

## Twelve new species of dactylogyrids (Platyhelminthes, Monogenea) from West African barbels (Teleostei, Cyprinidae), with some biogeographical implications

*allocales*

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### Abstract

Fifteen species of dactylogyrid monogeneans, belong to *Dactylogyrus* and *Dogielius* were observed in seven different African species of *Barbus* and *Varicorhinus* (Teleostei, Cyprinidae). The barbels examined in West Africa were: *Barbus occidentalis* Boulenger, 1911, known in the large Sahel-Sudan rivers and in Gabon; *B. waldroni* Nordman, 1935, *B. petitjeani* Daget, 1962, *B. sacratus* Daget, 1963, *B. parawaldroni* Lévêque, Thys van den Audenaerde & Traoré, 1987 and *Varicorhinus wurtzi* (Pellegrin, 1908) are distributed in various coastal rivers in the Gulf of Guinea. *B. bynni* (Forsk., 1775) the seventh species, is found in East Africa where it is known in the Nile Basin and the lakes connected with it. Three previously reported monogeneans were found: *Dactylogyrus pseudanchoratus* Price & Géry, 1968, was identified on all the host species studied; *D. falcilocus* Guégan, Lambert & Euzet, 1988, was found on *V. wurtzi* from Little Scarcies in Guinea; *D. ruahae* Paperna, 1973, was found on *B. sacratus*, *B. parawaldroni* and *V. wurtzi* in the rivers flowing from the Fouta Djallon mountains in Guinea to the Atlantic.

Twelve new species of monogeneans are described. Eight belong to *Dactylogyrus* Diesing, 1850 and the four others to *Dogielius* Bychowsky, 1936. Seven of the dactylogyrids described display strict specificity for their host fish: *Dactylogyrus clani* n. sp. and *D. petitjeanii* n. sp. on *B. petitjeani*; *Dactylogyrus sacrati* n. sp. and *Dogielius phrygius* n. sp. on *B. sacratus*; *Dactylogyrus parawaldronii* n. sp. on *B. parawaldroni*; and *Dactylogyrus wurtzii* n. sp. and *Dogielius vexillus* n. sp. on *V. wurtzi*. The remainder have a broader host spectrum: *Dactylogyrus archaeopenis* n. sp. on *B. petitjeani*, *B. sacratus* and *B. parawaldroni*; *Dogielius pedaloe* n. sp. on *B. parawaldroni* and *V. wurtzi*; *Dactylogyrus aferoides* n. sp. and *Dactylogyrus sahelensis* n. sp. on *B. occidentalis*, *B. waldroni*, *B. petitjeani* and *B. bynni*; and *Dogielius djolibaensis* n. sp. identified on *B. occidentalis*, *B. petitjeani* and *B. waldroni*.

Characteristics of gill parasitism in three particular hosts, *B. bynni*, *B. occidentalis* and *B. waldroni*, confirm the current opinion of the existence of clinal variations in individual *Barbus* specific complexes belonging to isolated basins. We discuss the differences in the composition of gill parasitofauna of barbels from different catchment areas. Cyprinids in isolated catchments in Guinea, Sierra Leone and Liberia are parasitised in particular by interesting monogeneans which are true relic taxa. The problem of the use of these parasite groups as palaeo-ecological markers is raised.

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## Introduction

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Monogeneans on *Barbus* and *Varicorhinus* in Africa are known through the works of Paperna & Thurston (1968) in Kenya and Uganda. Price & Géry (1968) in Gabon, Price, Korach & McPott (1969) in South Africa and Paperna (1973) in Tanzania. The morphological variability of large *Barbus* is well known and was shown in particular by Banister (1973) in East African species. In such a host group where the systematics appears very complex, cases of poor diagnosis have led to confusion concerning the host-parasite relationship between the Dactylogyridae and the Cyprinidae. It thus appeared potentially profitable to collaborate with ichthyologists from ORSTOM (Institut français de Recherche Scientifique pour le Développement en Coopération) in the study of monogeneans from these hosts.

Parasites collected on six species of barbels in West Africa and a seventh species in the Nile Basin are described. Hosts examined were: *Barbus occidentalis* Boulenger, 1911 known in the Chad, Niger, Senegal, Volta, Ouémé and Ogun Basins; *B. waldroni* Nordman, 1935 found in rivers in the Ivory Coast (Sassandra, Bandama, Nipoué, Niouniourou, Comoé) and in Ghana (Tano); *B. petitjeani* Daget, 1962 hitherto identified in the Bafing (Senegal Basin) and whose known distribution area has recently been extended to the Milo and the Niandan in the upper Niger Basin in Guinea (Lévêque & Guégan, 1990); *B. sacratus* Daget, 1963 found in coastal basins in West Africa from the Tominé (north-west Guinea and Guinea-Bissau) to eastern Liberia; *B. parawaldroni* Lévêque, Thys van den Audenaerde & Traoré, 1987 found in the rivers in western Ivory Coast and in the upper reaches of certain Liberian rivers in Guinea; *Varicorhinus wurtzi* (Pellegrin, 1908),

known in numerous coastal basins in West Africa from the Konkouré in Guinea to Ghana; and *B. bynni* (Forsk., 1775), confined to the Nile Basin and the various lakes to which it is connected (Lévêque & Guégan, 1990).

Three monogenean species collected had previously been described: *Dactylogyrus pseudanchoratus* Price & Géry, 1968 was described in the Ogooué in Gabon on *Barbus occidentalis affinis* (Price & Géry, 1968), reported on *B. macrolepis* in Tanzania (Paperna, 1979) and we collected it on all the barbels studied; *D. falcilocus* Guégan, Lambert & Euzet, 1988, described as specific to *Labeo coubie* in the Niger and Senegal Basins by Guégan, Lambert & Euzet (1988), was found on *V. wurtzi* from Little Scarcies in Guinea and Sierra Leone; and *D. ruahae* Paperna, 1973, initially described on *B. macrolepis* in the Ruaha River in Tanzania (Paperna, 1973), was found on *B. sacratus*, *B. parawaldroni* and *V. wurtzi* in Guinean river basins.

Twelve new species are described (eight belonging to the genus *Dactylogyrus* and four to the genus *Dogielius*). Five of them are found in numerous host taxa: *Dactylogyrus archaeopenis* n. sp. on *B. sacratus*, *B. petitjeani* and *B. parawaldroni*; *D. sahelensis* n. sp. on *B. occidentalis*, *B. waldroni*, *B. bynni* and *B. petitjeani*; *D. aferoides* n. sp. on *B. occidentalis*, *B. petitjeani*, *B. waldroni*, *B. bynni* and *B. parawaldroni* from numerous basins in West Africa; *Dogielius pedaloe* n. sp. on *B. parawaldroni* and *V. wurtzi*; and *Dogielius djolibaensis* n. sp. on *B. occidentalis*, *B. petitjeani* and *B. waldroni*. Five species of *Dactylogyrus* and two species of *Dogielius* were specific (oioxenic) to a single host: *Dactylogyrus petitjeanii* n. sp. and *Dactylogyrus clani* n. sp. on *B. petitjeani*; *Dactylogyrus sacrati* n. sp. and *Dogielius phrygiensis* n. sp. on *B. sacratus*; *Dactylogyrus wurtzii* n. sp. and *Dogielius vexillus* n. sp. on *V. wurtzi*; and *Dactylogyrus parawaldronii* n. sp. on *B. parawaldroni*.

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large adjacent Sahel-Sudan catchments. These coastal rivers are characterised in particular by a high level of endemic fishes (Daget, 1962). Ichthyologists have put forward two main hypotheses to account for the endemism of the fauna in these watercourses. The first relates to vicariant isolation of populations by the rising of the Guinea-Ivory Coast Ridge. The second proposes the existence of refugia in West Africa, where there are may be affinities with central African fauna in particular (Hugueny, 1989).

A systematic study was carried out on the monogenean communities of these West African Cyprinidae in order to assess to what extent this parasitological approach could provide information on evolutionary phenomena.

#### Geographical coverage, materials and methods

Various species of *Barbus* and *Varicorhinus* were collected from several river basins in West Africa and one in East Africa (Fig. 1). These included the large Sahel-Sudan systems (Niger, Senegal), large basins in the Ivory Coast (Bandama, Sassandra) and a series of small coastal basins lying on the Atlantic side of the Guinea-Ivory Coast Ridge, which runs from the Fouta Djallon Mountains (Guinea) to the Nimba Mountains (the frontier between Guinea, the Ivory Coast and Liberia). From west to east, these small basins sampled are: the Tominé (or Rio Corubal), the Fatala, the Konkouré, the Little Scarcies, the Rokel (or Seli or Jong), the Bagwe (or Sewa), the Moa (or Macona), the Loffa, the Nipoué (or Cess or Cestos), the Cavally and finally the Dodo. In addition, several samples of *B. bynni* from the Nile Basin were analysed.

Some cyprinids analysed were obtained directly from the collection of the Ichthyology Laboratory at the Museum National d'Histoire Naturelle (MNHN) in Paris. These were (exponent numbers correspond to collection sites in Fig. 1): *B. occidentalis*, Senegal Basin, Bakoye River near Kokofata<sup>(5)</sup>, Mali, MNHN 1988-1950. *B. bynni*, Nile Basin, Nile<sup>(31)</sup>, MNHN B2840 and B2841:

Blue Nile<sup>(32)</sup>, MNHN 06.276; Mariout Lake near Alexandria<sup>(30)</sup>, Egypt, MNHN 5249. *B. waldroni*, Sassandra basin near Soubré<sup>(26)</sup>, Ivory Coast, MNHN 1963-375; Bandama Basin near Niakaramandougou<sup>(29)</sup>, MNHN 1989-1267, Ivory Coast. *B. petitjeani*, Senegal Basin, Fouta Djallon, Upper Bafing River near Timbo<sup>(6)</sup>, Guinea, MNHN 59-108 and 1988-1879; Niger Basin, Upper Milo near Lelekro<sup>(2)</sup>, Guinea, MNHN 1988-1874 and 1988-1880; Niger Basin, Upper Niandan near Gdoboro and Loutou<sup>(3)</sup>, Guinea, MNHN 1988-1878 and 1988-1875. *B. sacratus*, Konkouré Basin, Kakrima River<sup>(11)</sup>, Guinea, MNHN 1989-1001; Tominé near Gaoual<sup>(8)</sup>, Guinea, MNHN 1982-1329; Moa River near Nangoa<sup>(19)</sup>, Guinea, MNHN 1989-1012; Zié at Diougou, Monts Nimba<sup>(25)</sup>, Guinea, MNHN 1959-119; Loffa River between Macenta and Sérédou<sup>(20)</sup>, Guinea, MNHN 1984-332. *B. parawaldroni*, Nipoué River at Binhoue<sup>(22)</sup>, Ivory Coast, MNHN 1986-971; Loffa River near Macenta<sup>(20)</sup>, Guinea, MNHN 1986-972 and 1986-969; Dodo on the road between San Pedro and Tabou<sup>(26)</sup>, Ivory Coast, MNHN 1986-973. *V. wurtzi*, Sassandra Basin, Feredougouba River near Badala<sup>(27)</sup>, Ivory Coast, MNHN 1988-1955; Little Scarcies Basin, Kaba river at Kouloundala<sup>(12)</sup>, Guinea, MNHN 1988-1882 and Mongo River at Marela<sup>(13)</sup>, Guinea, MNHN 1988-1881.

The monogeneans from fish conserved at the MNHN were mounted directly in Berlese fluid and observed under a microscope.

Five field missions were carried out in different countries in West Africa during which specimens of the following species were collected:

*B. occidentalis*: Niger Basin at Bamako<sup>(1)</sup>, Mali, MNHN 1989-971; Senegal Basin, Upper Bafing near Sokotoro<sup>(6)</sup>, Guinea, MNHN 1988-1873 and 1989-987; Senegal Basin, Baoulé River at Misira<sup>(4)</sup>, Mali (fish not kept).

*B. petitjeani*: Senegal Basin, Upper Bafing near Sokotoro<sup>(6)</sup>, Guinea, MNHN 1988-1874, 1988-1876 and 1989-986.

*B. sacratus*: Little Scarcies Basin, Mongo River<sup>(13)</sup>, MNHN 1989-1015 and Kaba<sup>(12)</sup> River, Guinea, MNHN 1989-1017; Fatala Basin near Mahbé<sup>(9)</sup>, Guinea, 1989-979; Rokel River at Kondembaya<sup>(16)</sup>, Sierra Leone, MNHN 1989-978.

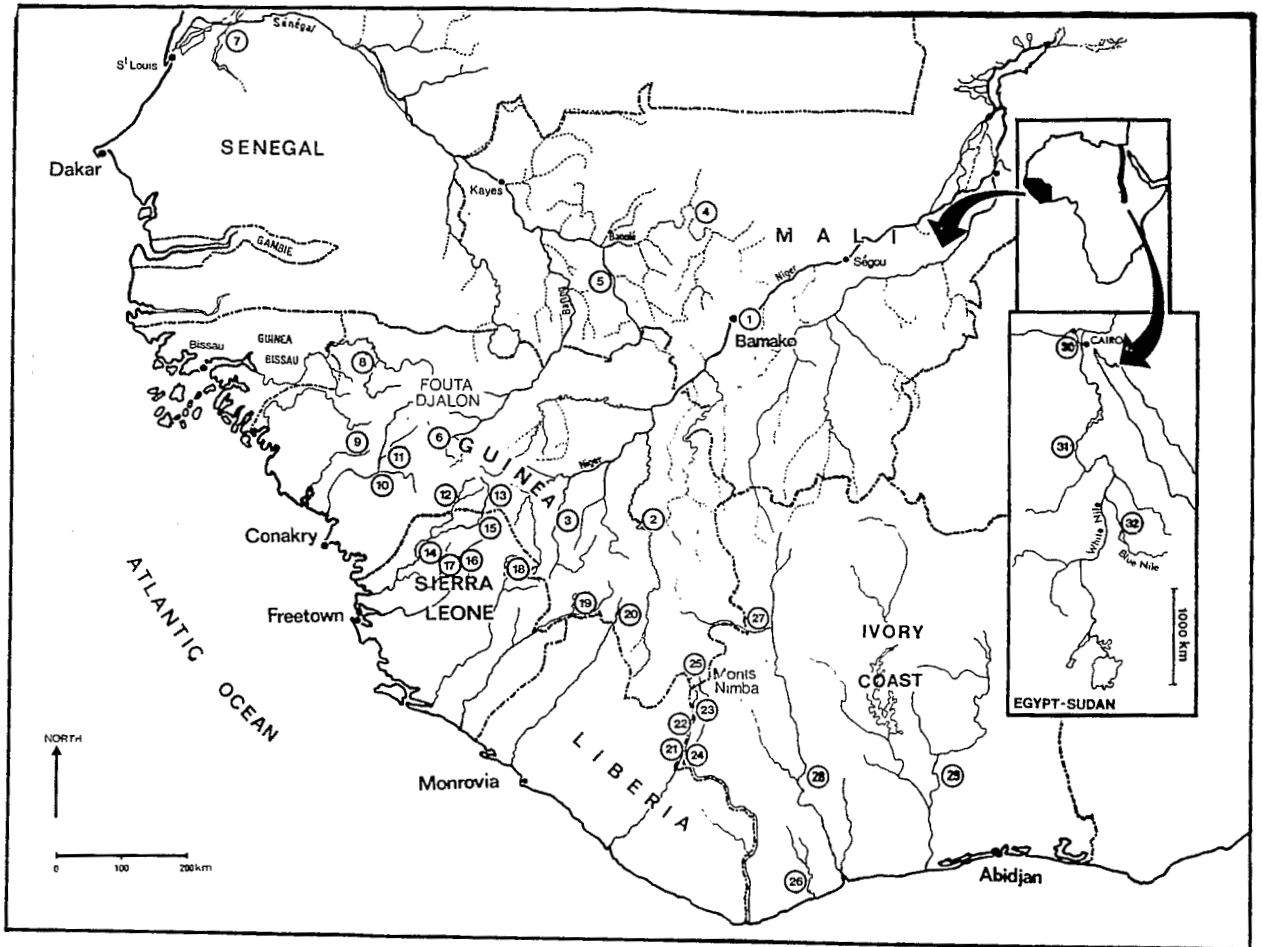


Fig. 1. Distribution and site codes of the different stations sampled in West Africa (1–29) and north-east Africa (30–32). Niger Basin: 1. Niger. 2. Milo. 3. Niandan; Senegal Basin: 4. Baoulé. 5. Bakoye. 6. Bafing. 7. Guiers Lake; Tominé Basin (or Rio Corubal): 8. Tominé; Fatale Basin: 9. Fatale; Konkouré Basin: 10. Konkouré. 11. Kakrima; Little Scarcies Basin: 12. Kaba. 13. 14 and 15. Mongo; Rokel Basin: 16 and 17. Rokel; Bagbwe Basin: 18. Bagbwe; Moa Basin (or Macona): 19. Moa; Loffa Basin: 20. Loffa; Nipoué Basin (or Cess): 21. 22 and 23. Nipoué; Cavally Basin: 24. Cavally. 25. Zié; Dodo Basin: 26. Dodo; Sassandra Basin: 27. Férédougouba. 28. Sassandra; Bandama Basin: 29. Bandama blanc; Nile Basin: 30. Mariout Lake. 31. Nile. 32. Blue Nile.

*B. parawaldroni*: Cavally Basin at Sahoubli<sup>(24)</sup>, Ivory Coast. MNHN 1988–1952.

*V. wurtzi*: Little Scarcies Basin, Kaba<sup>(12)</sup>, Guinea, MNHN 1988–1882 and 1989–1977; Mongo<sup>(13)</sup>, Guinea, MNHN 1988–1881 and 1989–1976; Sassandra Basin. Férédougouba River near Ngorodougou<sup>(27)</sup>, Ivory Coast, MNHN 1988–1953; Nipoué Basin at Toyébli<sup>(21)</sup>, Ivory Coast, MNHN 1988–1954; Cavally Basin at Sahoubli<sup>(24)</sup>, Ivory Coast, MNHN 1988–1951; Konkouré<sup>(10)</sup>, Guinea, MNHN 1989–1000; Bagbwe River<sup>(18)</sup>, Sierra

Leone. MNHN 1989–1974; Rokel River<sup>(15,16)</sup>, Sierra Leone. MNHN 1989–1972 and 1989–1975.

These fish were caught with gill-nets and cast-nets. Determination of the different species of cyprinids was carried out by ORSTOM ichthyologists. Host specimens were deposited as vouchers at the Laboratoire d'Ichtyologie Générale et Appliquée, MNHN, Paris. Lévêque & Daget's nomenclature (1984) is used for the different species of Cyprinidae. Barbel species were revised recently (Lévêque & Guégan, 1990).

In the laboratory, the detached gill-arches were immersed in freshwater for examination under a binocular microscope. The monogeneans were fixed between slide and cover-slip in Malmberg's mixture (glycerine and ammonium picrate). The preparations were sealed. The parasites were then examined under the microscope and the sclerotised parts of the haptor and the copulatory apparatus were drawn with a drawing tube. Naming and numbering of haptor hooks was in conformity with those adopted at ICOPA IV (Euzet & Prost, 1981).

Hamulus measurements of *Dactylogyrus* were those proposed in Bykhovskaya-Pavlovskaya (1962) (Fig. 2). The 'b' measurements of species which belong to *Dogielius* were defined in a slightly different manner for practical reasons (Fig. 2A). Measurements of all specimens are in micrometres ( $\mu\text{m}$ ).

In all cases in which there was a doubt as regard to the value of the morpho-anatomical criteria for diagnosis, statistical methods (analysis of variance) or factorial analysis (principal component analysis or discriminant factorial analysis) were used. The studies were carried out on a set of quantitative variables corresponding to standard measurements of haptor parts (*a, b, c, d, e, X, W*) and various measurements of the copulatory apparatus (length of accessory piece, penis length, vagina length, vagina width). Conventional ANOVA was carried out on pairs of characters.

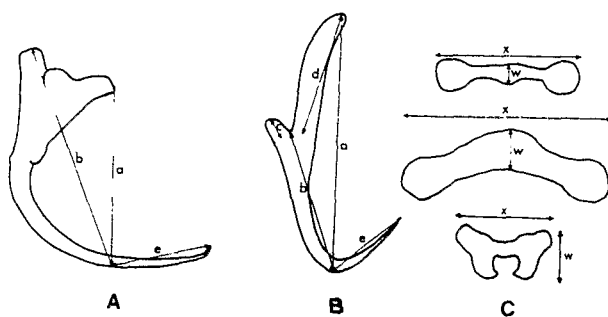


Fig. 2. Measurements of haptor pieces used in this work: A. *Dogielius hamuli*; B. *Dactylogyrus hamuli*; C. Transverse bars: a. Overall hook length; b. Length of shaft and inner root (for A); b. Length of shaft (for B); c. Length of outer root; d. Length of inner root; e. Length of the tip; W. Width of transverse bar; X. Length of transverse bar.

The results obtained for two discriminant variables to within the threshold of security are shown by a scatter diagram. When several characters play an almost identical effect, principal component analysis was used to describe the data (Fénelon, 1981). This was completed by factorial discriminant analysis. The results are illustrated by projection in the principal plane defined by the factors of the greatest importance in the hosts and their parasites. Analyses were carried out using the program BIOMECA Version 3.2 supplied by the CEPE-CNRS Biometry Group, route de Mende, BP 5051, 34033 Montpellier CEDEX, France.

#### *Dactylogyrus pseudanchoratus* Price & Géry, 1968 (Fig. 3)

*Type-host and locality: Barbus occidentalis affinis*, Ogooué System, Gabon. Holotype examined: USNM No. 62984.

*Other previous records: Barbus macrolepis*, Ruaha River, Tanzania (Paperna, 1979).

*Present records: Barbus occidentalis*, stations 1, 5, 6 and 7; *B. petitjeani*, stations 2, 3 and 6; *B. sacratus*, stations 8, 9, 10, 11, 12, 13, 16, 19, 20 and 25; *B. parawaldroni*, stations 20, 22, 24 and 26; *B. waldroni*, stations 28 and 29; *V. wurtzi*, stations 10, 12, 13, 17, 18, 21 and 27.

#### Redescription

(Based on 91 specimens *in toto*). Body length 550 (420–770); width 100 (70–140) usually at level of ovary. Anchor lengths (see Table I). Hook lengths: I, II, III, IV: 15–20; V, VI, VII: 17–20; 4A: 8–10. Male copulatory apparatus consisting of penis 27 (25–30) and accessory piece, length 19 (14–22), trifold, with more finely sclerotised shaft starting at main body of piece and passing round penis. Vagina forming slightly sclerotised pocket narrowing to fine tube, 25 (20–30).

#### Remarks

Two forms were identified, differing in the ratio of the dorsal bar inner root length (Fig. 4): firstly

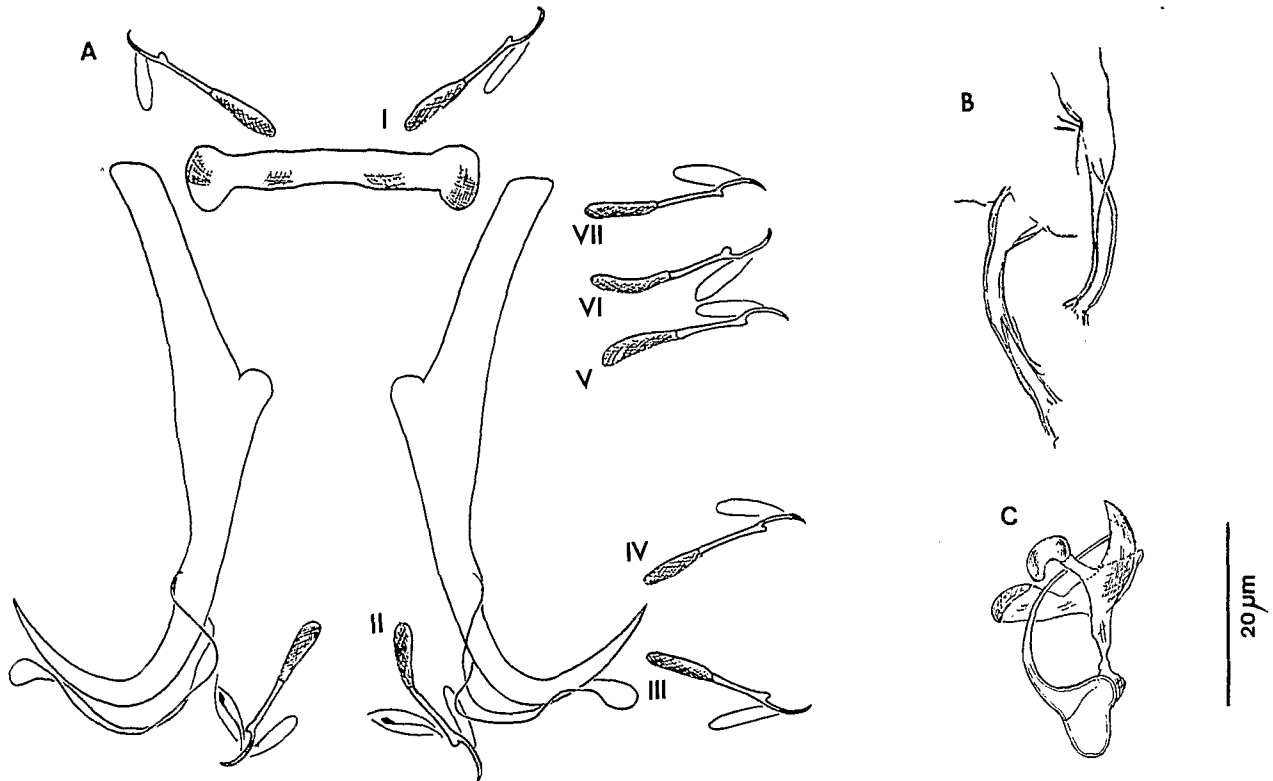


Fig. 3. *Dactylogyrus pseudanchoratus* Price & Géry, 1968. A. Haptor apparatus: B. Vagina: C. Male copulatory organ: I-VII. Marginal hooklets.

the "petitjeani" morphotype found in *B. petitjeani* in the Bafing (Upper Senegal), the Milo and the Niandan (Upper Niger), and secondly the morphotype present in all the other barbels examined. The differences observed were not sufficiently distinct to characterise specific morphs of these various host taxa. It is, therefore, considered for

the moment that the monogeneans present in *B. occidentalis*, *B. waldroni*, *B. parawaldroni*, *B. sacraus* and *V. wurtzi* in various river basins in West Africa belong to the same morphotype complex.

*Dactylogyrus pseudanchoratus* displays certain morphological similarities to *D. tubarius* Guégan, Lambert & Euzet, 1988, which is specific to *Labeo*

Table 1. Metric variations of haptor pieces in *Dactylogyrus pseudanchoratus* Price & Géry, 1968 in relation to the host species.

Host	forma "petitjeanii" ex <i>Barbus petitjeani</i> (25)	forma "complexa" ex <i>Barbus</i> spp.* (66)
Anchor lengths:		
a	54 (48-49)	56 (48-62)
b	33 (30-36)	34 (30-38)
c	3 (2-5)	3 (2-5)
d	31 (24-33)	25 (21-31)
e	18 (15-20)	17 (15-20)
Dorsal bar length	25 (22-28)	32 (29-35)

\* *Barbus* spp. examined were as follows: on *B. occidentalis* 32 parasites; on *B. sacraus* 18 parasites; on *B. waldroni* 5 parasites; on *V. wurtzi* 8 parasites; on *B. parawaldroni* 3 parasites.

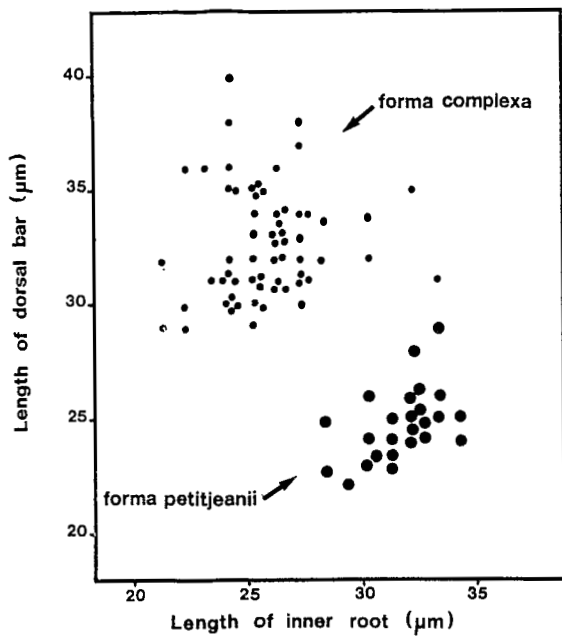


Fig. 4. Scatter diagram representing length of inner root versus length of dorsal bar for two forms of *Dactylogyrus pseudanchoratus* from *Barbus petitjeanii* and from all other barbels ( $P < 0.01$ ).

*senegalensis* in the Niger and Senegal Basins. They nevertheless differ in that there is a simple bifid form in *D. tubarius*, whereas *D. pseudanchoratus* has a trifid piece.

***Dactylogyrus falcilocus* Guégan, Lambert & Euzet, 1988 (Fig. 5)**

*Type-host and locality: Labeo coubie*, Niger System at Bamako, station 1, Mali. Holotype MNHN (Worms) No. 264 HC.

*Other records: L. coubie*, station 4; *L. parvus* and *V. wurtzi*, stations 12 and 13.

**Redescription**

(Based on 47 specimens *in toto*). Body length 380 (260–480); width 60 (50–80) usually at level of ovary. Anchor lengths (see Table II). Hook lengths: I,II,III,IV, 17 (14–19); V,VI,VII, 20 (18–21); 4A, 8–10. Male copulatory apparatus (19–23) consisting of basal ampulla followed by

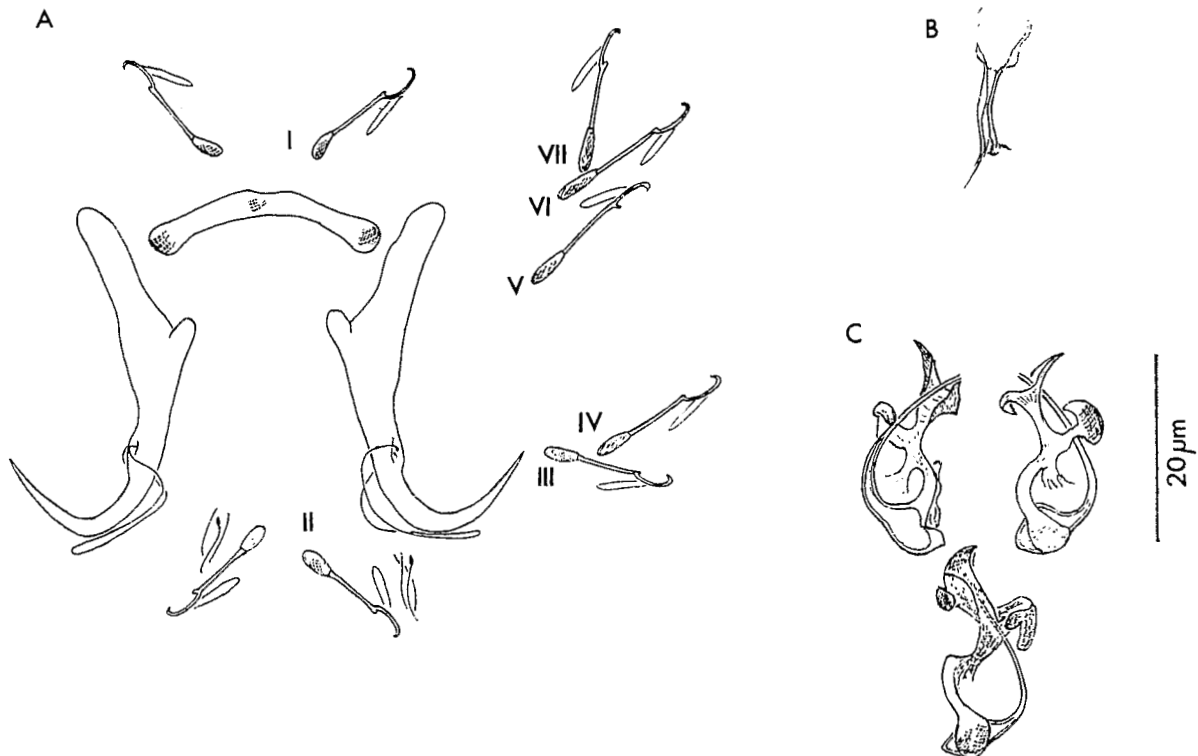


Fig. 5. *Dactylogyrus falcilocus* Guégan, Lambert & Euzet, 1988. A. Haptor apparatus; B. Vagina; C. Male copulatory organ; I–VII. Marginal hooklets. This representation of *D. falcilocus* is for specimens of the form found on *Labeo parvus* from the Little Sarcies.



Table II. Metric variations of haptor and copulatory pieces in *Dactylogyrus falcilocus* Guégan, Lambert & Euzet, 1988 in relation to the host species.

Host	ex <i>V. wurtzi</i>	ex <i>L. parvus</i>	ex <i>L. coubie</i>
Number	(11)	(15)	(21)
Locality	Little Scarcies		Niger
Anchor lengths:			
a	41 (39-43)	36 (34-39)	36 (30-40)
b	27 (26-29)	23 (22-24)	25 (23-27)
c	2 (1-3)	1-3	1-2
d	19 (18-21)	16 (14-18)	16 (12-19)
e	14 (13-15)	12-13	14 (11-16)
Dorsal bar length	27 (26-29)	25 (23-27)	25 (24-28)
Copulatory organ length	22 (19-23)	22 (20-24)	22 (17-25)
Penis length	21 (18-23)	21 (18-23)	20 (17-20)
Vagina length	17 (15-20)	12 (10-14)	15 (13-16)

fine, incurvate penis (18-23). Characteristic accessory piece bifid; proximal branch forms elbow and distal part is in shape of small gutter with raised edges in which slides penis. Vagina, with finely sclerotised wall, forms hollow tube.

#### Remarks

The individuals of *Dactylogyrus falcilocus* collected on *V. wurtzi* from the Little Scarcies in Guinea were similar to monogeneans originally described as being specific to *L. coubie* in the Niger and Senegal Basins in Mali (Guégan *et al.*, 1988). We also report that this species was found on *L. parvus* in the same basin (Little Scarcies) (Guégan & Lambert, in press). The specimens found in *V. wurtzi* possess distinctly larger hamuli (Fig. 6). We consider that *D. falcilocus* is a parasite which displays broad or euryxenic specificity (Euzet & Combes, 1980).

#### *Dactylogyrus ruahae* Paperna, 1973 (Fig. 7)

*Type-host and locality:* *Barbus macrolepis*, Ruaha River, Tanzania. Holotype examined MRAC No.35.903.

*Other records:* *B. sacratus*, stations 9, 10, 12, 13, 16, 18, 19 and 25; *B. parawaldroni*, station 20; *V. wurtzi*, stations 12, 21 and 27.

#### Redescription

(Based on 58 specimens *in toto*). Material deposited at MNHN (Worms) No. 79 HF, slide Ti

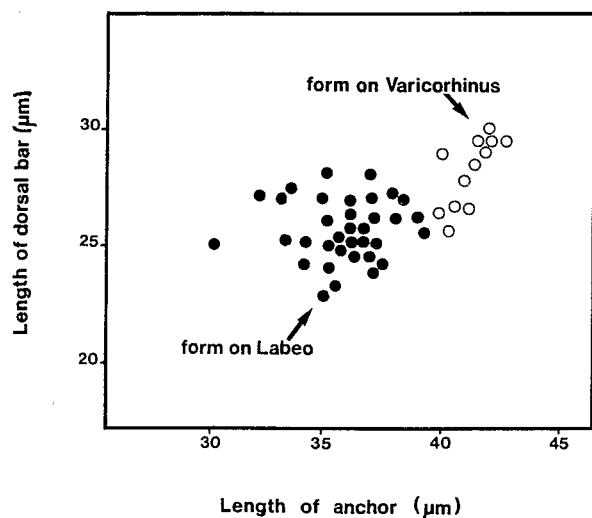


Fig. 6. Scatter diagram representing length of anchor versus length of dorsal bar for two forms of *Dactylogyrus falcilocus* from *Labeo coubie* (Niger and Senegal Basins), *Labeo parvus* (Little Scarcies Basin) and *Varicorhinus wurtzi* (Little Scarcies System) ( $P < 0.05$ ).

94. See Table III for the metric variations according to host species.

#### Remarks

These individuals are similar to the single specimen used by Paperna for the diagnosis of the species *Dactylogyrus ruahae* Paperna, 1973, found on *B. macrolepis* in the Ruaha River in Tanzania (Paperna, 1973). In spite of several slight variations in the size of haptor parts depending on the host species (Table III), no character appeared to

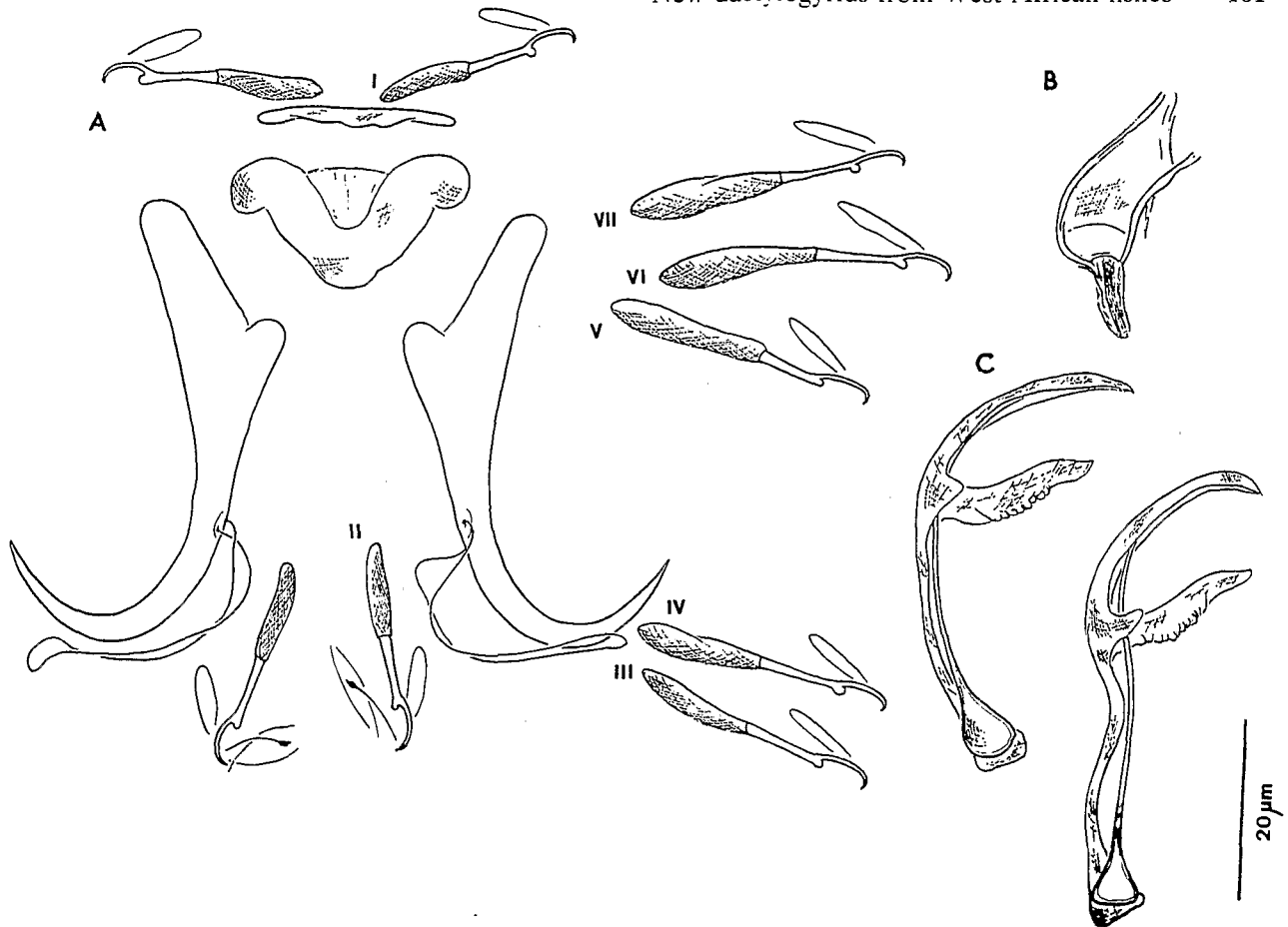


Fig. 7. *Dactylogyrus ruahae* Paperna, 1973. A. Haptor apparatus; B. Vagina; C. Male copulatory organ; I-VII. Marginal hooklets.

Table III. Metric variations of the species *Dactylogyrus ruahae* Paperna, 1973, in relation to the host species.

Host Number	ex <i>B. sacraus</i> (29)	ex <i>V. wurtzi</i> (21)	ex <i>B. paravaldroni</i> (8)
Body length	590 (480-720)	400 (340-450)	500 (380-620)
Body width	100 (70-120)	70 (50-90)	80 (60-110)
Anchor lengths:			
a	50 (44-53)	48 (41-52)	46 (43-50)
b	37 (32-40)	36 (34-41)	35 (32-37)
c	3 (2-5)	3 (2-5)	4 (2-5)
d	18 (16-21)	16 (13-18)	16 (13-18)
e	15 (14-16)	15 (12-16)	15 (14-16)
Dorsal bar length	25 (23-28)	26 (23-29)	23-25
Ventral bar length	21 (18-23)	20 (18-22)	18-20
Hook lengths:			
I	24 (20-25)	23 (20-26)	23-25
I	24(20-25)	23 (20-26)	23-25
III	26 (23-28)	27 (24-30)	25-27
IV	26 (23-28)	27 (24-30)	25-27
V	30 (25-32)	30 (26-35)	30-33
VI	33 (30-35)	33 (29-35)	34-35
VII	30 (25-32)	30 (26-35)	30-33
4A	7-10	8-11	8-10
Penis length	55 (47-60)	53 (47-57)	52 (48-56)
Vagina length	28 (25-37)	26 (22-30)	28 (23-32)

statistically discriminate sufficiently to distinguish groups. We consider that for the moment all the specimens found on *B. sacratus*, *B. parawaldroni* and *V. wurtzi* belong to the same species, *D. ruahae*.

These monogeneans display morphological similarities to species identified on various *Barbus* spp. in India: *Dactylogyrus barbi* Gussev, 1973 on *B. sarana*, *D. tori* Gussev, 1973 on *B. tor* and *D. dubii* Gussev, 1973 on *B. dubius* (Gussev, 1973).

***Dactylogyrus aferoides* n. sp.** (Fig. 8)

*Type-host and locality:* *Barbus occidentalis*. Niger System at Bamako, station 1, Mali.

*Other records:* *B. occidentalis*, stations 4, 5, 6 and 7; *B. petitjeani*, station 6; *B. bynni*, stations 29, 30 and 31; *B. waldroni*, stations 28 and 29; *B. parawaldroni*, station 22.

*Type-material:* Holotype MNHN No. 74 HF, slide Ti 84, paratype MNHN No. 74, slide Ti 85.

**Description**

(Based on 64 specimens *in toto*). Body length 620 (450–800), width 100 (80–140) usually at level of ovary. Anchor lengths: a, 62 (55–70); b, 40 (31–44); c, 5 (4–7); d, 26 (22–31); e, 18 (16–20). Dorsal bar length 30 (25–33). Vestigial ventral bar length 10–13. Hook lengths: I,II, 24 (20–28); III, 20 (18–23); IV, 23 (20–26); V,VI,VII, 30 (26–35); 4A, 9–12. Male copulatory apparatus consisting of a curved penis, length 70 (55–78), becoming thinner towards extremity, and complex accessory piece 43 (33–48) whose distal part forms gutter. Vagina finely sclerotised at vaginal pore.

*Etymology.* The specific name is derived from the affinities with *Dactylogyrus afer*.

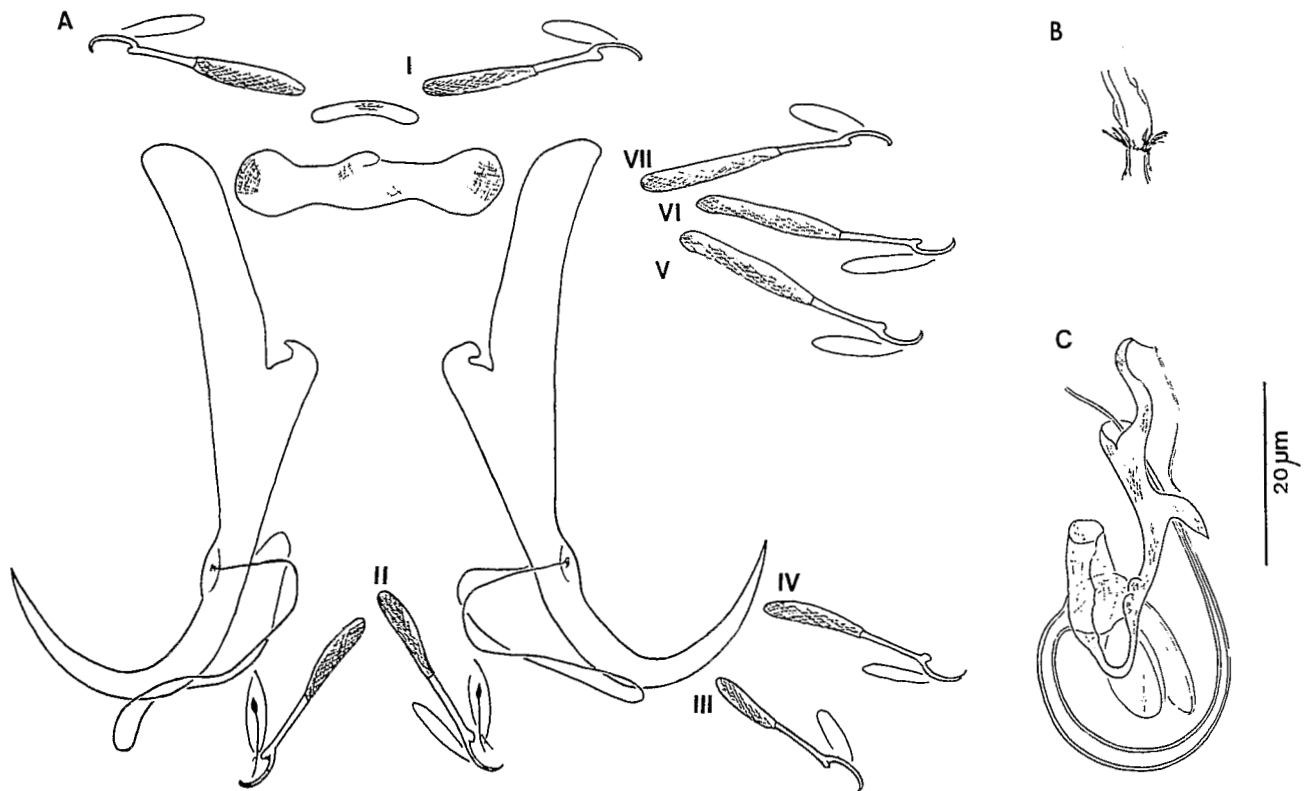


Fig. 8. *Dactylogyrus aferoides* n. sp. A. Haptor apparatus: B. Vagina: C. Male copulatory organ: I-VII. Marginal hooklets.

*Remarks*

*Dactylogyrus aferoides* n. sp. is reported in the Senegal Basin on *B. occidentalis* and *B. petitjeani*, in the Niger on *B. occidentalis*, in the Nile on *B. bynni*, in the Bandama and Sassandra Basins in the Ivory Coast on *B. waldroni* and in a very small quantity (2 parasite specimens) on *B. parawaldroni* in the Nipoué. The morphology of the copulatory apparatus resembles that of *D. afer* Price & Géry, 1968, identified for the first time in the Ivindo basin in Gabon (Price & Géry, 1968) on *Barbus* cf. *batesii*. Examination of the holotype of *D. afer* (USNM 62981) nevertheless makes it possible to characterise the individuals that we present as belonging to a new species.

The different specimens of *D. aferoides* n. sp. do not display strong variations in the morphology of the copulatory apparatus or in the size of the haptor pieces in relation to the host species and

river basins studied. *D. aferoides* n. sp. in a monogenean whose known distribution covers the Nile Basin, the large Sahel-Sudan basins (Niger and Senegal) and several basins in the Ivory Coast. It can be considered that the real distribution repeats the distribution of the host line of *B. bynni*, to which *B. occidentalis* and *B. waldroni* belong (Lévêque & Guégan, 1990).

*Dactylogyrus archaeopenis* n. sp. (Fig. 9)

*Type-host and locality:* *Barbus parawaldroni*, Loffa River near Macenta, station 20, Guinea. *Other records:* *B. sacratus*, stations 8, 10, 19, 20 and 25; *B. petitjeani*, station 2 and 6.

*Type-material:* Holotype, MNHN No. 70 HF, slide Ti 76; paratype, MNHN No. 70 HF, slide Ti 77.

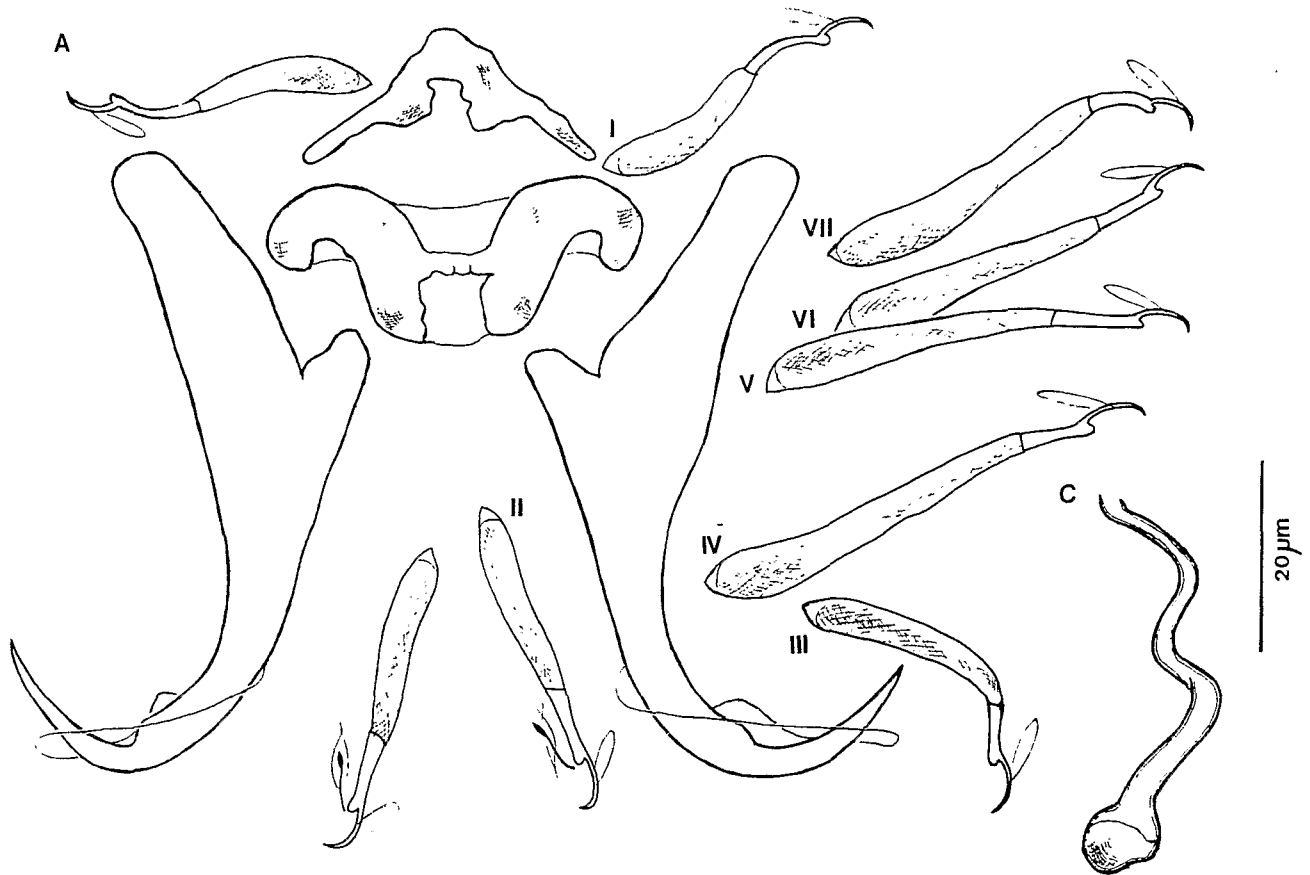


Fig. 9. *Dactylogyrus archaeopenis* n. sp. A. Haptor apparatus; B. Vagina; C. Male copulatory organ; I-VII. Marginal hooklets.

*Description*

(Based on 14 specimens *in toto*). Body length 700 (550–800); width 90 (70–120) usually at level of ovary. Anchor lengths: a, 60 (55–65); b, 43 (40–46); c, 6 (3–9); d, 24 (22–27); e, 16 (15–17). Two bars: first dorsal, large, with butterfly-like structure, length 45 (40–48), width 19 (16–20); second ventral bar smaller, length 35 (30–37), width 8–12. Hooks very large and heavy, often half or greater than half length of anchor. Hook lengths: I,II, 31 (28–34); III, (30–37); IV,V, 43 (40–48); VI,VII, 46 (44–52); 4A, 8–10. Penis is long, wide tube, 54 (53–57), with slight curve terminated distally with rounded ampulla. Funnel not distinct. Accessory piece absent or reduced. Vagina not sclerotised.

*Etymology.* The specific name is from Greek (*archaeo*, old) and reflects the archaic apparatus of the penis.

*Remarks*

These monogeneans found on *Barbus parawaldroni* from the Loffa (Guinea), on *B. sacratus* from the Loffa, the Moa, the Zié, the Tominé and the Konkouré (Guinea), on *B. petitjeani* from the upper Bafing (Guinea) are not closely related to any monogenean species hitherto described. Given the small number of specimens collected, we have not observed any variation in size between specimens from different hosts and river basins. It is considered for the moment, in the absence of other discriminant data, that these monogeneans belong to the same species *D. archaeopenis* n. sp.

*Dactylogyrus sahelensis* n. sp. (Fig. 10)

*Type-host and locality:* *Barbus occidentalis*. Niger system at Bamako, station 1, Mali.

*Other records:* *B. occidentalis*, stations 2, 3, 4, 6 and 7; *B. petitjeani*, station 6; *B. bynni*, station 30 and 32; *B. waldroni*, station 28 and 29.

*Type-material:* Holotype MNHN No. 68 HF, slide Ti 72; paratype MNHN No. 68 HF, slide Ti 73.

*Description*

(Based on 32 specimens *in toto*). Body length 750 (550–900), width 100 (80–140) usually at level of ovary. Anchor lengths (see Table IV). Two bars: dorsal bar length 34 (33–38); vestigial ventral bar length 28 (26–31). No characteristic variation between specimens from different hosts and basins. Hook lengths: I,II,III, 29 (26–32); IV,V,VII, 36 (32–40); VI, 40 (37–43); 4A, 9–12. Male copulatory apparatus characteristic of "D. varicorhini group", length 39 (31–43). Accessory piece 30 (22–35); penis c.70 (65–85). Tubular vagina 48 (40–55).

*Etymology.* The specific name is derived from the area of sub-Saharan Africa in which this new species is found.

*Remarks*

These specimens display morphological similarities with *Dactylogyrus gabonensis* Price & Géry, 1968, first discovered in *Barbus occidentalis affinis* from the Ogooué River in Gabon (Price & Géry, 1968). Even if they belong to the same morphological type, according to their copulatory apparatus, examination of the *D. gabonensis* holotype (USNM 62982) makes it possible to characterise the monogeneans presented here as belonging to a new species. As determination of *Barbus* is very difficult and the Gabonese ichthyofauna is little known, Manhart & Géry (1982) indicated some doubt with regard to the identification of *B. occidentalis affinis*.

The specimens collected on *B. occidentalis*, *B. bynni*, *B. waldroni* and *B. petitjeani* display variations in size of the hamuli depending on the host species and river basin (Table IV). However, no variations were observed in the copulatory apparatus of the different specimens examined. We consider that this is a complex of forms present in hosts which are phylogenetically related (*B. occidentalis*, *B. bynni* and *B. waldroni*) (Lévêque & Guégan, 1990) or related ecologically (*B. occidentalis* and *B. petitjeani*). The characterisation of different parasite morphs made here does not solve the question of their taxonomic level, since

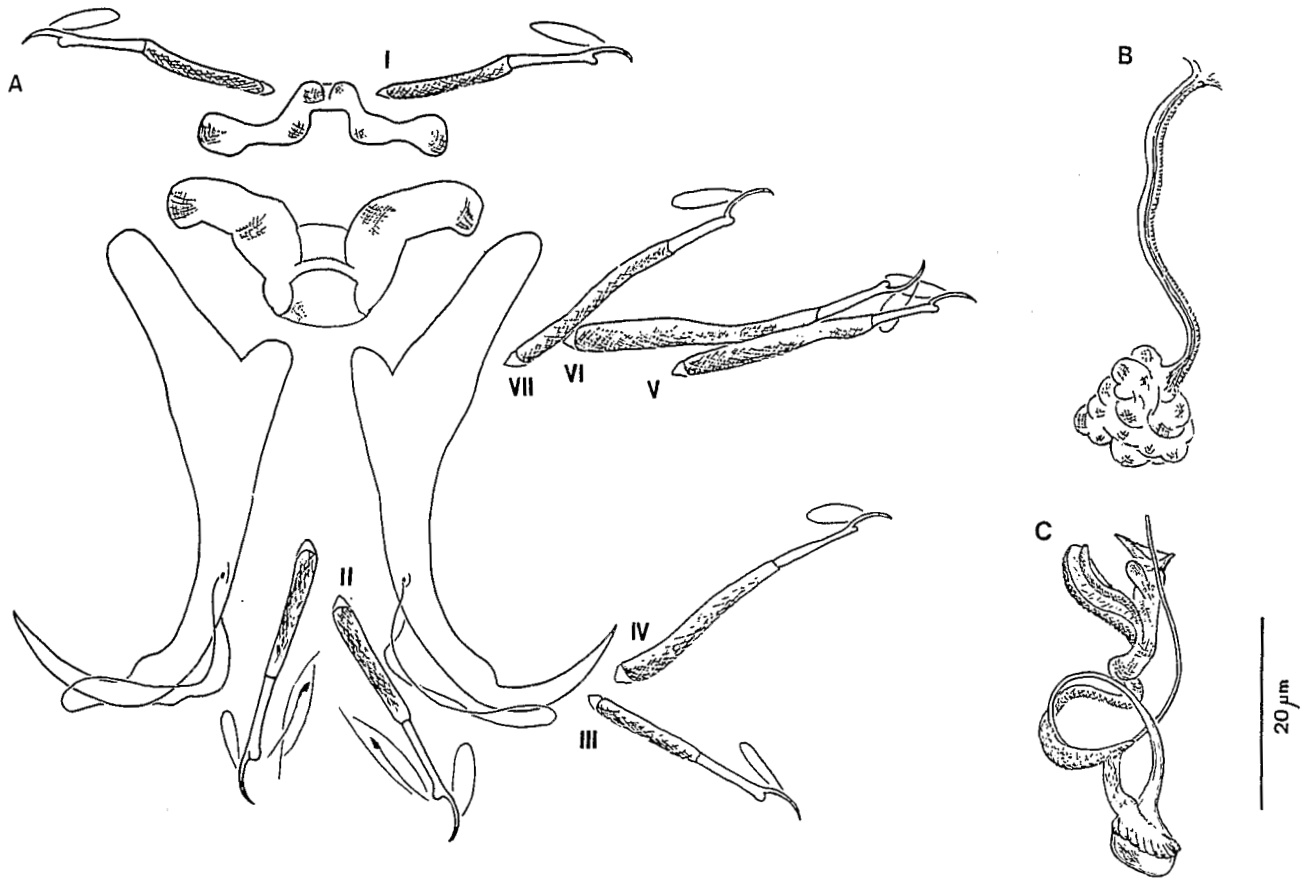


Fig. 10. *Dactylogyrus sahelensis* n. sp. A. Haptor apparatus; B. Vagina; C. Male copulatory organ; I-VII. Marginal hooklets.

only breeding experiments can do this. The existence of size variations in *D. sahelensis* n. sp. depending on the host species and the river basin corroborates the hypothesis put forward by ichthyologists (Lévêque & Guégan, 1990) for the existence of a cline in the *B. bynni*-*B. occidentalis*-*B. waldroni* group from the Nile Basin to the Sahel-Sudan basins and then to those of the Ivory Coast.

***Dactylogyrus petitjeanii* n. sp. (Fig. 11)**

*Type-host and locality:* *Barbus petitjeani*. Senegal system. Upper Bafing near Sokotoro, station 6. Guinea.

*Other records:* *B. petitjeani*, stations 2 and 3.

*Type-material:* Holotype, MNHN No. 71 HF, slide Ti 78; paratype MNHN No. 71 HF, slide Ti 79.

Table IV. Metric variations of hamuli in *Dactylogyrus sahelensis* n. sp. in relation to the host species and river basin.

Host	<i>ex B. occidentalis</i>	<i>ex B. petitjeani</i>	<i>ex B. waldroni</i>	<i>ex B. bynni</i>
Number	(14)	(11)	(4)	(3)
Locality	Bafing Niger	Bafing	Sassandra Bandama	Nil
a	53 (50-56)	58 (56-65)	50 (49-51)	55-56
b	41 (38-43)	45 (43-50)	38 (36-39)	40-42
c	5 (3-6)	4 (3-5)	5-6	4-7
d	18 (16-20)	19 (17-20)	16 (15-17)	19-22
e	15 (14-16)	15 (14-17)	12 (11-13)	16-17

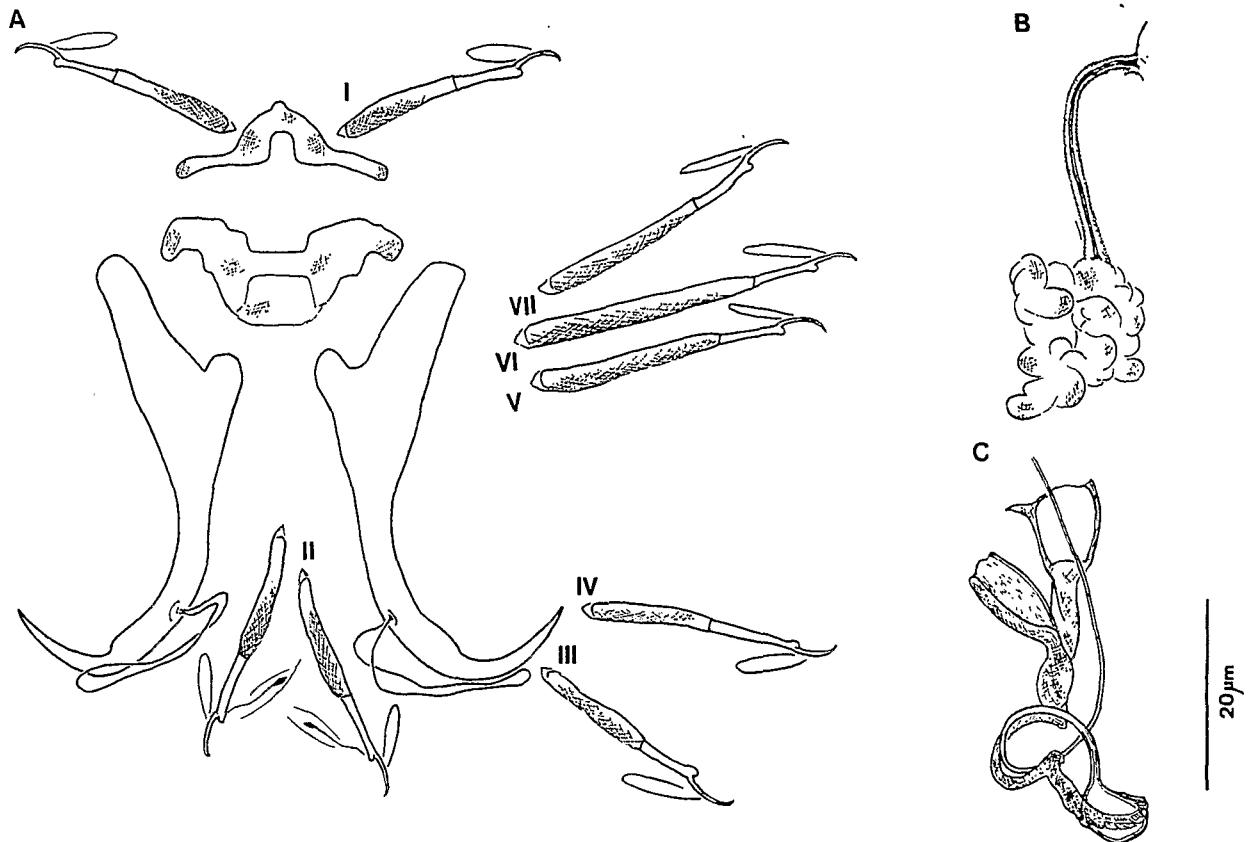


Fig. 11. *Dactylogyrus petitjeanii* n. sp. A. Haptor apparatus; B. Vagina; C. Male copulatory organ; I-VII. Marginal hooklets.

#### Description

(Based on 25 specimens *in toto*). Body length 750 (620–900); width 100 (80–130) usually at level of ovary. Anchor lengths; a, 47 (45–49); b, 37 (35–38); c, 3–4; d, 15–16; e, 14–15. Two bars: dorsal bar length 27 (24–29); vestigial ventral bar length 26 (22–28). Hook lengths: I, II, III, 24 (22–26); IV, 29 (28–30); V, VI, VII, 36 (30–40); 4A, 8–10. Male copulatory apparatus 40 (32–46), of “*D. varicorhini* type”, consists of penis (70–80) and characteristic accessory piece, length 35 (28–38), whose main branch has palette-shaped extremity. Vagina is long, fine tube (40–50) joining shapeless cell mass.

**Etymology.** The specific name is derived from the host name *B. petitjeani*.

#### Remarks

These dactylogyrids, which are specific to *B. petitjeani* from the Bafing, the upper Milo and the

upper Niandan in Guinea, resemble *Dactylogyrus spinicirrus* Paperna & Thurston, 1968, encountered in numerous *Barbus* spp. in East Africa (Paperna & Thurston, 1968). The morphology and size of the copulatory organ and the hamulus size are nonetheless different. *D. petitjeanii* n. sp. was found only on *B. petitjeani* and not on *B. occidentalis*, which is sympatric with it in the Bafing, the Milo and the Niandan. We, therefore, consider that the presence of *D. sahelensis* n. sp. (see above) on *B. petitjeani* is the result of capture made possible by the coexistence of these two cyprinids in the same biotope.

#### *Dactylogyrus sacrati* n. sp. (Fig. 12)

**Type-host and locality:** *Barbus sacratus*, Little Sarcies System, Kaba at Kouloundala, station 12, Guinea.

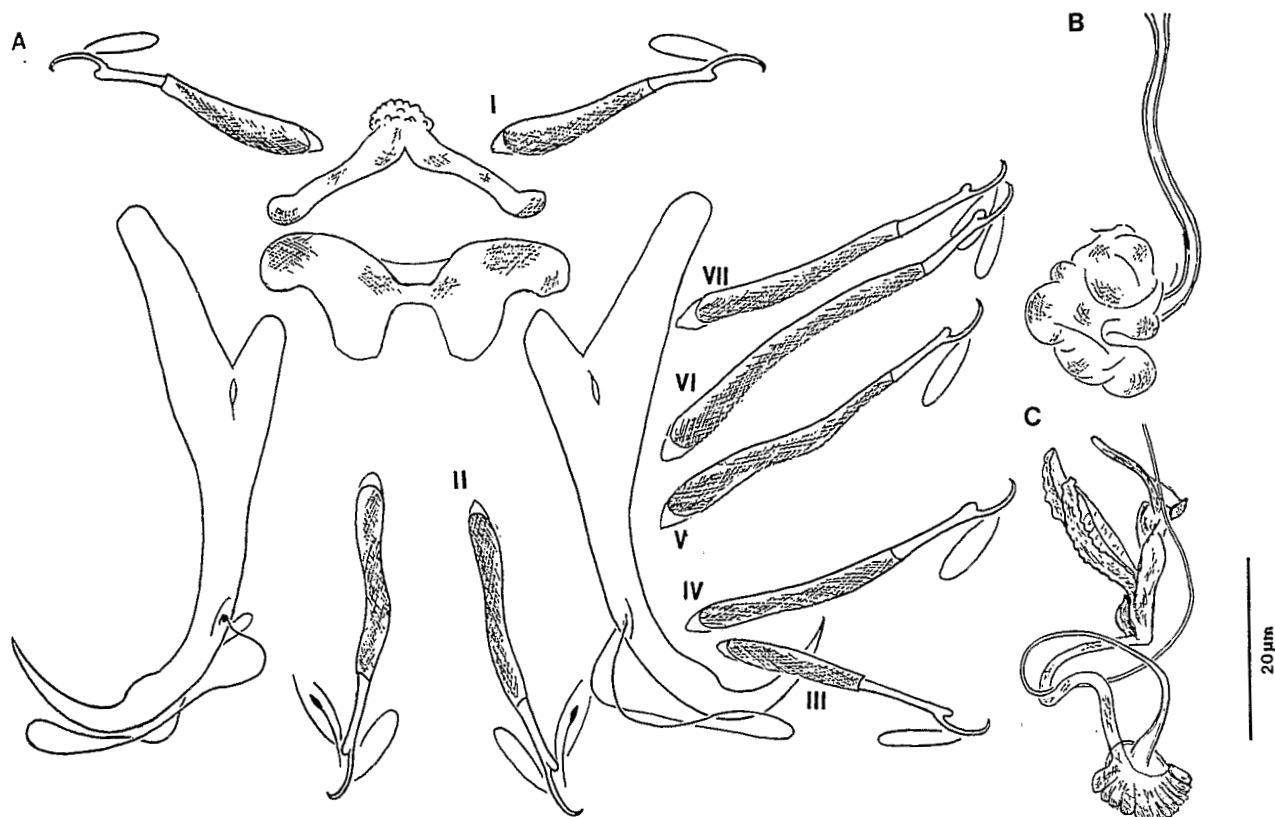


Fig. 12. *Dactylogyrus sacrati* n. sp. A. Haptor apparatus: B. Vagina: C. Male copulatory organ: I-VII. Marginal hooklets.

*Other records:* *B. sacratus*, stations 8, 9, 10, 13, 16, 20 and 25.

*Type-material:* Holotype, MNHN No. 73 HF, slide Ti 82; paratype, MNHN No. 73 HF, slide Ti 83.

**Description**

(Based on 32 specimens *in toto*). Body length 820 (650–1,000); width 110 (90–160) usually at level of ovary. Anchor lengths: a, 59 (49–64); b, 44 (38–49); c, 6 (3–9); d, 21 (17–24); e, 14 (13–15). Two bars: dorsal bar length 35 (32–40); vestigial ventral bar length 31 (25–35). Hook lengths: I,II,III, 31 (25–35); IV, 40 (30–45); V, 45 (40–51); VI, 50 (44–56); VII, 42 (38–47); 4A, 8–10. Male copulatory apparatus 42 (35–49), typical of “*D. varicorhini* group”. Sclerotised accessory piece 33 (25–39), one branch of which displays lateral extension (see illustration). Penis 75 (60–88). Sclerotised, tube-shaped vagina 46 (38–55).

*Etymology.* The specific name is derived from the host name.

**Remarks**

These specimens found on *Barbus sacratus* resemble *D. sahelensis* n. sp. They differ however in the different sizes of hamuli and the fine structure of the accessory piece of the male copulatory structure (Fig. 10).

***Dactylogyrus wurtzii* n. sp. (Fig. 13)**

*Type-host and locality:* *Varicorhinus wurtzi*, Little Scarcies System, Kaba at Kouloundala, station 12, Guinea.

*Other records:* *V. wurtzi*, stations 13, 14, 15, 17, 18, 21, 24 and 26.

*Type-material:* Holotype, MNHN No. 67 HF,

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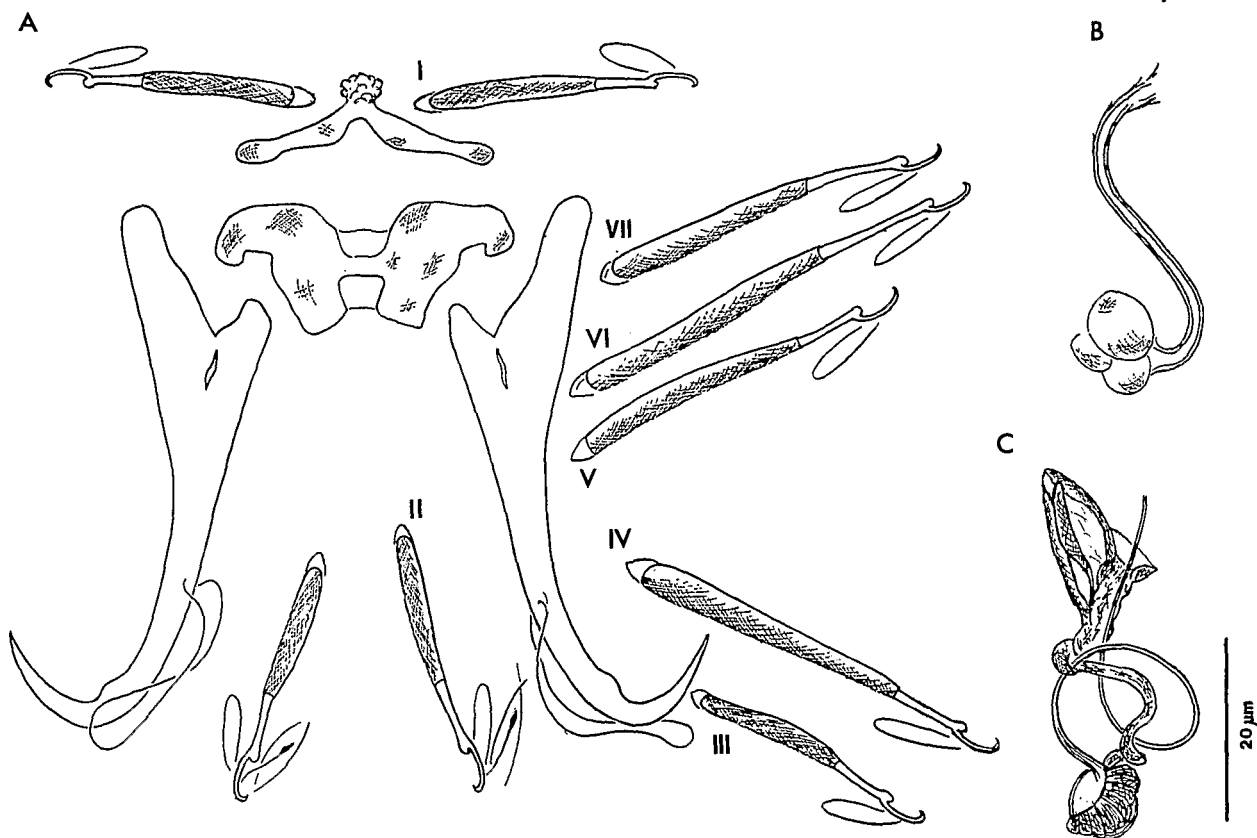


Fig. 13. *Dactylogyрус wurtzii* n. sp. A. Haptor apparatus; B. Vagina; C. Male copulatory organ; I-VII. Marginal hooklets.

slide Ti 70; paratype, MNHN No. 67 HF, slide Ti 71.

**Description**

(Based on 34 specimens *in toto*). Body length 570 (460–630); width 70 (50–90) usually at level of ovary. Anchor lengths: a, 57 (51–60); b, 44 (37–47); c, 6 (5–8); d, 17 (16–19); e, 12 (10–14). Two transversal bars: dorsal bar length 33 (30–37); vestigial ventral bar length 30 (28–33). Hook lengths: I,II,III, 29 (25–32); IV, 40 (36–43); V, 46 (42–50); VI, 50 (46–53); VII, 39 (37–42); 4A, 8–11. Male genital apparatus length 37 (33–43), of “*D. varicorhini* type”. Accessory piece characteristic of type, length 32 (25–37). Long, flagellate penis, 75 (70–85). Vagina is long sclerotised tube, 45 (38–50).

**Etymology:** The specific name is derived from the host name.

**Remarks**

These specimens discovered on *Varicorhinus wurtzi* in different river basins in Guinea, Sierra Leone and the Ivory Coast resemble (in the general morphology of the hamuli and copulatory organ) *Dactylogyрус sacrati* n. sp. (Fig. 12). Although they belong to the same morphological type according to their male copulatory apparatus, they differ both in the structure of the accessory piece and in the size of hamuli

***Dactylogyрус parawaldronii* n. sp. (Fig. 14)**

**Type-host and locality:** *Barbus parawaldroni*, Loffa River near Macenta, station 20, Guinea.

**Other records:** *B. parawaldroni*, station 26.

**Type-material:** Holotype, MNHN No. 69 HF, slide Ti 74; paratype MNHN No. 69 HF, slide Ti 75.

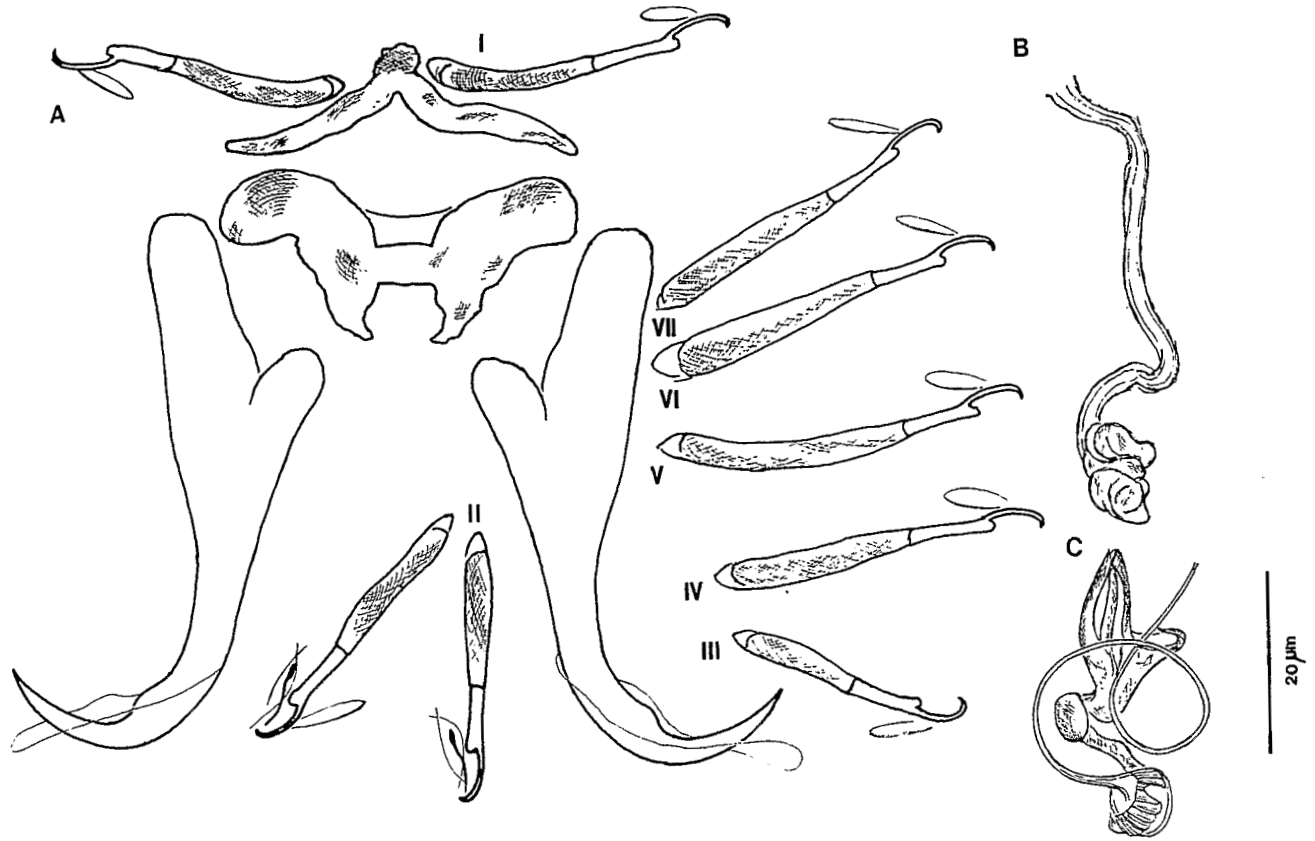


Fig. 14. *Dactylogyrus parawaldronii* n. sp. A. Haptor apparatus; B. Vagina; C. Male copulatory organ; I-VII. Marginal hooklets.

**Description**

(Based on 10 specimens *in toto*). Body length 520 (400-650); width 100 (80-120) usually at level of ovary. Anchor lengths: a, 56 (53-59); b, 43 (41-45); c, 5 (4-6); d, 19 (16-22); e, 13 (12-15). Two transverse bars: dorsal bar length 44 (42-49); vestigial ventral bar 36 (28-42). Hook lengths: I,II,III, 33 (29-37); IV, 40 (38-45); V, 45 (42-49); VI, 50 (47-55); VII, 43 (40-45); 4A, 8-10. Short male copulatory apparatus 32 (28-35), consisting of accessory piece characteristic of "D. varicorhini type", 23 (21-25), and fine, flagellate penis, 77 (70-85). Vagina is long, sclerotised tube, 40 (35-45).

**Etymology.** The specific name is derived from the host name.

**Remarks**

The morphology of the accessory piece of the male copulatory apparatus of the monogeneans

found on *Barbus parawaldroni* in the Loffa in Guinea and in the Dodo in the Ivory Coast shows that they belong to the "D. varicorhini group". However, these specimens differ from the species described above in the size and morphology of the copulatory apparatus and in the size of the haptoral pieces.

***Dactylogyrus clani* n. sp. (Fig. 15)**

**Type-host and locality:** *Barbus petitjeani*, Senegal System, Bafing at Sokotoro, station 6, Guinea.

**Other records:** *B. petitjeani*, stations 2 and 3.

**Type-material:** Holotype, MNHN No. 76 HF, slide Ti 88; paratype MNHN No. 76 HF, slide Ti 89.

**Description**

(Based on 18 specimens *in toto*). Body length 630 (520-800); width 100 (80-140) usually at level of

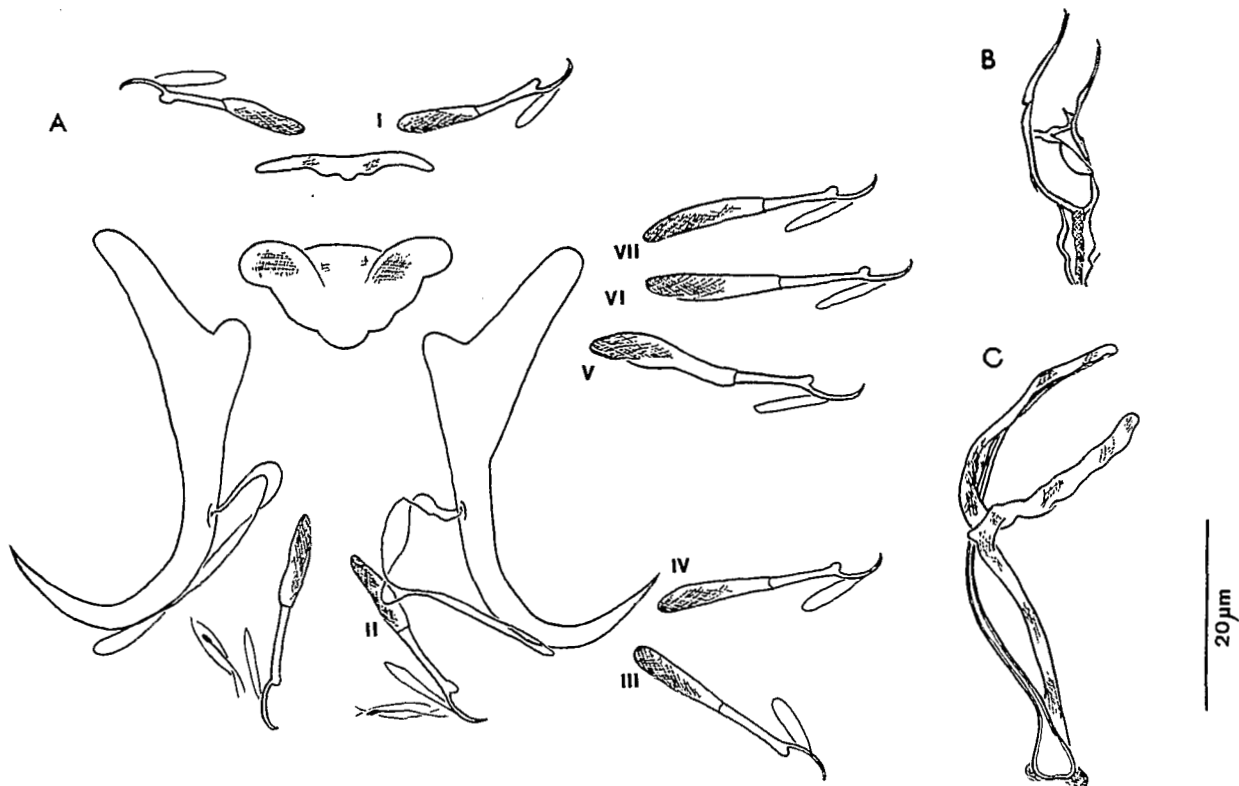


Fig. 15. *Dactylogyрус clani* n. sp. A. Haptor apparatus: B. Vagina: C. Male copulatory organ: I-VII. Marginal hooklets.

ovary. Anchor lengths: a, 44 (41-48); b, 33 (31-35); c, 4 (3-5); d, 16 (15-20); e, 15 (12-16). Two transverse bars: dorsal bar length 24 (22-26); very narrow vestigial ventral bar, length 18 (16-20). Hook lengths: I, 23 (21-24); II, 25 (23-26); III, IV, 27 (24-29); V, VI, VII, 32 (28-35); 4A, 8-10. Male copulatory apparatus consisting of tubular penis, 52 (45-58), and large bifid accessory piece, 53 (46-60). Vagina apparatus consists of long, sclerotised pocket extended into narrower neck, 28 (22-33).

**Etymology.** The species name is derived from the Gaelic word "clan" because of the phylogenetic importance that we attribute to this species in the hierarchy of monogeneans.

**Remarks**

The general morphology of these monogeneans, which are specific to *Barbus petitjeani* from the upper Bafing (Senegal Basin), the upper Milo and

the upper Niandan (Niger Basin) in Guinea, resembles that of *Dactylogyрус ruahae* Paperna, 1973, which is allopatric from other watercourses in West Africa (Fig. 7). The specimens described nevertheless exhibit different sizes of haptor pieces and a simpler morphology of the male copulatory apparatus.

***Dogielius djolibaensis* n. sp. (Fig. 16)**

**Type-host and locality:** *Barbus occidentalis*, Niger System at Bamako, station 1, Mali.

**Other records:** *B. occidentalis*, stations 3, 5 and 6; *B. petitjeani*, stations 3 and 6; *B. waldroni*, station 28.

**Type-material:** Holotype, MNHN No. 78 HF, slide Ti 92, paratype, MNHN No. 78 HF, slide Ti 93.

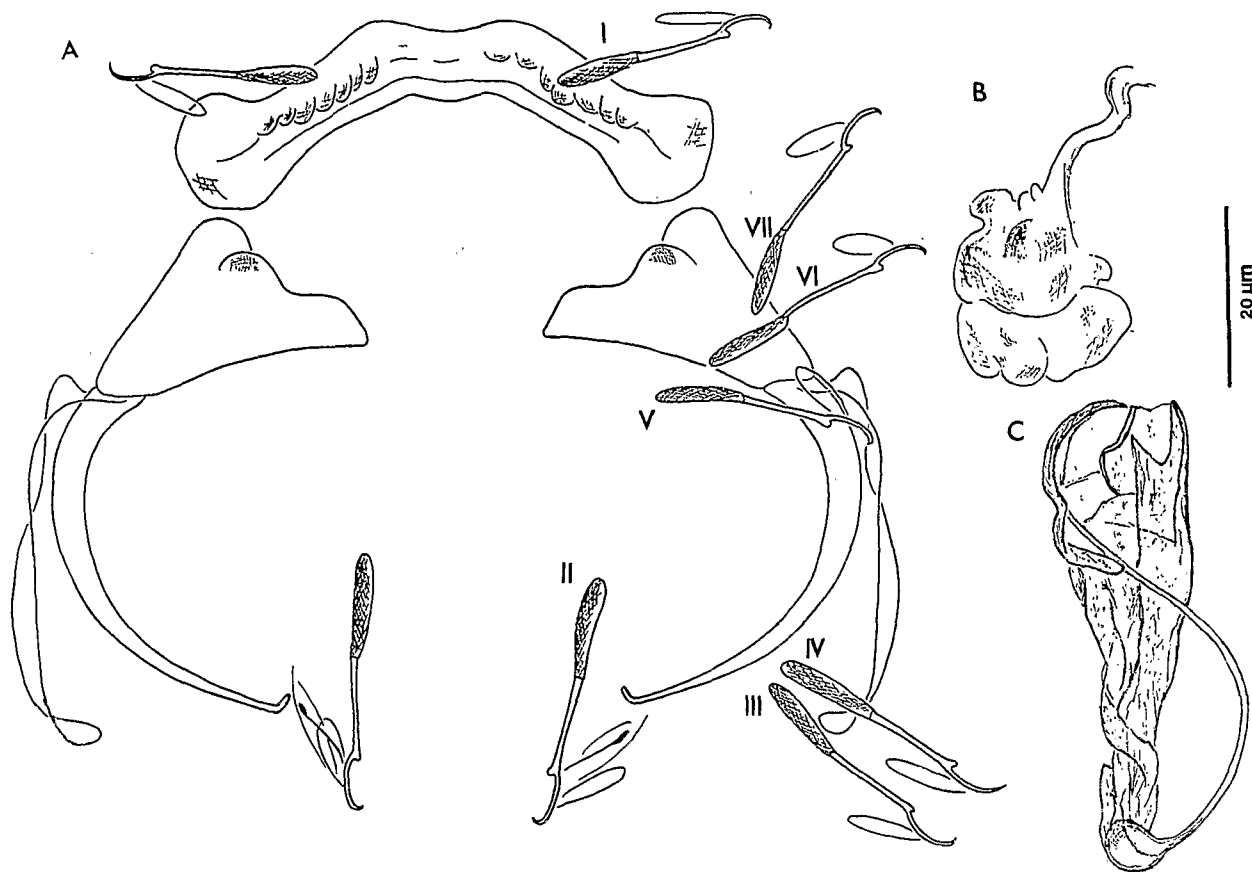


Fig. 16. *Dogielius djolibaensis* n. sp. A. Haptor apparatus: B. Vagina: C. Male copulatory organ: I-VII. Marginal hooklets.

**Description**

(Based on 25 specimens *in toto*). Body length 570 (450-700); width 110 (90-150) usually at level of ovary. With general characters of genus. Anchor lengths: a, 45 (42-47); b, 51 (48-53); c, 17 (16-20). Dorsal bar length 59 (54-63). Hook lengths: I,II, 23 (22-26); III,IV,V,VI,VII, 26 (22-28); 4A, 10-12. Male copulatory apparatus consisting of long, curved, fine penis, 55 (48-65), and irregularly sclerotised accessory piece, 47 (41-51). Vagina is long tube with sclerotised walls (45-70) joining mass of granular formations.

**Etymology.** The specific name is derived from the local appellation of Niger (=Djoliba).

**Remarks**

These specimens, found on *B. occidentalis* in the Niger and Senegal Basins, on *B. petitjeani* in the

upper Bafing (Senegal Basin) and on *B. waldroni* in the Ivory Coast, belong to the same stenoxenic species. Among other features, the specimens found on *B. occidentalis* and *B. petitjeani*, which are sympatric in the upper Bafing, do not display any variation in size or morphology.

This species displays morphological affinities with *D. grandiphallus* Paperna, 1973, described from *B. macrolepis* in Tanzania (Paperna, 1973), but are clearly distinct in the structure of the male copulatory apparatus accessory piece.

***Dogielius phrygius* n. sp. (Fig. 17)**

**Type-host and locality:** *Barbus sacratus*, Little Scarcies System, Kaba at Kouloundala, station 12, Guinea.

**Other records:** *B. sacratus*

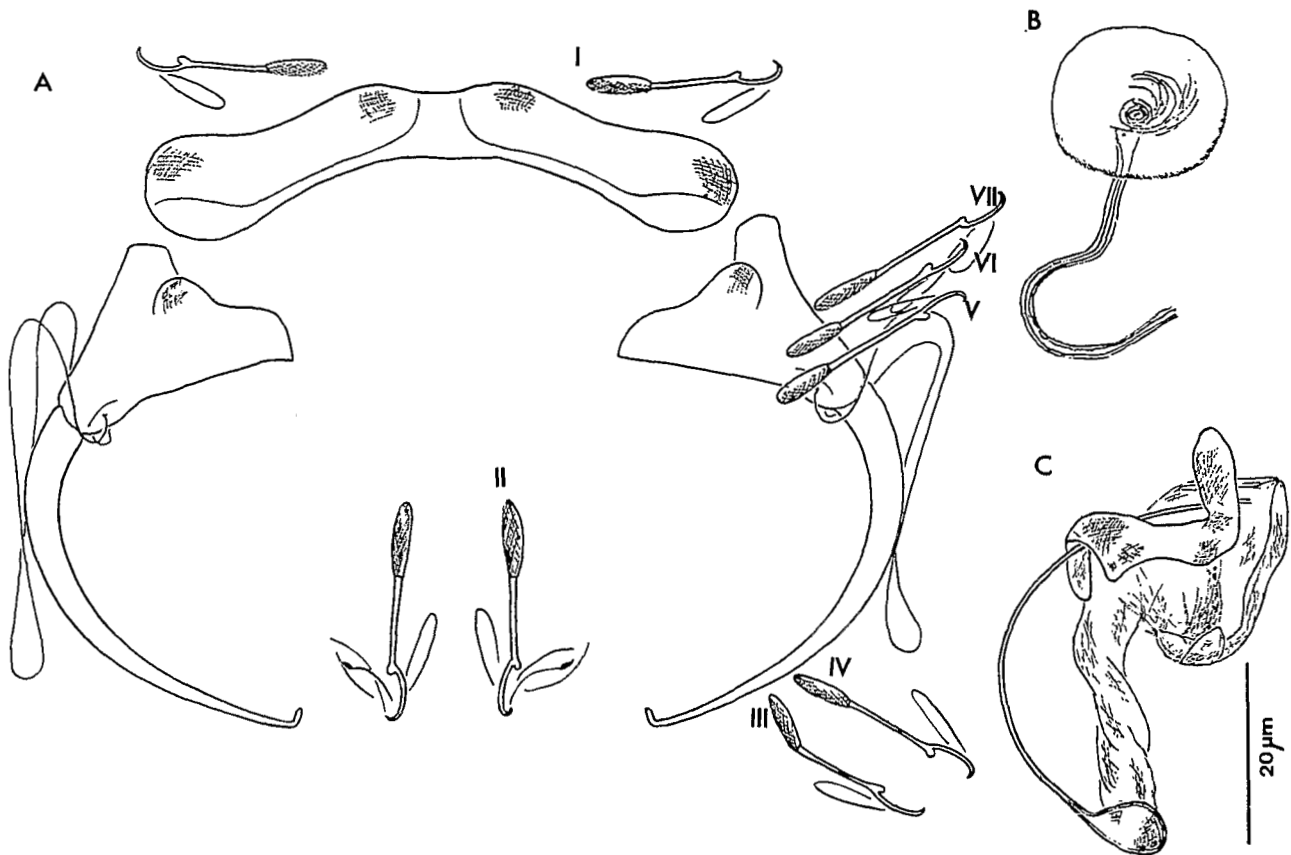


Fig. 17. *Dogielius phrygius* n. sp. A. Haptor apparatus; B. Vagina; C. Male copulatory organ; I-VII. Marginal hooklets.

**Type-material:** Holotype MNHN No.72 HF, slide Ti 80; paratype MNHN No. 72 HF, slide Ti 81.

**Description**

(Based on 22 specimens *in toto*). Body length 470 (400–600); width 90 (70–120) usually at level of ovary. With general characters of genus. Anchor lengths: a, 42 (38–46); b, 49 (46–52); e, 17 (16–20). Dorsal bar length 74 (50–85). Hook lengths: I,II, 23 (21–24); III, 25 (24–26); IV,V,VI,VII, 23 (22–26); 4A, 8–11. Male copulatory apparatus 45 (38–55), consists of fine, long, curved penis, 50 (40–55), and complex accessory piece. Vagina is sclerotised tube, 45 (30–55). Vaginal pore bears broad, finely sclerotised cupula.

**Etymology.** The specific name is from the likeness of the accessory piece to the Phrygian cap emblem of liberty used during the French Revolution.

**Remarks**

These monogeneans found on *Barbus sacratu*s from different basins in Guinea and Sierra Leone do not resemble any other known species.

***Dogielius vexillus* n. sp. (Fig. 18)**

**Type-host and locality:** *Varicorhinus wurtzi*, Sassandra System, Feredougouba River near Touba, station 27, Ivory Coast.

**Type-material:** Holotype, MNHN No. 75 HF, slide Ti 86; paratype MNHN No. 75 HF, slide Ti 87.

**Description**

(Based on 14 specimens *in toto*). Body length 350 (300–410); width 100 (60–120) usually at level of ovary. With general characters of genus. Anchor



Fig. 18. *Dogielius vexillus* n. sp. A. Haptor apparatus; B. Vagina; C. Male copulatory organ; I-VII. Marginal hooklets.

lengths: a, 33 (31-35); b, 45 (42-47); c, 15 (14-17). Dorsal bar length 61 (50-68). Hook lengths: I, 18-20; II, III, IV, V, VI, VII, 18-23; 4A, 8-10. Male copulatory apparatus 41 (38-43), consists of fine, slightly curved penis, 38 (38-42), and very simple accessory piece consisting of slightly sclerotised stem with larger, flag-shaped part at distal extremity. Vagina is fine, slightly sclerotised tube, 30 (27-35), which displays distinctly greater sclerotisation near vaginal pore.

**Etymology.** The specific name is from the likeness of the accessory piece to a standard (Latin *vexillus*, standard, flag).

**Remarks**

These specimens found on *Varicorhinus wurtzi* from the FéréDougouba (Sassandra Basin, Ivory Coast) are not similar to any species known hitherto. The male copulatory apparatus enables us to consider these monogeneans to belong to a new

species that we name *Dogielius vexillus* n. sp. We did not find this species of *Dogielius* in the other river basins studied. This monogenean does not appear to follow the distribution of *V. wurtzi* in West Africa, but appears thus far to be confined to the FéréDougouba.

***Dogielius pedaloe* n. sp. (Fig. 19)**

**Type-host and locality:** *Barbus parawaldroni*, Loffa near Macenta, station 20, Guinea.

**Other records:** *B. parawaldroni*, station 26; *Varicorhinus wurtzi*, stations 10 and 22.

**Type-material:** Holotype, MNHN No. 77 HF, slide Ti 90; paratype, MNHN No. 77 HF, slide Ti 91.

**Description**

(Based on 9 specimens *in toto*). Body length 400 (350-480); width 90 (70-110) usually at level of

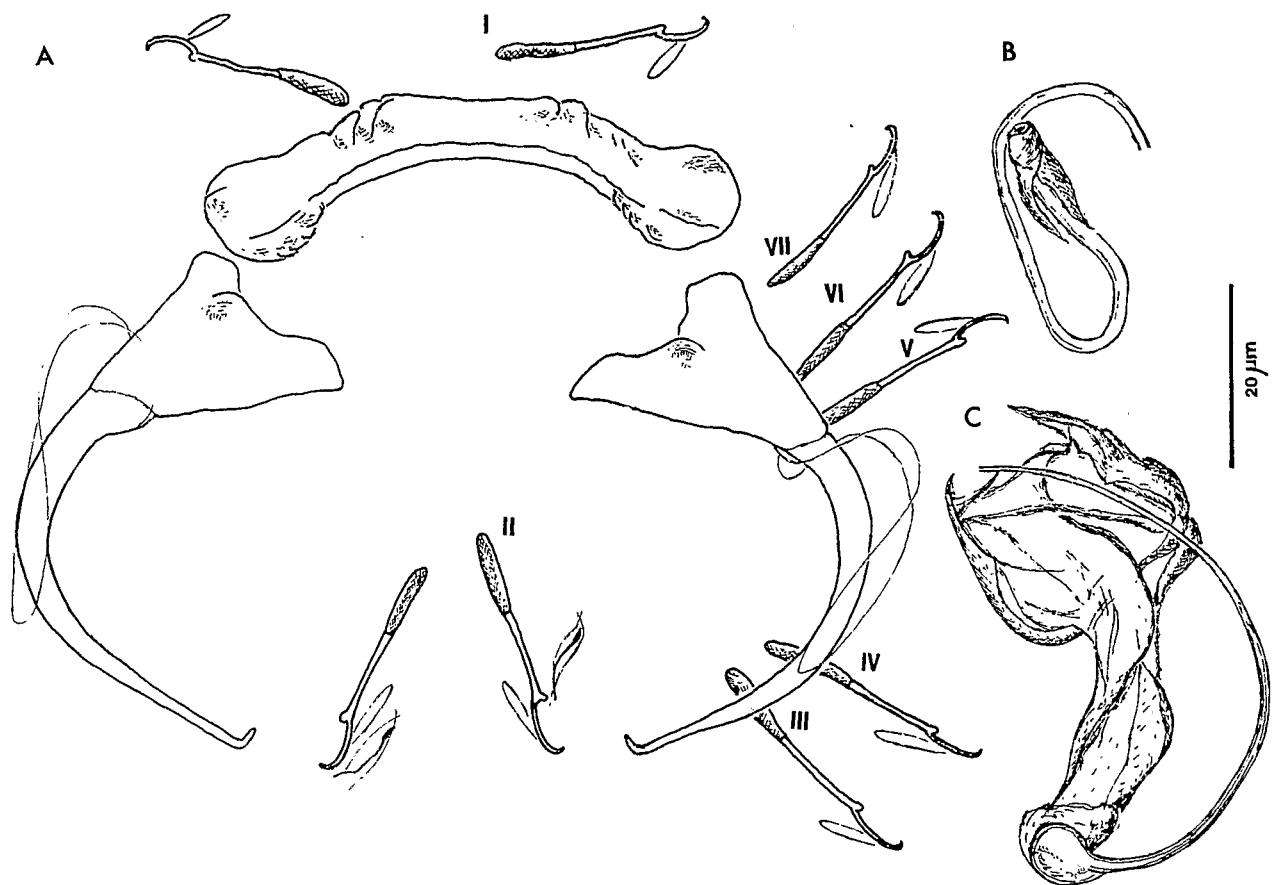


Fig. 19. *Dogielius pedaloe* n. sp. A. Haptor apparatus; B. Vagina; C. Male copulatory organ; I-VII. Marginal hooklets.

ovary. With general characters of the genus. Anchor lengths: a, 40 (38–42); b, 49 (46–54); c, 11 (16–18). Dorsal bar length 65 (59–77). Hook lengths: I,II,III,IV,V,VI,VII, 25 (23–27); 4A, 8–11. Male copulatory apparatus large, 55 (51–62), and consists of fine, long penis, 76 (71–80), forming 180° curve. At insertion in basal ampulla, apical part of finely sclerotised accessory piece displays complex shape. Vagina is long tube, 65 (60–77), whose more sclerotised pore displays characteristic ornamentation.

*Etymology.* The specific name is from the multidisciplinary French programme P.E.D.A.L.O. (Poissons d'Eau Douce d'Afrique de l'Ouest).

*Remarks*

These dactylogyrids resemble *Dogielius phrygius*

n. sp. (Fig. 17) found on *Barbus sacratus* in several river basins in Guinea and Sierra Leone. However, their sizes and copulatory apparatus morphology differ. On the basis of the accessory piece of the copulatory apparatus, we consider that these forms belong to a new species present on *B. parawaldroni* in the Loffa Basin in Guinea and in the Dodo in the Ivory Coast, and on *V. wurtzi* in the Konkouré Basin in Guinea and the Nipoué Basin in the Ivory Coast. The capture of cyprinids in Africa, and in particular that of *B. parawaldroni* is extremely random. Very few specimens were caught. Thus the very occasional presence of *D. pedaloe* n. sp. in the Atlantic river basins in West Africa probably does not reflect the natural distribution of the species. Analysis of the gills of specimens of *B. parawaldroni* from other basins should enable us to verify the true distribution of this monogenean.

## Discussion

Previous research (Guégan *et al.*, 1988, 1989) of parasite fauna on the gills of cyprinids of the genus *Labeo* in West Africa showed that all dactylogyrids have very strict host specificity. The oioxenic specificity of two monogeneans in particular led us to characterise a new species of *Labeo* hitherto unknown in the Sahel-Sudan River basins (Paugy, Guégan & Agnèse, 1990).

All the barbels studied here had concurrent infections. Two genera of dactylogyrids were found frequently: *Dactylogyrus* and *Dogielius*. Some of the species observed were stenoxenic and in contrast others had a strict specificity. Lambert & Romand (1984) observed the same phenomenon in dactylogyrids on European cyprinids.

*Dactylogyrus pseudanchoratus* is present in all the barbels in the zone investigated. This species seems to be specific to the host genus *Barbus*.

*D. falcilocus*, originally described as specific to *Labeo coubie* in the Niger and Senegal Basins (Guégan *et al.*, 1988), was also found in *Varicorhinus wurtzi* and *L. parvus* from the Little Scarcies Basin in Guinea. The presence of this monogenean in cyprinids belonging to two distinct genera would appear to indicate resemblance of an ecological type between these hosts.

*D. ruahae*, found on *B. sacratus*, *B. parawaldroni* and *B. wurtzi* in numerous Guinean basins, is also present on *B. macrolepis* in Tanzania in the River Ruaha (Paperna, 1973). *D. clani* n. sp., which is similar to it, is in contrast specific to *B. petitjeani* in the Bafing (upper Senegal Basin) and in the Milo and Niandan (upper Niger Basin). Three species described by Gussev (1973) in the south of India, *D. tori*, *D. sarana* and *D. dubii* on *B. tor*, *B. sarana* and *B. dubius* respectively, display strong similarities to *D. ruahae* and *D. clani* n. sp. (Fig. 20a).

*D. aferoides* n. sp., found on *B. occidentalis*, *B. petitjeani*, *B. waldroni*, *B. bynni* and *B. parawaldroni*, characterises in a general manner the barbels from the Sahel-Sudan rivers (Senegal, Niger), the Nile Basin (Nile) and Ivory Coast basins (Bandama, Sassandra, Nipoué). This new species is morphologically very close to *D. afer*,

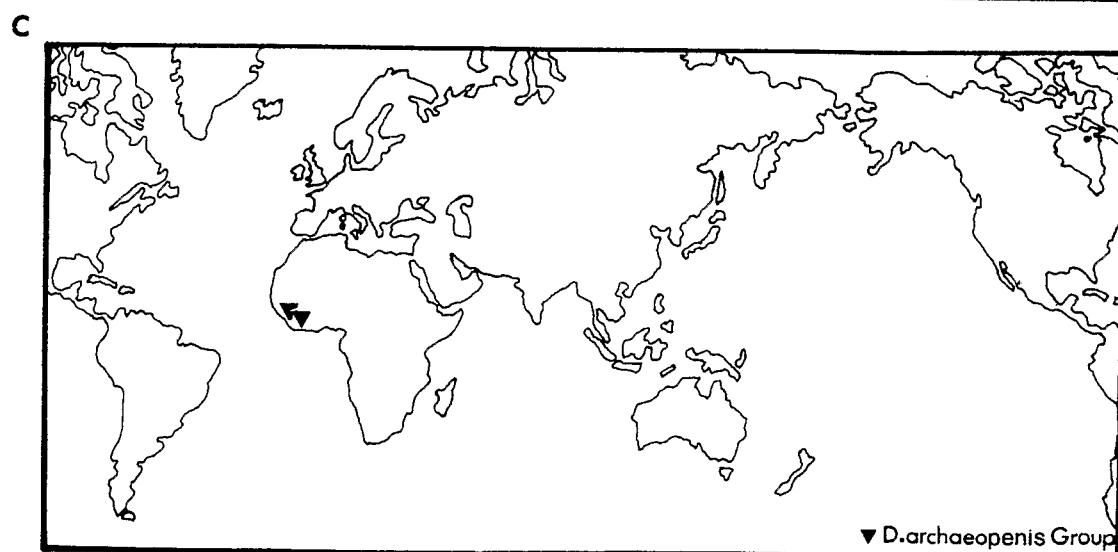
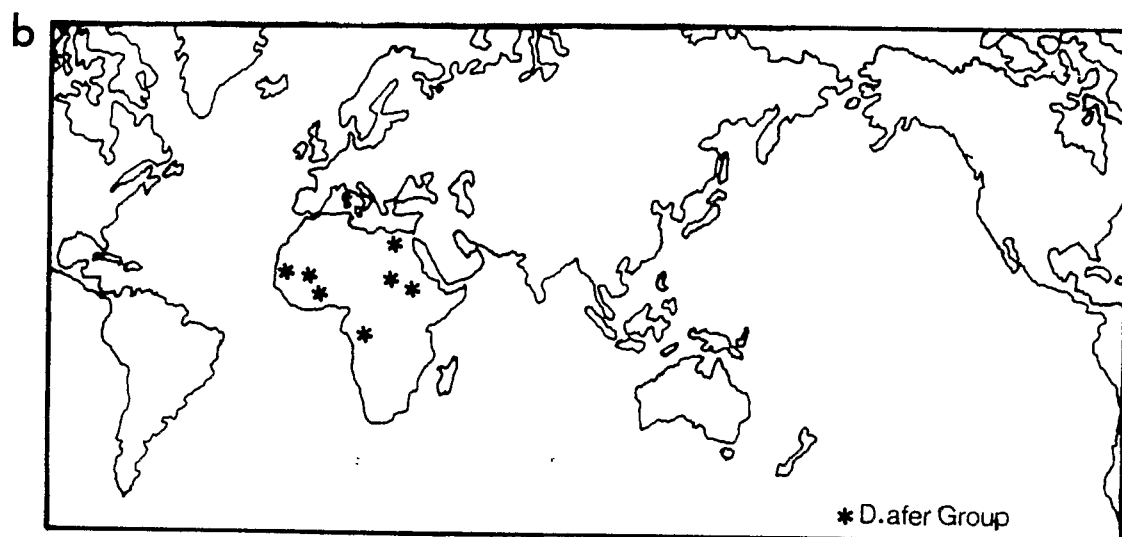
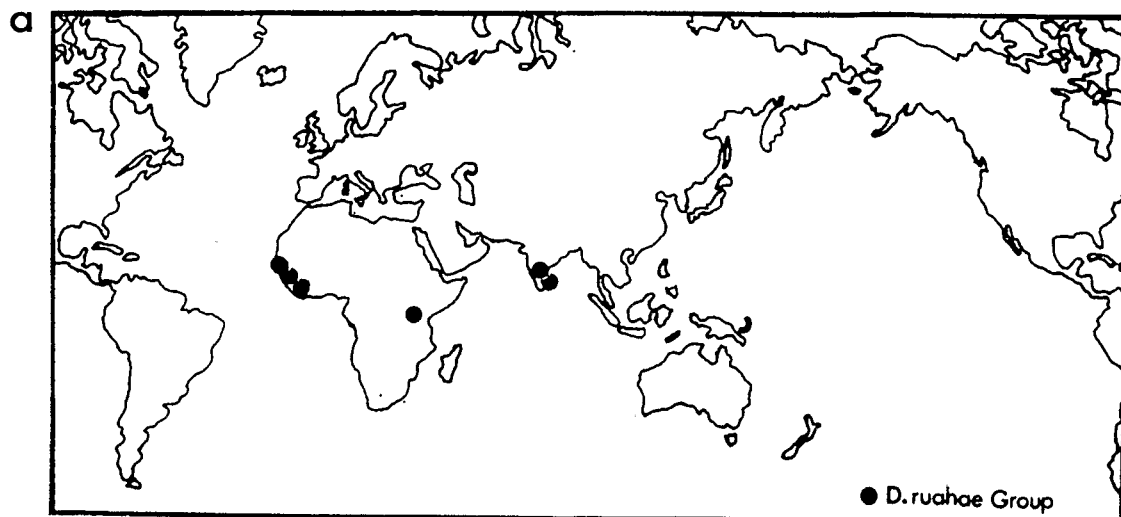
found in the Ivindo basin (Gabon) on *B. cf. batesii* (Fig. 20b).

*D. archaeopenis* n. sp., found on *B. petitjeani*, *B. sacratus* and *B. parawaldroni*, is only found in certain coastal rivers in West Africa, exceptions being the Bafing (upper Senegal Basin) and the Milo (upper Niger Basin). Affinities between this archaic monogenean and other Afro-tropical forms are uncertain (Fig. 20c).

The different species which belong to the "D. varicorhini type" all display strict specificity for their host (Fig. 21). The species *D. sahelensis* n. sp. is a special case since morphs were identified on different *Barbus* from different river basins. The hosts of these morphs, which used to be called *B. bynni*, *B. occidentalis* and *B. waldroni*, in fact belong to the same *B. bynni* species complex, which displays clinal variations in relation to the river basin (Lévêque & Guégan, 1990). The presence of *D. sahelensis* on *B. petitjeani* is interpreted as a capture made possible by the sympatry with *B. occidentalis*. The "D. varicorhini group" is present in a large proportion of the continent: South Africa (Price *et al.*, 1969), Gabon (Price & Géry, 1968), Uganda and Kenya (Paperna & Thurston, 1968; Paperna, 1973, 1979), Tanzania (Paperna, 1973), Egypt, the Sudan, Mali, Guinea, Senegal, Sierra Leone, Liberia and the Ivory Coast (present study) and Morocco (work in progress). It is also widely distributed in numerous *Barbus* and *Varicorhinus* spp. in the Palaearctic region: Spain (Gonzalez-Lanza, 1984), Israel (Paperna, 1979), Tadzhikistan and Azerbaijan (Bykhowsky, 1957; Mikhailov, 1974; Gussev, 1985), Iran (Bykhowsky, 1957) and India (Gussev, 1973). It is difficult to verify the existence of this group in South-East Asia and this, therefore, remains to be confirmed (Fig. 20d).

Species belonging to the genus *Dogielius* generally display strict specificity for their host, with the exception of *D. djolibaensis* n. sp. and *D. pedaloe* n. sp. The former is found on both *B. occidentalis* and *B. petitjeani* when they are sympatric in the Bafing (upper Senegal). We interpret this as capture between syntopic hosts. The presence of this species of *Dogielius* on *B. waldroni* in the Ivory Coast basins might be explained by





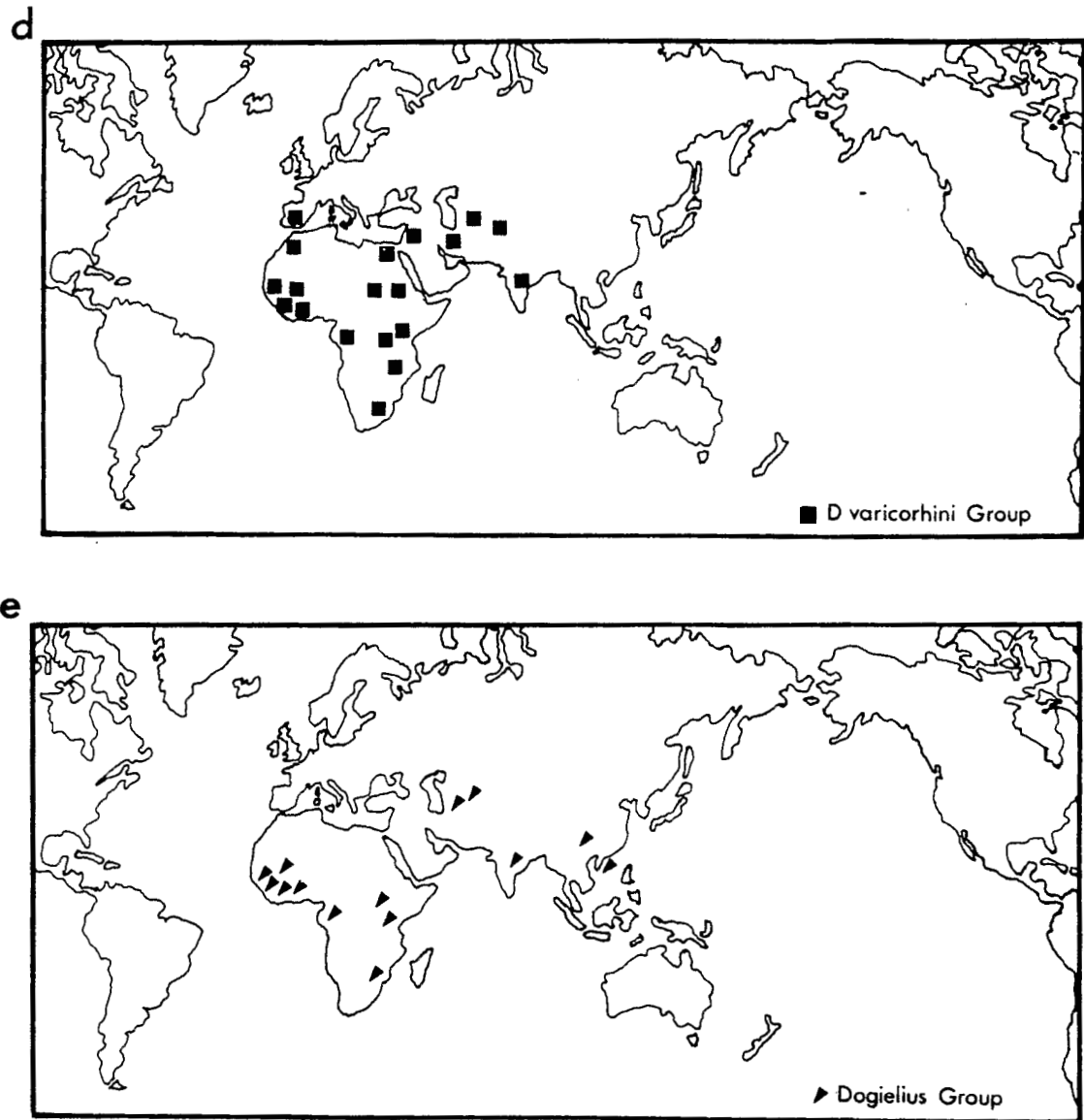


Fig. 20. Distribution of five groups of dactylogyrids superimposed on maps of contemporary geography. a. "D. ruahae group"; b. "D. afer group"; c. "D. archaeopenis group"; d. "D. varicorhini group"; e. "Dogielius group".

the existence of a host cline. The second species, *D. pedaloe* n. sp., is present both in *B. parawaldroni* and *V. wurtzi* in numerous Atlantic river basins. The distribution of the genus *Dogielius* is almost identical to that of the "D. varicorhini group", with wide coverage of tropical African and Indo-Malaysian regions: Mali (Guégan *et al.*, 1989), Senegal, Guinea, Sierra Leone, Ivory Coast (present study), Cameroon (Birgi & Lam-

bert, 1987), Zimbabwe (Price & Yurkiewicz, 1968), Tanzania and Kenya (Paperna, 1973, 1979), Ghana (Paperna, 1969), soviet central Asia (Gussev, 1985), India (Gussev, 1976) and China (Lang Suo, 1981; Zhang Jianying & Guo Qizhi, 1982) (Fig. 20e).

West African *Barbus* and *Varicorhinus* are parasitised by monogeneans of the same morphological groups. We suggest that on the basis of this

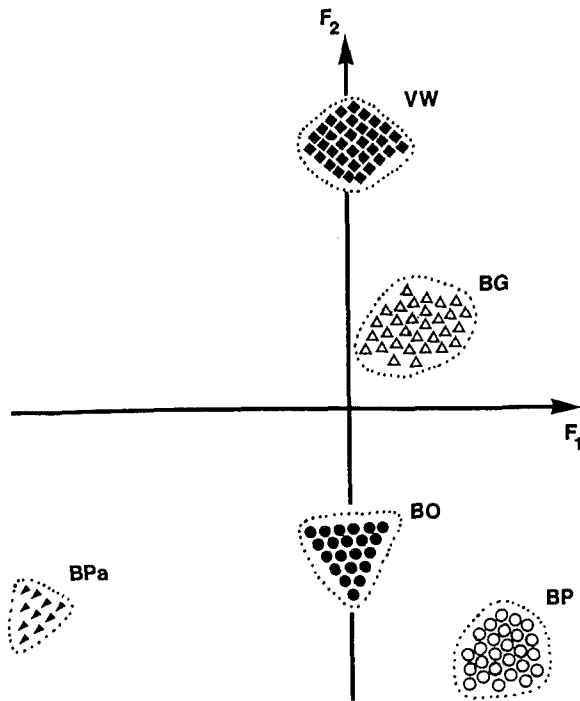


Fig. 21. Discriminant factorial analysis which is a projection on the principal plane of all the *Dactylogyrus* of the "D. varicorhini group" and their five host species. There is a distinct correlation between each species of dactylogyrid described and its host species.

Abbreviations: BO, *Barbus occidentalis* and *Dactylogyrus sahelensis*; BP, *B. petitjeani* and *D. petitjeanii*; BS, *B. sacratus* and *D. sacrati*; BPa, *B. parawaldroni* and *D. parawaldronii*; VW, *Varicorhinus wurtzi* and *D. wurtzii*.

parasite criterion these two cyprinids belong to the same large monophyletic group, at least as regards West African ichthyofauna (Lévêque & Guégan, 1990).

On the subject of the biogeographical aspects, three groups of monogeneans appear to be particularly interesting in relation to such a study: (1) the "D. ruahae group", consisting of the species *D. ruahae* and *D. clani* n. sp.; (2) the "D. archaeopenis group" consisting of *D. archaeopenis* n. sp. alone; and (3) the "D. afer group" which also has in West Africa only one member-species, *D. aferoides* n. sp. The presence of these three monogenean groups is shown on a map of West Africa (Fig. 22). Two groups, "D. ruahae" and "D. archaeopenis" are found in the river basins in Gui-

nea, Sierra Leone and Liberia. In contrast, the peripheral basins contain the "D. afer group" but not the two latter groups. A study carried out in parallel on monogeneans in another group of cyprinids (the specific complex *Labeo parvus*) gave very similar results, i.e. the existence of original parasitism in Guinean host populations in comparison with the *L. parvus* populations in other river basins in West Africa (Guégan & Lambert, in press).

These distributions can be interpreted in the following way. In a study on the distribution of African birds, butterflies and mammals, Endler (1982) and then Mayr & O'Hara (1986) reported three probable refugia for these types of fauna. The first corresponds to Liberia and Sierra Leone, the second to Gabon and Cameroon and the third in eastern Zaïre. The mountain regions of Fouta Djallon and the Nimba mountains (Ivory Coast) correspond well with the first refugium. The coastal rivers flowing from these uplands form a hydrographical unit in West Africa (Grove, 1985): this area is well known for its richness in endemic fishes (Daget, 1962).

The fish parasites found in this zone are very old. In particular, *D. archaeopenis* n. sp. displays all the phylogenetic characters of a "living fossil" (Brooks & Bandoni, 1988). The presence of species which belong to the "D. ruahae group" in biogeographically distinct regions - coastal catchments in West Africa, Ruaha river in East Africa, southern India - naturally raises the question of their origin.

Examination of world distribution of the five groups of Monogenea ("D. afer", "D. archaeopenis", "D. ruahae", "D. varicorhini" and *Dogielius*) shows a general biogeographical trend (Fig. 20a,b,c,d,e, respectively). As the cosmopolitan distribution of many present taxa is linked with the close relations between all continental units currently visible (Janvier, 1982), distribution of the monogenean groups can be interpreted by considering the palaeogeography of Gondwanaland during the Mesozoic era (Fig. 23). The "D. ruahae group", which is closely associated with barbels in West Africa (*B. sacratus*, *B. parawaldroni*, *B. petitjeani*, *V. wurtzi*) and East Africa (*B.*

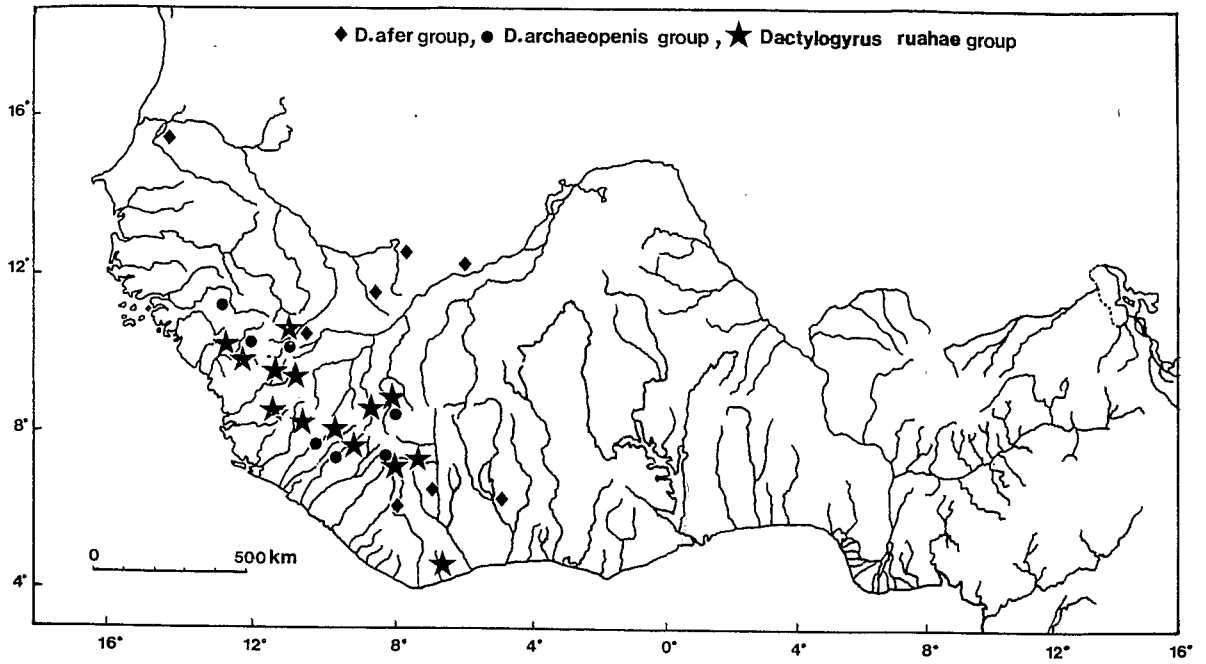


Fig. 22. Area of distribution of three groups of *Dactylogyrus* – the “*D. ruahae*”, “*D. archaeopenis*” and “*D. afer*” groups – in river basins in West Africa. There is a clear exclusion between the presence of the two groups “*D. ruahae*” and “*D. archaeopenis*” in coastal rivers and the “*D. afer* group” which is characteristic of Sahel-Sudan and Ivory Coast rivers.

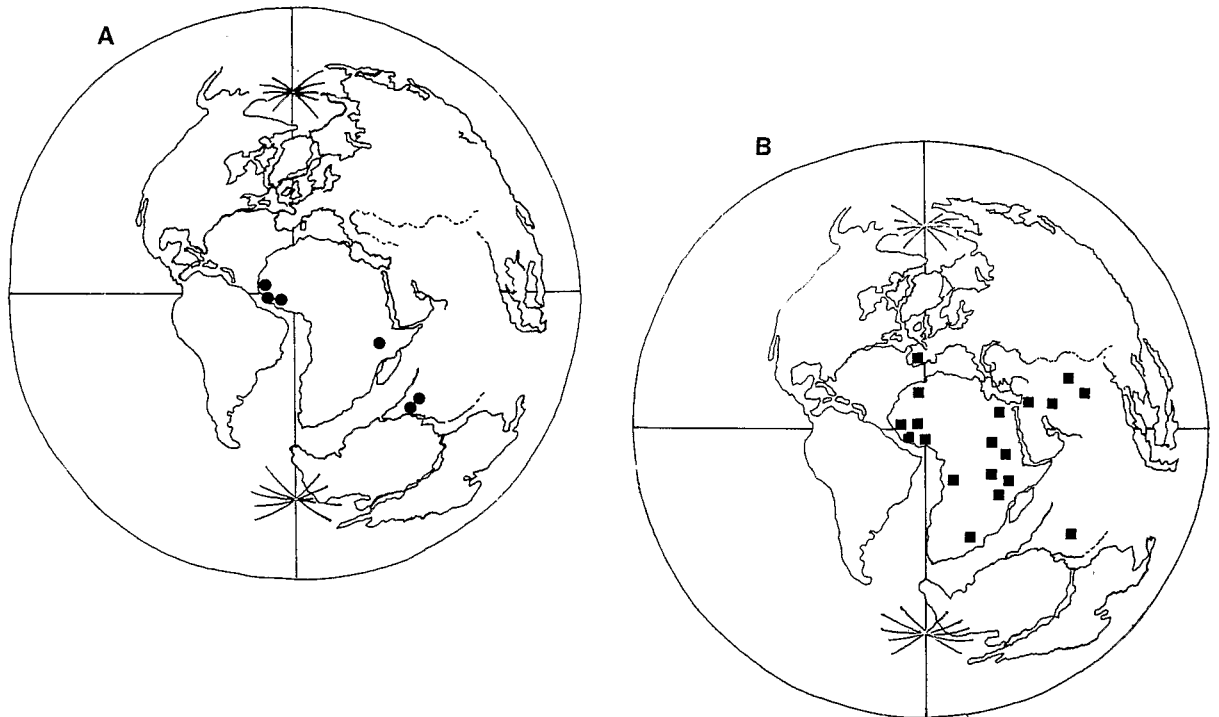


Fig. 23. Present distribution of two groups of dactylogyrids superimposed on maps of mesozoic geography: a. “*D. ruahae* group”; b. “*D. varicorhini* group”.

*macrolepis*) is found on barbels in India (*B. tor*, *B. sarana*, *B. dubius*) which can be thought to have the same common ancestor. The "D. varicorhini" and *Dogielius* groups have mainly broad tropical African and Indo-Malaysian distribution. These observations naturally raise the problem of the evolution of this fauna and in particular the heuristic value of the first fossils of African Cyprinidae dated in the Miocene or Pliocene (Greenwood, 1974). It would of course be presumptuous to build hypotheses on these fragmentary elements. However, two facts seem interesting and could guide new research. The first is parasitological. As was shown by Euzet (1982) for proteocephalid cestodes which parasitise siluriform catfish, Africa may be the original centre of numerous monogenean-teleost associations. For example, the genera *Cichlidogyrus*, *Protoancylo-discoides* and *Synodontella* exist only in Africa, although their cichlid or siluriform hosts are known in other biogeographical regions. This African parasite fauna nevertheless bears a certain resemblance to that of the Indo-Malaysian area. The discovery of a very rudimentary monogenean, *D. archaeopenis* n. sp., raises again the delicate problem of the centre of origin of the Dactylogyridae. Are they African or Asian? According to Hennig's "Progressionregel", everything would appear to indicate that the Dactylogyridae spread in the tropical African zone and may have originated with an ancestral form (*Dactylogyrus archaeopenis* n. sp.?) after the transfer of an ancyrocephaline (Kritsky & Boeger, 1989) present on fishes moving up the watercourses (Atherinidae, Clupeidae)!

The second fact concerns host-parasite relations and Szidat's rule in parasitology which specifies that primitive parasites are always associated with hosts whose rank is as primitive. If this rule is applied to the Dactylogyridae, the West African barbels (*B. sacratus*, *B. petitjeani*, *B. parawaldroni*) then represent taxa which are very little derived in relation to ancestral barbels or even in comparison with the Cyprinidae on which the archaic parasite forms differentiated. In this case, do cyprinids share the same origin in Africa? Para-

sitological research in other refugia in Africa should shed light on this.

It would be premature to reply to all these questions. The study of fish monogeneans is interesting and valuable in that it raises questions and deserves to be taken into consideration in the discussions of ichthyologists and palaeontologists on the evolution of these faunas.

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