudrilidae      | *Hyperodrilus africana* Beddard, 1891 | Omodeo 1955a, p 213; Tondoh 2006, p 336                                       |
| Eudrilidae      | *Scolellus compositus* Omodeo, 1958 | Omodeo 1958, p 91; Tondoh et al. 2007, p 587                                 |
| Eudrilidae      | *Scolellus tantillus* Omodeo, 1958 | Omodeo 1958, p 90                                                             |
| Eudrilidae      | *Stuhlmannia palustris* (Omodeo and Vaillaud, 1967) | Omodeo and Vaillaud, 1967, p 938; Lavelle 1973, p 79; Tondoh et al. 2007, p 587 |
| Eudrilidae      | *Stuhlmannia porifera* Omodeo and Vaillaud, 1967 | Omodeo and Vaillaud, 1967, p 941; Lavelle 1973, p 79; Tondoh 2006, p 336          |
| Eudrilidae      | *Stuhlmannia zielae* (Omodeo, 1958) | Omodeo 1958, p 87; Omodeo and Vaillaud 1967, p 941; Lavelle 1973, p 79; Tondoh 2006, p 336; Tondoh et al. 2007, p 587 |
Materials and methods

Study site

Earthworms were collected in the Oumé region (6°37'N, 4°40'W), located in the Centre-West Ivory Coast and characterized by semi-deciduous degraded forests (Chatelain et al. 2003). Altitude ranges from 100 to 180 m and rainfall (1976–2003) ranges from 849 to 1764 mm. The annual rainfall in 2004 peaked at 1540.9 mm while monthly average temperature is about 26°C. Morphological characterizations revealed that the soils of the area are ferrasols (FAO-UNESCO 1989) of homogeneous distribution across the landscape, but with differences related to topography (Angui, unpublished data). The surface organic layer is thin (20–30 cm), friable (resistance to penetration varies between 200 and 1000 kPa), and well mineralized.

Earthworm sampling protocol

Earthworms were sampled based on the tropical soil biology and fertility methods (Anderson and Ingram 1993). At each sampling point, a soil monolith of 25 cm² and 30 cm depth was extracted after digging a trench 30 cm deep all round. The monolith was sampled at three depths (0–10, 10–20, and 20–30 cm); earthworms were hand sorted and preserved in 4% formaldehyde for taxonomic identification. Altogether, 107 soil monoliths were sampled across the study site.

Penial setae handling

The penial setae were removed by dorsal dissecting of the specimens and mounted in Euparal for light microscopic study. Microscopic photos were taken using a Nikon Coolpix 990 digital camera attached to a Nikon E660 DIC microscope.

All the material is deposited in the Oligochaeta collection of the Hungarian Natural History Museum (HNHM). The following abbreviations are used in the text: \( L \), length; \( D \), diameter; No. segments, number of segments.

Systematics

**Family ACANTHODRILIDAE** Claus, 1880

**Subfamily BENHAMIINAE** Michaelsen, 1897

**Genus Dichogaster** (*Dichogaster*) Beddard, 1888

*Dichogaster* Beddard 1888, p 251.

*Dichogaster*: Michaelsen 1900, p 334 (part).

*Dichogaster*: Omodeo 1955a, p 224 (part); Omodeo 1958, p 61 (part).

*Dichogaster* (*Dichogaster*): Csuzdi 1996, p 354.

*Dichogaster* (*Dichogaster*) *baeri* Sciacchitano, 1952

(Figure I–D)

*Dichogaster baeri* Sciacchitano 1952, p 477; Omodeo 1955a, p 225; Wasawo and Omodeo 1963, p 211.

*Dichogaster* (*Dichogaster*) *baeri*: Csuzdi 1995, p 111; Csuzdi 1996, p 355; Csuzdi 2000, p 55.
Material examined

Centre-West Ivory Coast, Oumé (6°37′N, 4°40′W). Leg. J. Tondoh, August 2004. Teak plantation HNHM AF/5093, 2 ex., Fallow AF/5094, 2 ex., Degraded forest AF/5095, 1 ex.

Diagnosis

L. 110–167 mm, D. 4–7 mm. No. segments 130–221. Colour greenish. First dorsal pore in 12/13. Clitellum ½13–19. ♀ 14 unpaired, ventral-median. Prostatic pores 17, 19. Spermathecal pores 7/8, 8/9, spermathecae with rounded ampoule and longer duct bearing a multilobed diverticulum. Gizzard in 5–6, last pair of hearts in 13. Penial setae uniform, covered by an undulated membrane, L. 2.5–3 mm, D. 0.03 mm. Tip funnel-shaped, ornamentation lacking.

Remarks

In the original description (Sciacchitano 1952) the female pores are mentioned as paired openings, but on the drawings of Omodeo (1955a, p 226, Figure 6a) depiction is as a single ventral-median organ. In our material the female pore is also single and this casts doubt on the correctness of the original description on this point.

Dichogaster (Dichogaster) eburnea sp. nov.
(Figure 2A–D)

Material examined

Holotype: Centre-West Ivory Coast, Oumé (6°37′N, 4°40′W). Leg. J. Tondoh, August 2004. Teak plantation HNHM AF/5101. Paratype: HNHM AF/5130, 1 ex. Locality same as that of the holotype.
Derivatio nominis

The specific epithet is from the Latin *eburneus* = *ivory*, referring to the country.

**Diagnosis**

*L.* 22–25 mm, *D.* 0.7 mm. No. segments 82–114. Pigmentation lacking. First dorsal pore in 13/14. Clitellum $\frac{1}{2}13-\frac{1}{2}20$. $\varphi$ 14 unpaired, ventral-median. Prostatic pores 17, 19. Spermathecal pores 7/8, 8/9, spermathecae with T-shaped ampoule, with a short duct. The pseudo-diverticulum slim, half as long as the ampoule. Gizzard in 5–6, last pair of hearts in 13. Penial setae are of two types, larger *L.* 0.35 mm, *D.* 0.005 mm, tip sharply pointed, ornamentation strong teeth. Smaller *L.* 0.3 mm, *D.* 0.005 mm, tip rounded, ornamentation almost lacking.

**External characters**

Holotype: *L.* 25 mm, *D.* 0.7 mm, No. segments 114. The sole paratype: *L.* 22 mm, *D.* 0.7 mm, No. segments 82. Colour pale, pigmentation lacking. Prostomium pro-epilobous retracted. First dorsal pore in 13/14. Setae all ventral, setal arrangement after the clitellum $aa:ab:bc:cd:dd=9:1.5:7:1:50$. Clitellum extends over segments $\frac{1}{2}13-\frac{1}{2}20$, with a barrel-shaped male field. Prostatic pores paired on 17, 19 in the setal line b. Male pores externally not visible, they are on 18, in the seminal groves. Female pores unpaired on 14 near between setae a-a (Figure 2A). Spermathecal pores paired in 7/8, 8/9 near to the setae b. Porophores absent.
Internal characters

The first septum 6/7, thickened septa lacking. Oesophageal gizzards two, in segments 5 and 6. Three pairs of calciferous glands located in segments 15–17, their size increasing backwards. Excretory system meroic, with three meronephridia on each side. Paired hearts are present in segments 10–13. Typhlosole strong, begins in segment 20.

Testes are free in 10 and 11. Seminal vesicles small in 11, 12, and ovary in segment 13. Seminal duct convoluted, discharging in segment 18. Two pairs of small prostatic glands are present in 17 and 19, confined into their own segment and each provided with a penial setal sack containing two different types of penial setae. The larger one is about 0.35 mm long and 0.005 mm wide with a sharply pointed tip (Figure 2C). Ornamentation consists of strong scattered teeth. The smaller one is almost smooth, about 0.3 mm long and 0.005 mm wide with rounded tip (Figure 2D). There are two pairs of T-shaped spermathecae in segment 8 and 9. The ampoule is folded back and bears a small finger-like pseudodiverticulum. The duct is small and joins to the ampoule at right-angles (Figure 2B).

Remarks

This species belongs to the cyrtochaeta species group and resembles D. (D.) sexdecim and D. (D.) septemdecim which also have two types of penial setae. Nevertheless it differs from both in the ornamentation of the penial setae as well as in the more backward location of the last pair of hearts.

**Dichogaster (Dichogaster) ehrhardtii** (Michaelsen, 1898)

(Figure 3A–C)

Balanta ehrhardtii Michaelsen 1898, p 165.
Dichogaster ehrhardtii: Michaelsen 1900, p 356; Sims 1967, p 25.
Dichogaster ehrhardtii var. linnelli Michaelsen 1910, p 113.
Dichogaster linnelli: Omodeo and Vaillaud 1967, p 938.

Figure 3. *Dichogaster (D.) ehrhardtii*. (A) Ventral part of the clitellar region (f, female pore; p, prostate pores); (B) spermatheca; (C) penial seta.
**Dichogaster pascuali** Somon 1995 syn. nov.

*Dichogaster (Dichogaster) ehrhardti*: Csuzdi 1995, p 111; Csuzdi 1996, p 355; Csuzdi 2000, p 55.

**Material examined**

Centre-West Ivory Coast, Oumé (6°37′N, 4°40′W). Leg. J. Tondoh, August 2004. Mixed crop field HNHM AF/5092, 1 ex., AF/5097, 1 ex.

**Diagnosis**

$L. 35–110$ mm, $D. 2–4$ mm. No. segments 78–160. Pigmentation lacking. First dorsal pore in 13/14. Clitellum 13–20. $\varphi$ 14 unpaired, ventral-median. Prostatic pores 19. Spermathecal pores 7/8, spermathecae with egg-shaped ampoule and a racemose diverticulum. Gizzard in 5–6, last pair of hearts in 12. Penial setae uniform, $L. 2$ mm, $D. 0.02$ mm, tip spatula-like, ornamentation serrulate.

**Remarks**

This is the most widely distributed West African *Dichogaster* species. The description of *D. pascuali* Somon, 1995 completely fits with *D. (D.) ehrhardti*. It is especially obvious if we look at the figures of penial setae (Somon 1995, p 51, Figure 2e). Therefore *D. pascuali* must be regarded as a synonym of *D. (D.) ehrhardti*.

**Dichogaster (Dichogaster) mamillata** sp. nov.

(Figure 4A–C)

**Material examined**

Holotype: Centre-West Ivory Coast, Oumé (6°37′N, 4°40′W). Leg. J. Tondoh, August 2004. Degraded forest HNHM AF/5102. Paratype: HNHM AF/5090, 1 ex. Locality same as that of the holotype.

**Derivatio nominis**

The specific epithet from the Latin *mamillae* = nipples, refers to the special protuberances of the prostatic pores.

**Diagnosis**

$L. 30–32$ mm, $D. 1.5$ mm. No. segments 126. Pigmentation lacking. First dorsal pore in 13/14. Clitellum $\frac{1}{2} 13–19$. $\varphi$ 14 unpaired, ventral-median. Prostatic pores 17. Spermathecal pores 8/9, spermathecae with elongate ampoule and a muscular duct containing several sperm chambers. Gizzard in 5–6, last pair of hearts in 13. Penial setae uniform, $L. 1$ mm, $D. 0.005$ mm, tip spatula-form, ornamentation scattered teeth.

**External characters**

Holotype: $L. 30$ mm, $D. 1.5$ mm, No. segments 126. The sole paratype: $L. 32$ mm, $D. 1.5$ mm, No. segments 126. Colour pale, pigmentation lacking. Prostomium prolobous
retracted. First dorsal pore in 13/14. Setae all ventral, setal arrangement after the clitellum aa:ab:bc:cd:dd=10:2:8:1.5:60. Clitellum extends over segments \( \frac{1}{2}13-19 \), with less developed ventral side. Prostatic pores on paired protruding papillae in 17 (Figure 4A). Male pores not visible externally, they open near to the prostatic pores. Female pores unpaired on 14 near between setae a-a. Spermathecal pores paired in 8/9 near to the setae b. Porophores absent.

**Internal characters**

The first septum 4/5, thickened septa lacking. Oesophageal gizzards two, in segments 5 and 6. Three pairs of calciferous glands located in segments 15–17, their size slightly increasing backwards. Excretory system meroic, with four meronephridia on each side. Paired hearts are present in segments 10–13. Typhlosole strong, begins in segment 21.

Testes are free in 10 and 11. Seminal vesicles small in 11, 12, and ovary in segment 13. Seminal duct apparent highly convoluted, discharging in segment 17. A pair of small prostatic glands are present in 17, confined to their own segment, each with a penial setal sack containing one mature and one juvenile seta. The mature seta is about 1 mm long and 0.005 mm wide with spatula-like tip. The ectal third is undulated and ornamented with scattered teeth (Figure 4C). One pair of spermathecae in segment 9. The ampoule is elongated sac-like and as long as the muscular duct. In the wall of the duct there are several somewhat protruding seminal chambers (Figure 4B).

**Remarks**

This species belongs to the *penigera* group. In this group there are three species with microscolecin reduction of male apparatus; *D. (D.) lofaensis* Michaelsen, 1914 described
from Liberia, D. (D.) hammon Somon, 1995 described from Guinea, and D. (D.) nematochaeta Omodeo, 1958 occurs in Guinea/Ivory Coast. D. (D.) mamillata sp. nov. differs from D. (D.) lofaensis in the number of meronephridia, in its size and in the presence of penial setae. It differs from D. (D.) hammon in size (30 mm versus 300 mm) and in the position of the last hearts, and finally it differs from D. (D.) nematochaeta in the position of the last hearts and also in the size and structure of penial setae (which are of two types in D. (D.) nematochaeta).

**Dichogaster (Dichogaster) terraenigrae** Omodeo and Vaillaud, 1967

*Dichogaster terra-nigrae* Omodeo and Vaillaud 1967, p 934.

*Benhamia terraenigrae*: Csuzdi and Zicsi 1994, p 218.

*Dichogaster (Dichogaster) terraenigrae*: Csuzdi 1995, p 109; Csuzdi 2000, p 56.

**Material examined**

Centre-West Ivory Coast, Oumé (6°37’N, 4°40’W). Leg. J. Tondoh, August 2004. Degraded forest HNHM AF/5078, 1 ex., Fallow AF/5079, 1 ex., AF/5088, 1 ex., Cocoa Plantation AF/5080, 1 ex., Multispecies wood plantation AF/5081, 1 ex., AF/5084, 2 ex., AF/5087, 1 ex., Teak plantation AF/5083, 1 ex., Mixed crop field AF/5086, 1 ex.

**Diagnosis**

*L.* 160–175 mm, *D.* 4–5 mm. No. segments 305–320. Segments 1–2 simple, 3–12 tri- or multiannulate. Pigmentation lacking. First dorsal pore in 12/13. Clitellum ½13–19.  ♂ 14 unpaired, ventral-median. Prostatic pores 17, 19. Spermathecal pores 7/8, 8/9, spermathecae with elongated ampoule and longer duct. Diverticulum multilobed berry-shaped. Gizzard in 5–6, last pair of hearts in 12. Calciferous glands large in 15, 17 vestigial in 16. Excretory system meric with ca 10 pairs of meronephridia. Penial setae uniform, *L.* 2.6–3 mm, *D.* 0.0012 mm. Tip rounded, ornamentation lacking. Transverse pad-like genital papillae in segments 9, 10, 15, 19–23.

**Remarks**

Due to the presence of triannulate segments and pad-like genital papillae, *D. (D.) terraenigrae* greatly resembles the species of the genus *Millsonia* externally, but the presence of penial setae and the lack of intestinal caeca obviously place it in *Dichogaster*. However, the reduction of the calciferous glands in segment 16 requires further consideration regarding its taxonomic status.

**Genus Dichogaster (Diplothecodrilus)** Csuzdi, 1996

*Dichogaster (Diplothecodrilus)* Csuzdi 1996, p 355; Csuzdi 2000, p 58.

*Dichogaster (Diplothecodrilus)*: Blakemore 2005, p 5.

**Dichogaster (Diplothecodrilus) saliens** (Beddard, 1893)

*Microdrilus saliens* Beddard 1893a, p 683.

*Dichogaster crawi* Eisen 1900, p 228.
Dichogaster saliens: Michaelsen 1900, p 346; Stephenson 1931, p 65; Wasawo and Omodeo 1963, p 211; Gates 1972, p 281; Omodeo 1973, p 25; Blakemore 2002, p 114.
Dichogaster hatomaana Ohfuchi 1957, p 259.
Dichogaster (Diplothecodrilus) saliens: Csuzdi 1995, p 114; Csuzdi 1996, p 358.

Material examined
Centre-West Ivory Coast, Oumé (6°37’N, 4°40’W). Leg. J. Tondoh, August 2004. Degraded forest HNHM AF/5091, 2 ex.

Remarks
This is one of the most widely distributed peregrine Dichogaster species occurring in all tropical regions. It is easy to identify by the spectacle-like prostate pores on segment 17 and the presence of two pairs of spermathecae (incomplete microscolecine reduction).

Genus Millsonia Beddard, 1894
Millsonia Beddard 1894, p 380.
Dichogaster: Michaelsen 1900, p 334 (part).
Dichogaster: Stephenson 1930, p 851 (part).
Millsonia: Omodeo 1955a, p 218 (part); Omodeo 1958, p 59 (part).
Millsonia: Sims 1986, p 277 (part).
Millsonia: Csuzdi 1996, p 360 (part); Csuzdi 2006, p 36.

Millsonia lamtoiana Omodeo and Vaillaud, 1967
Millsonia lamtoiana Omodeo and Vaillaud 1967, p 932.
Millsonia lamtoiana: Sims 1986, p 297.
Millsonia lamtoiana: Csuzdi 1996, p 361; Csuzdi 2000, p 75; Csuzdi 2006, p 39.

Material examined
Centre-West Ivory Coast, Oumé (6°37’N, 4°40’W). Leg. J. Tondoh, August 2004. Multispecies wood plantation HNHM AF/5089, 2 ex.

Diagnosis
L. 300–415 mm, D. 7–9 mm. No. segments 300–570. Pigmentation dark brown. First dorsal pore in 5/6. Clitellum 13–20. ♂ 14 paired. Prostatic pores 17, 19. Spermathecal pores 7/8, 8/9, spermathecae turned pear-shaped, duct large, spherical, its wall contains sperm chambers. Gizzards 5–6, last pair of hearts in 12. Calciferous glands in 15–17. Intestinal caeca 19–24 pairs in 28–46, 52. Excretory system meroic, with 15 pairs of meronephridia.

Reginaldia (Peritogaster) Csuzdi, 2006
Millsonia: Omodeo 1955a, p 218 (part); Omodeo 1958, p 59 (part).
Millsonia: Sims 1986, p 277 (part).
Millsonia: Csuzdi 1995, p 116 (part); Csuzdi 1996, p 360 (part); Csuzdi 2000, p 75 (part).
Reginaldia (Peritogaster) Csuzdi 2006, p 43.

Reginaldia (Peritogaster) omodeoi Sims, 1986

Millsonia anomala f. leptocystis Omudeo and Vaillaud 1967, p 929.
Millsonia omodeoi Sims 1986, p 304; Csuzdi 1996, p 362; Csuzdi 2000, p 75.
Reginaldia (Peritogaster) omodeoi: Csuzdi 2006, p 43.

Material examined
Centre-West Ivory Coast, Oumé (6°37′N, 4°40′W). Leg. J. Tondoh, August 2004. Fallow HNHM AF/5077, 2 ex., Teak plantation AF/5082, 1 ex.

Diagnosis
L. 65–105 mm, D. 5–6 mm. No. segments 173–250. Pigmentation lacking. First dorsal pore in 5/6. Clitellum ½13–18. φ 14 paired. Prostatic pores 17, 19. Spermathecal pores 7/8, 8/9, spermathecae elongated sac-shaped without a recognizable duct. The ectalmost part of the spermathecae have a granulate collar filled with sperm-chambers. One gizzard in 6, septum 5/6 extraordinarily thickened. Last pair of hearts in 12. Calcerous glands in 15–17. Intestinal caeca seven pairs in 26–32. Excretory system meroic, with six pairs of meronephridia and a pair of enteronephric and stomate filiform megameronephridia running into a collecting channel alongside the nerve cord. Pad-like genital papillae in segment 6, 7, 8, 12/13–15/16, 19–21.

Family EUDRILIDAE Claus, 1880
Subfamily EUDRILINAE Claus, 1880

Hyperiodrilus Beddard, 1890

Hyperiodrilus Beddard 1890, p 563.
Alvania Beddard 1893b, p 271.
Hyperiodrilus: Michaelsen 1900, p 408.
Hyperiodrilus: Omodeo 1958, p 95.
Hyperiodrilus: Clausen 1967, p 202.
Hyperiodrilus: Sims 1987, p 384.

Hyperiodrilus africanus Beddard, 1891

Hyperiodrilus africanus Beddard 1891, p 236.
Hyperiodrilus africanus: Michaelsen 1900, p 410.
Hyperiodrilus africanus: Omodeo 1955a, p 213.
Hyperiodrilus africanus f. vogelii Omodeo 1955a, p 215.
Hyperiodrilus africanus: Zicsi and Csuzdi 1986, p 405.
Hyperiodrilus africanus: Sims 1987, p 384.
Material examined

Centre-West Ivory Coast, Oumé (6°37’N, 4°40’W). Leg. J. Tondoh, August 2004. Fallow HNHM AF/5075, 2 ex.

**Subfamily PAREUDRILINAE** Beddard, 1894

*Lavellea* gen. nov.

*Scolecillus* Omodeo 1958, p.89 (part).

*Chuniodrilus*: Wasawo and Omodeo 1963, p.217 (part).

*Stuhlmannia*: Sims 1987, p.380 (part).

**Derivatio nominis**

The new genus is named in honour of the renowned earthworm ecologist and pioneer of the Ivorian earthworm study Dr Patrick Lavelle, Paris.

**Diagnosis**

Pareudrilinae with single ventral-median male pore close to 17/18. Spermathecal pore single ventral-median in or around segment 13. Female pores paired in 14 close to 14/15. Oesophageal gizzard absent, two or more intestinal gizzards present. Oesophagus with lamellar widening in or around 14–16. Dorsal blood vessel simple throughout. Holoic, nephridial bladders present. Spermathecal receptaculum single ventral-median. Simple penial setae present.

**Type species.** *Scolecillus compositus* Omodeo, 1958.

**Other species.** *Chuniodrilus vuattouxi* Wasawo and Omodeo, 1963.

**Remarks**

*Scolecillus compositus* was described by Omodeo (1958) as a second species besides the generotype *Scolecillus tantillus* Omodeo, 1958. However, *S. compositus* differs from *S. tantillus* in several characters of great taxonomic importance such as the presence of penial setae and the paired nature of the oviductal system. This led Wasawo and Omodeo (1963) to place this species together with the newly described *C. vuattouxi* in the genus *Chuniodrilus* Michaelsen, 1913. But these species differ again from the Liberian generotype *C. schomburgki* Michaelsen, 1913 by lacking an oesophageal gizzard, therefore Sims (1987) transferred *compositus* to *Libyodrilus* and *vuattouxi* to *Stuhlmannia* (but in this case with a question mark).

Recently, Clausen (2004) reviewed the genus *Libyodrilus* and proved that *S. compositus* differs substantially from the members of this genus. Therefore she rejected this placement without suggesting a proper place for this species. As *S. compositus* and *C. vuattouxi* (both from the Ivory Coast) do not fit any existing Pareudrilinae genus, *Lavellea* gen. nov. is proposed to accommodate them.

The new genus differs from *Scolecillus* in having penial setae and from *Chuniodrilus* in the lack of oesophageal gizzards.
**Lavellea composita** (Omodeo, 1958)

*Scolecillus compositus* Omodeo 1958, p 91.

*Chuniodrilus compositus*: Wasawo and Omodeo 1963, p 217; Jamieson 1969, p 42.

*Lybiodrilus compositus*: Sims 1987, p 379.

*Scolecillus compositus*: Clausen 2004, p 1877.

**Material examined**

Centre-West Ivory Coast, Oumé (6°37’N, 4°40’W). Leg. J. Tondoh, August 2004. Fallow HNHM AF/5100, 1 ex.

**Diagnosis**

*L.* 30–41 mm, *D.* 0.8–1.2 mm. No. segments 120–170. Pigmentation lacking. Clitellum 14–17. ♀ 14/15 paired. Prostatic pore single ventral-median in 17 close to 17/18. Spermathecal pore single ventral-median in 13 close to 13/14. One or two round genital markings close to the prostatic pore. Spermathecal receptaculum single. Calciferous glands and oesophageal gizzard absent, three intestinal gizzards in segments 24–26. Simple penial setae present.

**Remarks**

This species is very similar to *Lavellea vuattouxi*. The only substantial differences are in the number and position of the intestinal gizzards. In *L. composita* there are three gizzards in 24–26; in *L. vuattouxi* there are two gizzards in 21–22.

**Stuhlmannia** Michaelsen, 1890

*Stuhlmannia* Michaelsen 1890, p 24.

*Platydrilus* Michaelsen 1892, p 49.

*Metschaina* Michaelsen 1903, p 462.

*Stuhlmannia*: Jamieson 1967, p 96.

*Platydrilus*: Omodeo 1973, p 38.

*Stuhlmannia*: Omodeo 1973, p 36.

*Stuhlmannia*: Sims 1987, p 380 (part).

**Stuhlmannia palustris** (Omodeo and Vaillaud, 1967)

*Chuniodrilus palustris* Omodeo and Vaillaud 1967, p 938.

*Stuhlmannia palustris*: Sims 1987, p 380.

**Material examined**

Centre-West Ivory Coast, Oumé (6°37’N, 4°40’W). Leg. J. Tondoh, August 2004. Multispecies wood plantation HNHM AF/5099, 4 ex.
**Stuhlmannia zielae** (Omodeo, 1958)

*Chuniodrilus zielae* Omodeo 1958, p. 87.

*Chuniodrilus zielae*: Omodeo and Vaillaud 1967, p. 940.

*Stuhlmannia zielae*: Sims 1987, p. 380.

**Material examined**

Centre-West Ivory Coast, Oumé (6°37’N, 4°40’W). Leg. J. Tondoh, August 2004. Multispecies wood plantation HNHM AF/5098, 2 ex.

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**References**

Anderson JM, Ingam JSI. 1993. Tropical soil biology and fertility: a handbook of methods. 2nd ed. Wallingford (UK): CABI.

Beddard FE. 1888. On certain points in the structure of *Urochaeta*, E.P., and *Dichogaster*, nov. gen., with further remarks on the nephridia of earthworms. Quarterly Journal of Microscopical Science 29:235–282.

Beddard FE. 1890. A preliminary note on a new earthworm belonging to the family Eudrilidae. Zoologische Anzeiger 13:561–563.

Beddard FE. 1891. On the structure of two new genera of earthworms belonging to the Eudrilidae, and some remarks on *Nemertodrilus*. Quarterly Journal of Microscopical Science 32:235–278.

Beddard FE. 1893a. On some new species of earthworms from various parts of the world. Proceedings of the Zoological Society, London 1892:666–706.

Beddard FE. 1893b. Two new genera and some new species of earthworms. Quarterly Journal of Microscopical Science 34:243–271.

Beddard FE. 1894. On two new genera, comprising three new species of earthworms from western tropical Africa. Proceedings of the Zoological Society, London 1894:397–391.

Blakemore RJ. 2002. Cosmopolitan earthworms: an eco-taxonomic guide to the peregrine species of the world. Kippax (Australia): VermEcoaly.

Blakemore RJ. 2005. Review of Pacific Ocean earthworms updated from Easton (1984) and Lee (1981). In: A series of searchable texts on earthworm biodiversity, ecology and systematics from various regions of the world [CD ed.]. Yokohama: Yokohama University.

Chatelain C, Dao H, Gautier L, Spichiger R. 2003. Forest cover changes in Côte d’Ivoire and Upper Guinea. In: Poorter L, Bongers F, Kouamé FN, Hawthorne WD, editors. Biodiversity of West Africa forests. An ecological atlas of woody plant species. Wallingford (UK): CABI. p. 15–31.

Clausen MW. 1967. The African Oligochaete genera *Hyperperiodrilus* Beddard, 1891 and *Legonea* Clausen, 1963 (Oligochaeta). Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening 130:179–207.

Clausen MW. 2004. Description of seven new species of *Libyodrilus* Beddard from Cameroon, with a key to the species of the genus (Oligochaeta: Eudrilidae). Journal of Natural History 38:1851–1880.

Csuzdi Cs. 1995. A catalogue of Benhamiinae species (Oligochaeta, Acanthodrilidae). Annalen des Naturhistorischen Museums in Wien 97B:99–123.

Csuzdi Cs. 1996. Revision der Unterfamilie Benhamiinae Michaelsen, 1897 (Oligochaeta, Acanthodrilidae). Mitteilungen aus dem Zoologischen Museum Berlin 72:347–367.

Csuzdi Cs. 2000. A review of Benhamiinae earthworms in the collection of the Natural History Museum, London (Oligochaeta, Acanthodrilidae, Benhamiinae). Opuscula Zoologica Budapest 32:51–80.
Csuzdi Cs. 2006. A review of the West African earthworm genus *Millsonia* Beddard, 1894 (Oligochaeta: Acanthodrilidae, Benhamiinae). Acta Zoologica Hungarica 52(1):35–48.

Csuzdi Cs, Zicsi A. 1994. Revision der Gattung *Benhamia* Michaelsen, 1889 (Oligochaeta, Octochaetidae). Revue Suisse de Zoologie 101(1):215–231.

Eisen G. 1900. Researches in American Oligochaeta with especial reference to those of the Pacific Coast and adjacent islands. Proceedings of the Californian Academy of Sciences 2:85–276.

FAO-UNESCO. 1989. Carte mondiale des sols. Légende révisée. Rapport sur les ressources en sols du monde n° 60. Rome, 125 p.

Gates GE. 1972. Burmese Earthworms, an introduction to the systematics and biology of Megadrile oligochaetes with special reference to South-East Asia. Transactions of the American Philosophical Society 62(7):1–326.

Jamieson BGM. 1967. A taxonomic review of the African megadrile genus *Stuhlmannia* (Eudrilidae, Oligochaeta). Journal of Zoology, London 152:79–126.

Jamieson BGM. 1969. A new Egyptian species of *Chuniodrilus* (Eudrilidae, Oligochaeta) with observations on internal fertilization and parallelism with the genus *Stuhlmannia*. Journal of Natural History 3:41–51.

Lavelle P. 1971. Recherches ecologiques dans la savane de lamto (Cote-d'Ivoire): production annuelle d'un ver de terre *Millsonia anomala* Omodeo. La Terre et la Vie 2:240–254.

Lavelle P. 1973. Peuplement et production des vers de terre dans les savanes de Lamto. Annales de l'Université d'Abidjan, Série E: Ecologie 6(2):79–98.

Lavelle P. 1978. Les vers de terre de la savane de Lamto (Cote d'Ivoire): peuplements, populations et fonctions dans l'écosystème. Publication du Laboratoire de Zoologie de L'ENS 12:1–301.

Lavelle P. 1981. Un ver de terre carnivore des savanes de la moyenne Cote d'Ivore: *Agastrodrilus dominicae* nov. sp. (Oligochoetes-Megascolecoidae). Revue d'Ecologie et de Biologie du Sol 18(2):253–258.

Michaelsen W. 1890. Beschreibung der von Herrn Dr. Franz Stuhlmann im Mündungsgebiet des Sambesi gesammelten Terricolen. Mitteilungen aus dem Naturhistorischen Museum in Hamburg 7:1–30.

Michaelsen W. 1892. Beschreibung der von Herrn Dr. F. Stuhlmann am Sansibar und dem gegenüberliegenden Festland gesammelten Terricolen. Mitteilungen aus dem Naturhistorischen Museum in Hamburg 9:1–72.

Michaelsen W. 1898. Über eine neue Gattung und vier neue Arten der Unterfamilie Benhamini. Mitteilungen aus dem Naturhistorischen Museum in Hamburg 15:165–178.

Michaelsen W. 1900. Oligochaeta. Das Tierreich 11:1–575.

Michaelsen W. 1903. Die Oligochäten Nordost-Afrikas, nach den Ausbeuten der Herren Oscar Neumann und Carlo Freiherr von Erlanger. Zoologische Jahrbücher Abteilung für Systematik, Ökologie und Geographie der Tiere 18:435–556.

Michaelsen W. 1910. Oligochäten von verschiedenen Gebieten. Mitteilungen aus dem Naturhistorischen Museum in Hamburg 27:47–170.

Ohfuchi S. 1957. On a collection of the terrestrial Oligochaeta obtained from the various localities in Riu-kiu Islands, together with the consideration of their geographical distribution (Part II). Journal of Agricultural Science Tokyo 3:243–261.

Omodeo P. 1955a. Eudrilinae e Octochaetinae della Costa d’Avorio (Oligochaeta). Memorie del Museo Civico di Storia Naturale di Verona 4:213–229.

Omodeo P. 1955b. Nuove specie dei generi a distribuzione anfialantica Wegeneriella e Neogaster (Acanthodrilidae, Oligochaeta). Annuario dell’Istituto e Museo di Zoologia della Università di Napoli 7(3):1–29.

Omodeo P. 1958. Oligochoetes. In, La reserve naturelle integral de Mont Nimba. Memoire de la Institut Francais Afrique Noire 53:9–109.

Omodeo P. 1973. Oligochètes dell’Angola. Publicacoes Culturais da Companhia de Diamantes de Angola 87:13–58.

Omodeo P, Vaillaud M. 1967. Les Oligoche’s de la savane de Gpokobo en Cote d’Ivoire. Bulletin de la Institut Francais Afrique Noire 29:925–944.

Sciacchitano I. 1952. Oligoche’s de la Côte d’Ivoire. Revue Suisse de Zoologie 59:447–486.

Sims RW. 1967. Earthworms (Acanthodrilidae and Eudrilidae: Oligochaeta) from Gambia. Bulletin of the British Museum (Natural History) Zoology 16:1–43.

Sims RW. 1986. Revision of the Western African earthworm genus *Millsonia* (Octochaetidae, Oligochaeta). Bulletin of the British Museum (Natural History) Zoology 50:273–313.

Sims RW. 1987. A review of the Central African earthworm family Eudrilidae (Oligochaeta). In: Pagliani AMB and Omodeo P, editors. On earthworms. Selected symposia and monographs. Volume 2. Modena: Mucchi. 359–388.

Somon S. 1995. Nouvelles espèces d’Oligoche’s du Mont Nimba (Guinée). Bulletin de la Société Zoologique de France 120:47–55.
Stephenson J. 1930. The Oligochaeta. Oxford: Clarendon Press. 987 p.
Stephenson J. 1931. Oligochaeta from Burma, Kenya and other parts of the world. Proceedings of the Zoological Society London 1931:33–92.
Tondoh EJ. 2006. Seasonal changes in earthworm diversity and community structure in Central Côte d’Ivoire. European Journal of Soil Biology 42:S334–S340.
Tondoh EJ, Monin Monin L, Tiho S, Csuzdi Cs. 2007. Can earthworms be used as bio-indicators of land-use perturbations in semi-deciduous forest? Biology and Fertility of Soils 43:585–592.
Wasawo DPS, Omodeo P. 1963. Some arboricolous Oligochaeta from Ivory Coast. Memorie del Museo Civico di Storia Naturale di Verona 11:211–223.
Zicsi A, Csuzdi Cs. 1986. Weitere Angaben zur Regenwurmfaula des Kongo-Gebietes (Oligochaeta: Eudrilidae und Glossoscolecidiae). Acta Zoologica Hungarica 32:385–412.