



## Review of the Brazilian species of *Physiculus* (Gadiformes: Moridae), with description of a new species from Saint Peter and Saint Paul Archipelago, equatorial Atlantic

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### Abstract

Three valid species of the genus *Physiculus* are known from the Brazilian marine-waters. A fourth, new species, *Physiculus cirm n. sp.*, is described based on seventeen specimens collected in the surroundings of Saint Peter and Saint Paul Archipelago, equatorial Atlantic. A review of the Brazilian species of *Physiculus* is provided, as well as a key to the species of the genus reported from the Atlantic Ocean. The new species is distinguished from all its congeners, except *P. cynodon* and *P. karrerae*, by the large number of longitudinal series of scales (156–189 vs. 70–150). *P. cynodon* from the Northern Pacific has about 200 longitudinal series of scales, and it differs from the new species by the number of rays of the first dorsal fin (6–8 vs. 10 in *P. cynodon*), pectoral-fin rays (20–25 vs. 27 in *P. cynodon*), and the presence of an outer row of large canine teeth on upper and lower jaw. From *P. karrerae*, which has 134–160 longitudinal series of scales, the new species differs by the presence of scales on the tip of the snout and dorsal-fin membrane, and the number of pectoral-fin rays (20–25 vs. 24–27 in *P. karrerae*). [Zoobank URL: [urn:lsid:zoobank.org:act:1AFBC251-2BB1-4479-98A4-307188EC5D66](http://zoobank.org/urn:lsid:zoobank.org:act:1AFBC251-2BB1-4479-98A4-307188EC5D66)]

**Key words:** deep-sea, diversity, identification key, oceanic islands, systematics

### Introduction

The family Moridae includes 18 genera and 106 species (Eschmeyer and Fong 2017; Biscoito and González, 2018; González *et al.*, 2018). Of these, the genera *Physiculus* Kaup 1858, *Gadella* Lowe 1843, and *Salilota* Günther 1887, share an easily visible feature, a ventral light organ externally observable as a scaleless dermal fossa anterior to the anus. *Physiculus* is distinguished from *Gadella* by the presence of a chin barbel, and from *Salilota* by the absence of vomerine teeth (Paulin, 1989).

Kaup (1858) erected *Physiculus* as a new monotypic genus based on his new species, *P. dalwigki*. Currently, the taxon includes 42 valid species that are found in tropical and temperate marine waters worldwide (Paulin & Matallanas, 1990; Shcherbachev, 1993; Anderson & Tweddle, 2002; Eschmeyer *et al.*, 2016; Biscoito and González, 2018; González *et al.*, 2018). The genus includes a wide array of species, from the common *Physiculus japonica* Hilgendorf, 1879, which has some economic importance in Japan (Kitagawa & Nagahora, 1983, as *P. maximowiczii*) to the still poorly known and recently described *Physiculus cyanostrophus* Anderson & Tweddle, 2002 and *P. caboverdensis* González, Triay-Portella & Biscoito, 2018. Several species have restricted distribution (e.g., *P. caboverdensis*, Cape Verde Islands; *P. heleniensis* Paulin, 1989, Saint Helena Island; *P. grinnelli* Jordan & Jordan, 1922 and *P. sterops* Paulin, 1989, Hawaiian Islands; *P. parini* Paulin, 1991, Easter Island), while others occur in wide geographic areas (e.g., *P. kaupii* Poey, 1865, and *Physiculus karrerae* Paulin, 1989, Tropical Atlantic; *P. longifilis* Weber, 1913 and *P. roseus* Alcock, 1891, Tropical Indo-Pacific), as reported by Paulin (1989, 1991), Cohen *et al.* (1990), and Shcherbachev (1993).

Eleven species of *Physiculus* are known from the Atlantic Ocean: *P. caboverdensis*, *P. capensis* Gilchrist, 1922, *P. cyanostrophus*, *P. dalwigki* Kaup 1858, *P. fulvus* Bean, 1884, *P. helenensis*, *P. huloti* Poll, 1953, *P. karrerae*, *P. kaupi*, *P. maslowskii* Trunov, 1991 and *P. micro barbata* Paulin & Matallanas, 1990 (Lloris, 1986; Paulin, 1989; Cohen, 1986; Cohen *et al.*, 1990; Paulin and Matallanas, 1990; Trunov, 1991; Shcherbachev, 1993; Bianchi *et al.*, 1999; Anderson and Tweddle, 2002; González *et al.*, 2018). *P. capensis* is here considered as occurring in the Atlantic Ocean due to the examined voucher USNM 188814. In addition, *P. natalensis* Gilchrist, 1922, occurs in the Indian Ocean near eastern South Africa and possibly reaches the Atlantic Ocean (Cohen, 1986). In Brazilian waters three species are reported to date: *Physiculus fulvus* from the northern Brazil, *P. karrerae* from the southeastern to southern Brazil, and *P. kaupi* from northeastern to southern Brazil (Paulin, 1989; Figueiredo *et al.*, 2002; Menezes and Figueiredo, 2003; Iwamoto and Cohen, 2003; Paiva *et al.*, 2011; Oliveira *et al.*, 2015).

The new species herein described, *Physiculus cirm*, was collected in depths ranging from 300 to 750 m in the surroundings of Saint Peter and Saint Paul Archipelago (SPSPA), a set of small rocky islands in the central Atlantic Ocean.

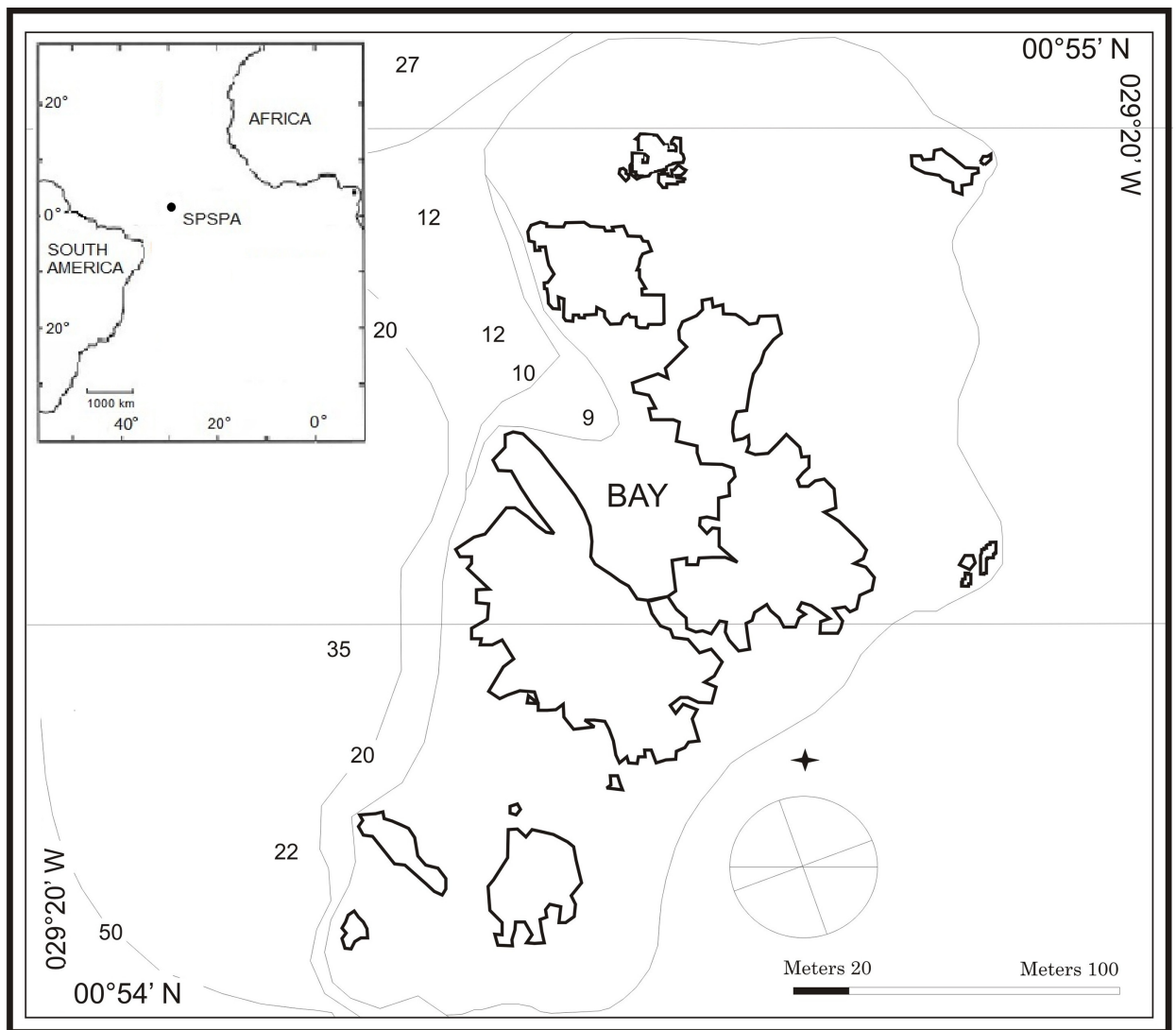


FIGURE 1. Saint Peter and Saint Paul's Archipelago, Brazil.

## Material and methods

Standard methods of measurements and counts follow Hubbs & Lagler (1958); measurements, counts and terminology specific to morids follow Paulin (1989), Meléndez & Markle (1997) and Anderson & Tweddle (2002). Measurements of the size and position of the light organ are expressed as a percentage of the distance between a transverse line between the anterior edges of the pelvic-fin insertions (the interventral line) to the anal-fin origin, the "Inv-af".

The abbreviations “Inv-an” and “Inv-lo” express, respectively, the distance from the interventral line to the anus, and the distance from the interventral line to the light organ. HL means head length.

The specimens were collected with bottom-traps from October 2012 to December 2017, at SPSPA (00°55'10"N, 029°20'33"W). Three traps, with different shapes and sizes (larger quadrangular: 2.0m x 0.9m x 0.9m; smaller quadrangular: 2.0m x 0.6m x 0.6m; and tapered: 1.0m x 0.3m x 0.6m), were connected to each other and tied to weights, to ensure they were maintained in the bottom during the operation, in depths between 300 and 750 m, remaining submerged for about 12 hours. The collected material was photographed, labeled, packaged and cooled at the local base, being fixed in formalin and later conserved in ethanol at the Fisheries Oceanography Laboratory of Universidade Federal Rural de Pernambuco, where counts and measurements were carried out. Measurements were made with digital and analogic calipers and rounded to the nearest 0.1 mm. Institutional abbreviations follow Sabaj-Perez (2016); the museum acronym MOCH refers to the Museu de Oceanografia Prof. Petrônio Alves Coelho, Universidade Federal de Pernambuco; the museum acronym DBUFC refers to the collection of the Departamento de Biologia da Universidade Federal do Ceará.

## Genus *Physiculus* Kaup

*Physiculus* Kaup, 1858: 88. Type species: *Physiculus dalwigki* Kaup, 1858: 88, by monotypy. The diagnosis and description of the genus follow Paulin (1989), Paulin & Matallanas (1990), Trunov (1991), and Shcherbachev (1993).

**Diagnosis.** Morid fishes with ventral light organ in advance of anus; chin barbel present; vomerine teeth absent.

**Description.** Morid fishes with elongated somewhat compressed body. Chin barbel present, eventually much reduced (as in *P. microbarbata*). Two dorsal and one anal fin of uniform height, separated from the caudal fin that is slightly rounded to rounded (the new species herein described has the posterior border of the caudal fin often rounded, as well as *P. maslowskii*). Snout broad, obtusely rounded, not projecting beyond mouth. Scales small, cycloid, covering entire body and head, extending or not onto snout, gular region, and fins. Ventral fins with outermost rays filamentous. Circular luminescent organ on midline of belly, connected to anus by a duct; this organ lies in body wall between ventral-fin bases and anus, it is externally obvious as a circular, scaleless, dermal fossa. Teeth in a brush-like band and variable: equal to sub-equal sized, or with outer ones slightly larger, or with distinct separation between larger and smaller teeth. No teeth on vomer.

## Species reported from Brazilian waters

### *Physiculus fulvus* Bean, 1884

Tables 2 and 3.

**Diagnosis.** This species differs from all other Atlantic species of the genus in having relatively large scales in longitudinal series (70–84 vs. 90–189), according to Paulin (1989, 1990), Trunov (1991), Anderson & Tweddle (2002), our examination of vouchers of this species, and of the new species herein described.

**Brief Description.** Light organ moderately large 7.5–13.2% InV-af and placed midway between interventral line and anus; distance from interventral line to anterior margin of light organ 17.6–25.6% InV-af; distance from posterior margin of light organ to anterior margin of anus 21.1–24.5% InV-af; teeth subequal. Continuous tube of lateral line not reaching origin of second dorsal fin. No scales on vertical fin membranes, gular region, tip of snout, and around nostrils. Nostrils contiguous, each one in a short tube without a skin flap. Gill rakers moderately long, slender, 2–4 + 8–11. Upper jaw reaching below posterior margin of pupil. Orbit 24–28% in head length. Dorsal-fin rays 9–12, 57–61; anal-fin rays 59–68; pectoral-fin rays 21–26; scales in longitudinal series 70–84, scales between base of first dorsal fin and lateral line 6–7; vertebrae 47–50.

**Color of preserved specimens.** Head and body pinkish tan to light yellowish brown; abdominal region bluish to purplish (often brown in long preserved specimens), with silvery tinge extending onto sides of body and head; axil of pectoral fin dark brown; margins of anal and dorsal fins dark brown to black; external border of lips and gular region dark brown; a dark brown blotch on sub-operculum; light organ dark brown to blackish. Maximum known size 133 mm SL.

**Distribution.** Temperate and tropical western Atlantic Ocean, from southern Canada (43° 16' N and 60° 58' W) and Cape Cod (USA), to Rio Grande do Norte, in the “hump” of Brazil, including the Gulf of Mexico, the Bahamas and the Caribbean Sea. Depth range 68–800 m, usually below 100 m. (Bean, 1884; Jordan and Evermann, 1898; Arai, 1983; Scott & Scott, 1988; Paulin, 1989; McEachran and Fechhelm, 1998; Klein-MacPhee, 2002; Iwamoto and Cohen, 2002; Oliveira *et al.*, 2015; Moore *et al.*, 2015).

### *Physiculus karrerae* Paulin, 1989

Table 2 and 3.

**Diagnosis.** This species differs from all other Atlantic species, except *P. helenaensis*, *P. dalwigki* and *P. kaupi*, by the smaller scales in longitudinal series and consequently larger number (134–160 vs. 70–130). From *P. helenaensis*, which does not have the number of scales in longitudinal series known to date, it differs by the discontinuous lateral line (vs. continuous to posterior part of body). From *P. dalwigki*, which has 119–135 longitudinal series of scales, it differs by the greater distance of the light organ to interventral line (8.2–16.8 Inv-af vs. 0–2.4 Inv-af). And from *P. kaupi*, it differs by the absence of scales on vertical fins and gular region (vs. scales present on vertical fins and gular region), according to Paulin (1989, 1990), Trunov (1991), Shcherbachev (1993), Anderson & Tweddle (2002), and our examination of vouchers of this species, and of the new species herein described.

**Brief Description.** Light organ large, 10.0–22.0% InV-af and placed closer to interventral line than anus; distance from interventral line to anterior margin of light organ 8.2–16.8% InV-af; distance from posterior margin of light organ to anterior margin of anus 13.3–17.6% InV-af; teeth subequal. Continuous tube of lateral line reaching beyond origin of second dorsal fin, almost to tenth second dorsal-fin ray. No scales on vertical fin membranes, gular region, tip of snout, and around nostrils. Nostrils contiguous, the anterior covered by a skin flap, the posterior open, oval, with a short anterior projection. Gill rakers long, slender, 1–3 + 7–9. Upper jaw reaching to below middle of the orbit; orbit 24–29% of head length. Dorsal-fin rays 7–8, 64–76; anal-fin rays 68–81; pectoral-fin rays 24–27; scales in longitudinal series 134–160; scales between base of first dorsal fin and lateral line 14–20; vertebrae 56–59. Color of preserved specimens: head and body brown, smaller specimens light pinkish tan on head and body; abdominal region bluish; gular region, branchiostegal membranes, lips, anterior margin of orbit, base of pectoral fin and tips of vertical fins dark brown; light organ dark brown to blackish. Color of fresh specimen: head and body uniform reddish brown; abdominal region dark bluish black often over whitish background; fins margins and lips dark brown; light organ dark brown to blackish. Maximum known size 274 mm SL.

**Distribution.** Tropical Atlantic Ocean, from Gulf of Mexico, Bermuda, off North Carolina, and Caribbean Sea to southern Brazil, and from Saint Helena Island, Tristan da Cunha Island, and Walvis Ridge (Eastern Atlantic). Depth range 50–800m, usually 200–500m, shallower (50–150m) waters of Tristan da Cunha (Paulin, 1989; Edwards, 1990; Trunov, 1991; Andrew *et al.*, 1995; Iwamoto and Cohen, 2002; Smith-Vaniz *et al.*, 1999).

### *Physiculus kaupi* Poey, 1865

Table 2 and 3.

**Diagnosis.** This species differs from all other Atlantic species of the genus, except *P. cyanostrophus*, *P. maslowskii*, and *P. microbarbata*, by the presence of scales on vertical fins and gular region and in having subequal rather than a graded series of teeth (graded in *P. maslowskii*, of which it also differs by the number of gill rakers, 2–3 + 5–10 vs. 4–5 + 9–12); from *P. microbarbata* it differs by the much longer chin barbel (4.3–6.2 in SL vs. 1.0); and from *P. cyanostrophus* it differs in all fins rays counts and by the higher number of scales between the first dorsal fin base and the lateral line (12–14 vs. 8), according to Paulin (1989, 1990), Trunov (1991), Anderson & Tweddle (2002), and our examination of vouchers of this species and of the new species herein described.

**Brief Description.** Light organ moderately large 8.8–11.2% InV-af and placed slightly closer to interventral line than anus; distance from interventral line to anterior margin of light organ 19.5–22.2% InV-af; distance from posterior margin of light organ to anterior margin of anus 26.4–28.8% InV-af; teeth subequal. Continuous tube of lateral line reaching beyond second dorsal fin origin, almost to tenth dorsal-fin ray; scales present on gular region, rarely absent; small scales present on vertical fin membranes; no scales on tip of snout and around nostrils. Nostrils

contiguous, each covered by a skin flap. Gill rakers moderate, blunt or slightly club shaped, spiny, 2–3 + 5–10. Upper jaw reaching below almost to the posterior border of pupil; orbit 22–28% in head length. Dorsal-fin rays 11–12, 57–66; anal-fin rays 62–69; pectoral-fin rays 27–31; scales in longitudinal series 120–140; scales between base of first dorsal fin and lateral line 12–14; vertebrae 52–54.

*Color of preserved specimens.* Head and body light pinkish tan to grey; abdominal region bluish white to purple; pores of lateral line on the posterior part of body usually as dark spots over pale background; branchiostegal membranes, lips, anterior margin of orbit, upper and lower base of pectoral fins, upper snout, and tips of vertical fins dark brown; light organ dark brown to blackish. *Color of fresh specimens:* head and body uniform pinkish tan; abdominal region iridescent bluish often over whitish background; golden tinge on body sides; pores of lateral line on the posterior part of body usually dark; fins margins and lips dark brown; pelvic fins pinkish orange; light organ dark brown to blackish. Two of the fresh examined specimens were almost dark brown overall with a golden tinge on upper anterior body and head, the belly somewhat washed with white and fins borders black. These fishes become darker than the lighter morphs when preserved, the pores of lateral lines not conspicuous. Maximum known size 275.3 mm SL (DBUFC 74) collected off Ceará, Brazil.

**Distribution.** Tropical Western Atlantic, from Caribbean Sea (Cuba, Nicaragua) to Southern Brazil. Depth range 200–500 m (Paulin, 1989; Jordan and Evermann, 1898; Iwamoto and Cohen, 2002; Figueiredo *et al.*, 2002; Paiva *et al.*, 2011).

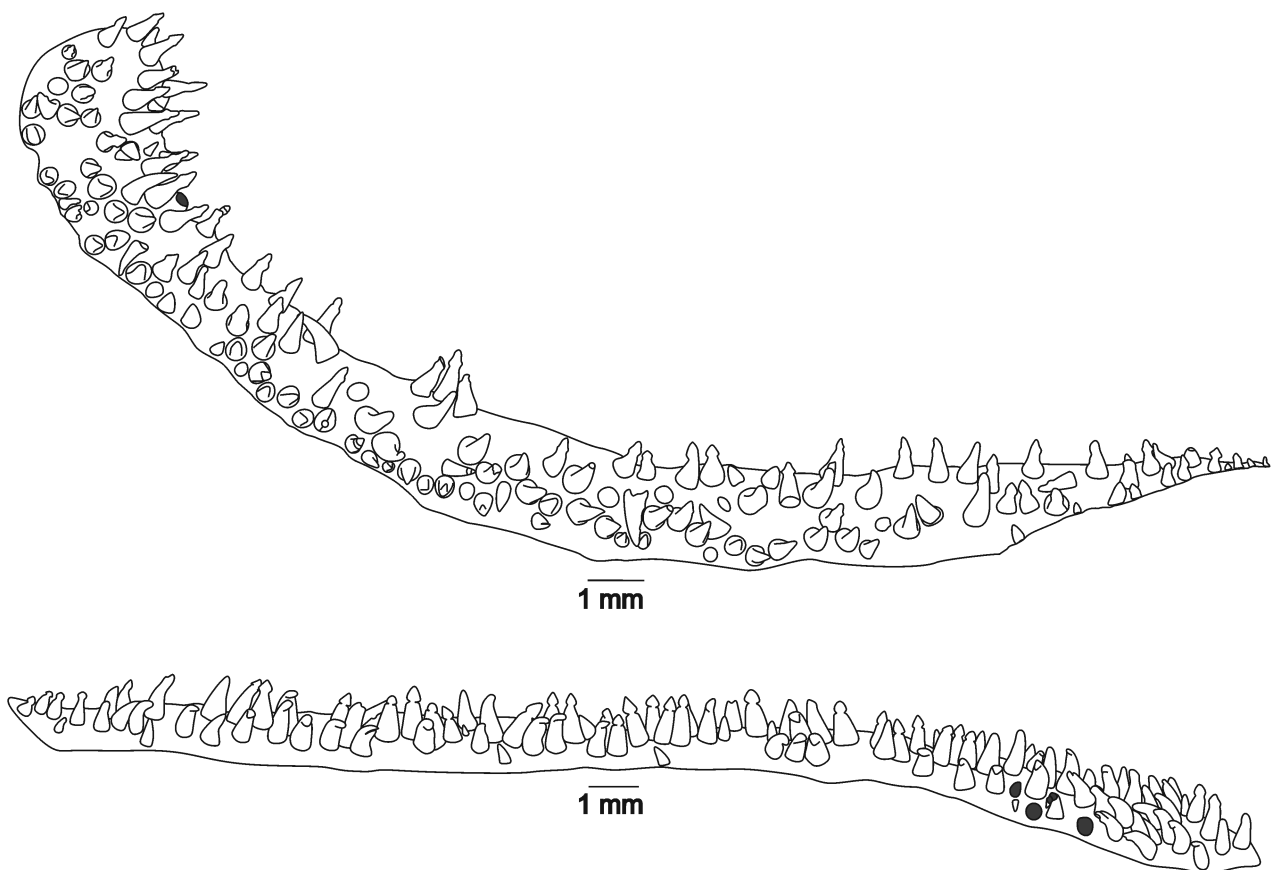
***Physiculus cirm*, n. sp. Carvalho-Filho & Pires**

Fig. 2–5; Table 1, 2 and 3.

**Holotype.** MZUSP 123403 (ex MOCH 1513, 1) (1, 197.2 mm SL, Brazil, Saint Peter and Saint Paul Archipelago, 0°54.498' N, 29°20.082' W, 410 m deep, col. A.M.A. Pires, 10 October 2012.



**FIGURE 2.** A. *Physiculus cirm*, n. sp., holotype, MZUSP 123403, 197.2 mm SL. B. *Physiculus cirm*, n. sp., paratype, MOCH 1521, 289.3 mm SL



**FIGURE 3.** Dentition of *Physiculus cirm* n. sp. from left side of dentary showing several arrow-shaped teeth from above (upper) and laterally (lower).

**Paratypes.** Fifteen specimens, all collected around Saint Peter and Saint Paul Archipelago: MNRJ 49453 (ex MOCH 1512, 1) (1, 245.3 mm SL), 0°54.621' N, 29°21.240' W, 415 m deep, col. R.C.P. Ferreira, 10 Oct. 2012; MNRJ 49454 (ex MOCH 1512, 2) (1, 242.3 mm SL), 0°54.621' N, 29°21.240' W, 415 m deep, col. R.C.P. Ferreira, 10 Oct. 2012; MOCH 1510 (1, 313 mm SL), 0°54.498' N, 29°20.082' W, 600 m deep, col. R. C. P. Ferreira, 04 April 2014; MOCH 1511 (1, 210mm SL), 0°55.681' N, 29°21.804' W, 420 m deep, col. A. M. A. Pires, 01 Jan. 2014; MOCH 1514 (1, 276 mm SL), 0°55.515' N, 29°21.100' W, 320 m deep, col. R. C. P. Ferreira, 04 April 2014; MOCH 1516 (2, 238.1-291.3 mm SL), 0°55.509' N, 29°21.910' W, 300 m deep, col. A.M.A. Pires, 14 Oct. 2012; MOCH 1517 (1, 191.3 mm SL), 0°55.515' N, 29°21.100' W, 600 m deep, col. R. C. P. Ferreira, 5 April 2014; MOCH 1518 (1, 279.8 mm SL), 0°55.145' N, 29°21.863' W, 750 m deep, col. A.M.A. Pires, 10 Oct. 2012; MOCH 1521 (2, 289.3-322.2 mm SL), 0°54.401' N, 29°22.111' W, 300 m deep, col. A. Pires, 10 Dec. 2017; MZUSP 121269 (ex MOCH 1515) (2, 177.2- 245.9 mm SL), 0°54.498' N, 29°20.130' W, 500 m deep, col. A.M.A. Pires, 27 Dec. 2013; MZUSP 123404 (ex MOCH 1513, 2) (1, 269.6 mm SL), 0°54.498' N, 29°20.082' W, 410 m deep, col. A.M.A. Pires, 10 Oct. 2012; ZUEC 8464 (1, 262.2 mm SL), 0°55.599' N, 29°20.198' W, 420 m deep, col. B. Macena, 01 Jan. 2012.

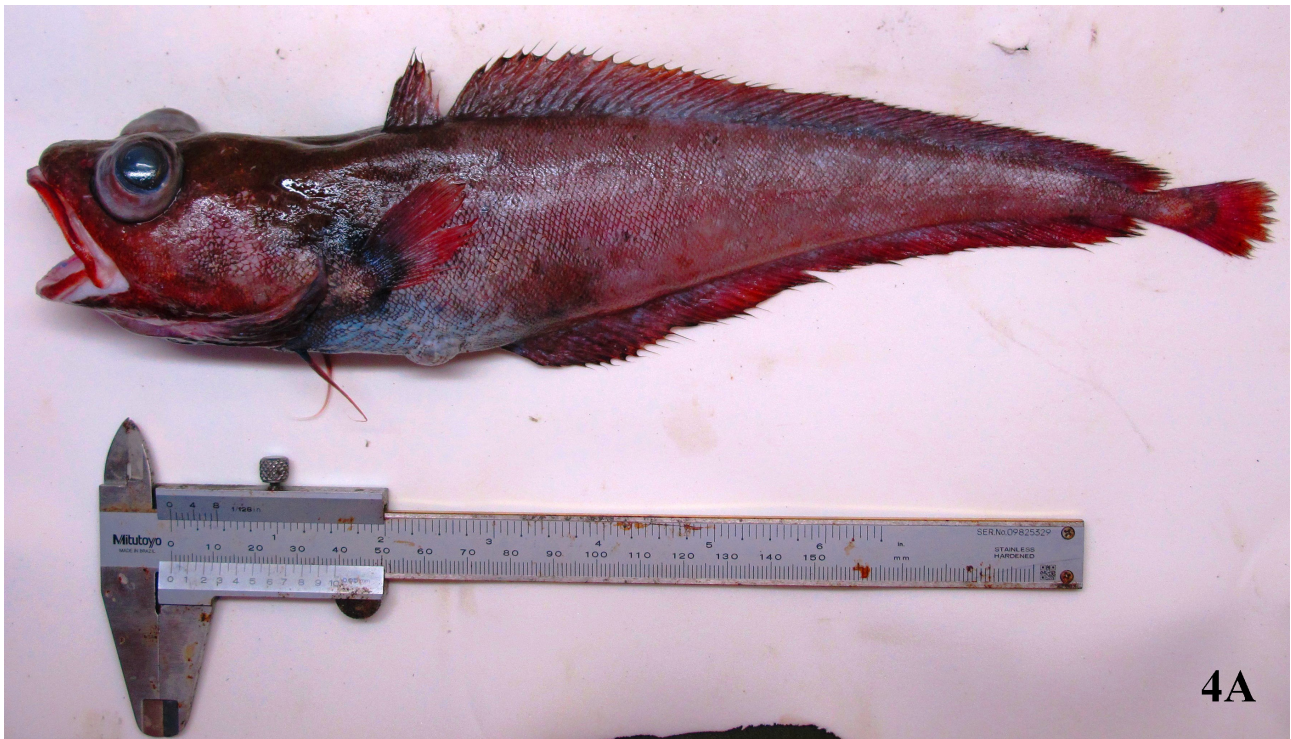
**Diagnosis:** A *Physiculus* species with D 6–8, 68–73; A 65–81; P 20–25; scales on longitudinal series 156–189; scales between base of first dorsal fin and lateral line 15–18; gular region usually with a patch of scales; snout tip usually scaled; dorsal-fin membrane with scales on several rays. The new species is distinguished from all its congeners, except *P. cynodon* Sazonov, 1987 and *P. karrerae*, by the large number of longitudinal series of scales (156–189 vs. 84–150). *P. cynodon* from the Northern Pacific has about 200 longitudinal series of scales, and it dif-

fers from the new species by the number of rays of the first dorsal fin (6–8 vs. 10), pectoral-fin rays (20–25 vs. 27), and the presence of an outer row of large canine teeth on upper and lower jaw. From *P. karrerae*, which has 140–160 longitudinal series of scales, the new species differs by the presence of scales on the tip of the snout and dorsal-fin membrane, and the number of pectoral-fin rays (20–25 vs. 24–27).

**TABLE 1.** Morphometric and meristic data of *Physiculus cirm* n. sp.

Character	Holotype	16 Paratypes
<b>Standard length (mm)</b>	197.2	177.2–322.2
Proportions in % of SL		
<b>Head length</b>	27.1	24.3–28.2
<b>Head width</b>	15.2	13.1–17.8
Snout length	7.1	6.1–8.0
Orbit diameter	7.7	5.9–7.9
Postorbital length	14.1	11.1–14.1
Interorbital width	5.1	4.6–5.7
Upper jaw length	12.6	11.3–14.4
Body depth	18.6	16.5–22.7
Pre dorsal-fin length	29.6	26.4–37.4
Pre anal-fin length	39.6	30.4–41.6
Pre pelvic-fin length	21.8	20.5–23.3
Caudal peduncle depth	2.4	1.9–3.1
Pectoral fin length	14.5	13.8–17.7
Dorsal fin base length	60.3	57.8–69.3
Anal fin base length	58.3	57.1–66.7
Proportions in Inv-af		
Inv-an	39.1	36.4–46.4
Light organ diameter	18.3	14.6–19.7
Inv-lo	7.3	7.3–15.4
<b>Light organ to anus</b>	13.9	9.8–15.8
<b><u>Meristic characters</u></b>		
Dorsal fin-rays	7 + 72	6–8 + 68–73
Anal fin-rays	75	65–81
Pectoral fin-rays	24	20–25
Gill rakers	3 + 9	3 + 7–11
LL to dorsal fin-origin scales	16	15–18
LL to anus scales	54	46–58
Lateral series of scales	171	156–189

**Description:** Meristic and morphometric data are presented in Table 1. Body elongated, anterior part weakly and caudal part strongly laterally compressed; caudal peduncle short, slender. Head moderately large, dorsoventrally flattened anteriorly. Snout rounded. Mouth large, broad; eye moderately large. Light organ 14.6–19.7% InV-af; distance from interventral line to anterior margin of light organ 7.3–15.4% InV-af; distance from posterior margin of light organ to anterior margin of anus 9.8–15.8% InV-af. Gill membranes narrowly joined anteriorly at isthmus. Suborbital space narrow; chin barbel varies from 25 to 50% of eye diameter. Upper jaw with mouth closed projects beyond lower jaw and reaches rear half of pupil posteriorly. Teeth noticeably curved inward, smooth, villiform, eventually a few arrowhead-shaped on jaws and graded on maxillary: outer row followed by similar inner rows of slightly smaller teeth forming a dense band of 5–7 teeth wide in maxillary; lower jaw with 3–5 rows of sub-equal teeth (Fig. 3). Nostrils contiguous; anterior nostril not in a tube and covered by a skin flap, the posterior open and oval. Opercular opening extending forward ventrally to below margin of orbit. Gill rakers 3 + 7–11, flattened, with numerous minute denticles along upper and lower borders; apices of rakers slightly thickened. Outer lens of photophore round, small. Light organ large, closer to interventral line than anus.



4A



4B

**FIGURE 4.** *Physiculus cirm*, n. sp., recently collected, Paratype ZUEC 8464, 262.2 mm SL. **A.** Lateral view. **B.** Belly view, showing photophore and anus.



Two dorsal fins of about same height, separated by a very narrow gap. First dorsal fin origin behind pectoral-fin base, third to fifth rays longest. Anal-fin origin under third to fifth ray of second dorsal fin. Pelvic-fin origin under last 25 to 33% of post-orbital length. Pectoral fin reaches 8<sup>th</sup>–13<sup>th</sup> anal-fin ray. Caudal fin slightly to evenly rounded. Fins covered with skin, denser on first dorsal and anterior part of second dorsal fin. Rays of all fins flexible, ends free.

Body covered with minute, deciduous cycloid scales, often present on snout tip (12 of 15 specimens), between nostrils, on several dorsal-fin rays, and on middle caudal-fin rays, on lower jaw, between anal opening and base of anal fin, and at pectoral-fin base and anterior part of its rays; scales absent on branchiostegal membrane, in the area immediately below nostrils, and anal-fin membrane and rays. Gular scales present in a small patch at isthmus or a large patch at posterior area of the gular region or in a small cluster of 2–5 scales, rarely totally absent (none in only two of sixteen specimens). Continuous lateral line tubes starting above opercle upper angle and extending to below 7<sup>th</sup> to 9<sup>th</sup> ray of the second dorsal fin. Vertebrae of two specimens, MOCH 1521, 56 and 57. Largest specimen, 322.2 mm SL, one of the specimens of voucher MOCH 1521.

**Color in life:** Head and body brown, lighter in lower third and posterior part of body. Abdomen to base of pectoral fin bluish. Gular region, branchiostegal membranes, lips, anterior margin of orbit, and tips of vertical fins dark brown to black. Throat white laterally. Lining of mouth white. Opercle may present a pinkish tinge. Pectoral fin orange to gray-red, its base bluish. Pelvic fin orange to grayish-red. Dorsal and caudal fins brown; anal fin brown, the basal half with a tint of blue. Barbel with red base and whitish tip. Outer lens of photophore and periproctum black. A single specimen observed in about 300 meters was dark blue overall (Fig. 5).



**FIGURE 5.** Alive in reef formation, depth about 300 m. Picture by Projeto Fontes hipertérmicas do Arquipélago de São Pedro e São Paulo, Universidade Federal Fluminense, 2017.

**Color in alcohol:** Body tan to brownish overall, with stains darker between eyes, on snout, gill covers and gill membranes; regions without scales whitish; fins dark. Ventral region from isthmus to anal fin, around the light organ, and laterally on the abdomen beyond the pectoral fins, bluish.

**Distribution:** *Physiculus cirm n. sp.* is known only from Saint Peter and Saint Paul Archipelago, equatorial Atlantic, in depths between 300 and 750 m.

**Etymology:** The species honors the Interministerial Commission for Marine Resources (Comissão Interministerial para os Recursos do Mar—CIRM), who has been, since the middle nineties, the main institution responsible for financing research and keeping a local research station, which made the present study possible. Proposed English name: St. Peter’s codling. Proposed Portuguese (Brazilian) name: abrótea de São Pedro e São Paulo.

## Discussion

Besides the diagnostic characters, *Physiculus cirm n. sp.* is distinguished from all Atlantic species by the presence of a few but clearly visible larger arrowhead-shaped teeth on jaws (Fig. 3). From *P. helenaensis* it also differs by the number of first dorsal-fin rays (6–8 vs. 11) and the short continuous tube of the lateral line (interrupted below 7<sup>th</sup> to 9<sup>th</sup> second dorsal-fin rays vs. long and continuous reaching the caudal peduncle). It further differs from *P. karrerae* by the dentition (graded vs. subequal). The higher number of scales in a transverse row between lateral line and second dorsal fin (13–18) also distinguishes the new species from *P. fulvus* (6–7), *P. microbarbata* (7–8), *P. caboverdensis* and *P. capensis* (8–9), and *P. huloti* (10–12). From *P. kaupi* the new species also differs by the number of pectoral-fin rays (20–25 vs. 28–31) and vertebrae (56 or 57 vs. 52–54). Considering the number of transverse scale rows on sides (156–189) the new species differs from *P. cyanostrophus* (126–130), *P. dalwigki* (119–126), *P. natalensis* (100–110) and *P. maslowskii* (120–130). Selected counts and measurements of Atlantic species are displayed in Tables 2 and 3.

**TABLE 2.** Meristic data of Atlantic *Physiculus* species. Based on Paulin, 1989; Paulin and Matallanas, 1990; Trunov, 1991; Shcherbachev, 1993; Anderson and Tweddle, 2002; González et al., 2018; and examined material, except juveniles.

Species	<i>capensis</i>	<i>dalwigkii</i>	<i>fulvus</i>	<i>helenaensis</i>	<i>huloti</i>	<i>karrerae</i>
N from literature	18	24	27	2	12	15
N examined spps.	02	30	45	00	01	02
Dorsal-fin rays	8–12, 52–62	6–9, 63–68	9–12, 57–61	11, ??	10–12, 53–57	7–8, 64–76
Anal-fin rays	58–65	66–75	59–68	??	57–62	68–81
Pectoral-fin rays	24–28	24–26	21–26	25–26	24	24–27
Scales L. series	96–110	119–135	70–84	???	100–108	134–160
Scales D to LL	8–13	11–17	6–7	13–14	10–12	14–20
Gill Rakers	2–3 + 8–9	2–3 + 7–9	2–4 + 8–11	2 + 5–7	3–4 + 6–9	1–3 + 7–9

continued.

Species	<i>kaupi</i>	<i>cyanostrophus</i>	<i>microbarbata</i>	<i>maslowskii</i>	<i>caboverdensis</i>	<i>cirm n. sp.</i>
N from literature	06	12	02	03	10	00
N examined spps.	15	00	02	00	00	15
Dorsal-fin rays	11–12, 57–66	8–9, 65–70	9, 69–70	11–12, 57–62	11–12, 57–67	6–8, 68–73
Anal-fin rays	62–69	71–76	72–73	65–72	63–69	65–81
Pectoral-fin rays	27–31	22–23	21–23	28–29	26–28	20–25
Scales L. series	120–140	126–130	Ca. 90–100	120–130	Ca. 111–128	156–189
Scales D to LL	12–14	8	7–8	8–11	8–9	15–18
Gill Rakers	2–3 + 5–10	3–5 + 9–11	3–4 + 10	4–5 + 9–10	4–5 + 10	3 + 7–11

The new species increases to twelve the number of species of the genus described from the Atlantic Ocean, not including *P. natalensis*, which has yet to be reported from the area, and to 43 species of the genus known worldwide. *Physiculus cirm n. sp.* may be another endemic species of the SPSPA, such as *Choranthias salmopunctatus* (Lubbock & Edwards), 1981, *Prognathodes obliquus* Lubbock & Edwards, 1980, *Enneanectes smithi* Lubbock & Edwards, 1981, *Odontanhias cauoh* Carvalho-Filho, Macena & Nunes, 2016, and *Tosanooides aphrodite* Pinheiro, Rocha & Rocha, 2018 (Feitoza et al., 2003; Carvalho-Filho et al., 2016; Rocha et al., 2018).

**TABLE 3.** Morphometric data of Atlantic *Physiculus* species. Based on Paulin, 1989; Paulin and Matallanas, 1990; Trunov, 1991; Shcherbachev, 1993; Smith Vaniz et al., 1999; Anderson and Tweddle, 2002; González et al. 2018; and examined material, except juveniles.

Species	<i>capensis</i>	<i>dalwigki</i>	<i>fulvus</i>	<i>helenensis</i>	<i>huloti</i>	<i>karrerae</i>
Character						
LO diameter/InV-af	5.4–10.0	17.5–20.0	7.5–13.2	8.8	7.0–12.5	10.0–22.0
InV-Lo/InV-af	19.0–30.6	0.0–2.4	17.6–25.6	27.5	22.8–27.9	8.2–16.8
LO-anus/InV-af	19.0–24.2	16.8–23.1	21.1–24.5	25.0	21.6–23.9	13.3–17.6
Head Length/SL	22.9–26.9	25.3–27.9	25.3–28.0	XX*	25.5–27.0	24.5–28.4
Eye diameter/SL	5.7–8.6	6.4–8.8	7.5–9.0	XX*	6.5–7.0	6.1–7.3
Snout Length/SL	4.8–7.4	5.2–8.0	6.4–8.0	XX*	5.4–6.7	6.7–8.7
Up. Jaw Length/SL	11.2–13.8	10.6–12.9	11.2–16.3	XX*	12.5–12.7	10.6–12.4
Inter-orb Length/SL	4.5–6.2	3.7–5.9	4.6–6.0	XX*	5.1–5.8	3.8–6.0
Pre-Dorsal L/SL	23.6–30.0	28.3–31.8	27.9–29.6	XX*	22.8–31.9	25.9–31.7
Pectoral Length/SL	14.8–17.3	14.4–15.8	14.9–19.6	XX*	15.9–17.2	13.3–17.4

continued.

Species	<i>kaupi</i>	<i>cyanostrophus</i>	<i>microbarbata</i>	<i>maslowski</i>	<i>caboverdensis</i>	<i>cirm n. sp.</i>
Character						
LO diameter/InV-af	8.8–11.2	8.0–9.8	5.2–6.3	9.3–12.5	6.8–13.3	14.6–19.7
InV-Lo/InV-af	19.5–22.2	31.0–39.7	34.3–36.0	23.8–34.8	20.0–26.3	7.3–15.4
LO-anus/InV-af	26.4–28.8	23.6–28.5	18.0–19.7	20.5–27.7	18.2–27.8	9.8–13.9
Head Length/SL	26.0–28.2	21.7–24.4	21.0–23.5	24.6–27.2	26.7–29.6	24.3–28.2
Eye diameter/SL	5.7–7.3	4.9–6.4	4.8–5.7	6.5–8.1	7.6–10.6 <sup>#</sup>	5.9–7.9
Snout Length/SL	7.1–8.2	3.6–4.8	4.1–5.9	7.5–8.9	8.2–10.4 <sup>#</sup>	6.1–8.0
Up. Jaw Length/SL	12.5–13.9	11.6–12.4	10.5–11.9	13.0–14.8	16.7–19.9 <sup>#</sup>	11.3–14.4
Inter-orb Length/SL	3.9–5.1	4.1–4.8	4.9–5.2	6.8–8.3	6.0–8.3 <sup>#</sup>	4.6–5.7
Pre-Dorsal L/SL	29.6–31.5	22.9–25.8	27.1–28.3	30.2–31.1	29.3–32.4	26.4–37.4
Pectoral Length/SL	16.4–19.0	15.9–17.9	14.5–17.2	14.2–18.4	15.5–21.7	13.8–17.7

LO: Light Organ; \*: SL unknown; #: adapted from González *et al.*, 2018.

## Comparative Material

*Physiculus capensis*: USNM 188814 (1, 79.8 mm SL) South Africa, off Lion's Head, 154 fms deep. BMNH 1902.5.28.19 (1, 93.4 mm SL) South Africa, 18<sup>1/2</sup> miles off Cape Point, 180 fms deep, J.D.F. Gilchrist.

*Physiculus dalwigki*: MCZ 56975 (27, 97.5–194.2 mm SL) Eastern Atlantic, off Sahara, Mauritania, RV Atlantis II 82, Station 8221, 21°43'N and 17°27'W, 311–366 m deep, 24 March 1974. USNM 266299 (3, 61.3–110.8 mm SL) Eastern Atlantic, Mauritania, RV Discovery, Station 8020, 20°45'06"N and 017°39'18"W, 261–297 m deep, 27 July 1972. BMNH 1979.12.12.1-2 (2, 184.2–214.2 mm SL), Madeira, December 1979.

*Physiculus fulvus*: LABIPE 1244 (1, 110.3 mm SL), 18 miles off Galinhos, Rio Grande do Norte, Brazil, 178–193 m deep, col. LABIPE, 23 May 2011. MCZ 39329 (1, 116.0 mm SL) Western Atlantic, Caribbean Sea, Cuba, off Playa Baracoa, Havana, RV Atlantis, Harvard-Havana Expedition, 23°05'N and 82°33'W, 260 fms deep, 23 March 1938. MCZ 147999 (1, 102.9 mm SL) Northwestern Atlantic, Mid Atlantic Bight, USA, RV Delaware II, 37°04'N and 74°41'W, 120–210 m deep, 12 Sept. 1991. MCZ 150803 (1, 150 mm SL) Northwestern Atlantic, Mid Atlantic Bight, USA, RV Albatross IV, 37°06'N and 74°44'W, 198 m deep, 06 Feb. 1997. MCZ 150804 (1, 109.8 mm SL) Northwestern Atlantic, Mid Atlantic Bight, USA, RV Albatross IV, 36°48'N and 74°43'W, 84 m deep, 06 Feb. 1997. MCZ 157764 (1, 110.2 mm SL) Northwestern Atlantic, Mid Atlantic Bight, USA, RV Albatross IV, 34°48'57"N and 75°28'28"W, 164 m deep, 09 March 1999. MCZ 158574 (1,

110 mm SL) Northwestern Atlantic, Mid Atlantic Bight, USA, RV Albatross IV, 36°54'20"N and 74°38'30"W, 119 m deep, 13 Feb. 2000. MCZ 166184 (1, 112.9 mm SL) Northwestern Atlantic, USA, RV Delaware II, J.K. Galbraith, 40°13'54"N and 70°53'24"W, 0–50 m deep, 26 Feb. 2003. MCZ 172377 (1, 119.2 mm SL) Western Atlantic, United States, FSV Henry B. Bigelow, J.K. Galbraith, 38.7636295° and -73.04098433°, 28 Sept. 2014. USNM 28766 Types (3, 55.1–80.4 mm SL) North Atlantic, US Fish Commission Vessel Fish Hawk, station 941, 40°01'N and 69°56'W, 144 m deep, hard sand and mud, 04 Aug. 1881. USNM 158233 (1, 113.8 mm SL) Gulf of Mexico, USA, Florida, South of Cape San Blas, vessel Oregon, station 32, 29°10'N and 85°55'W, 95 fms deep, 23 June 1950. USNM 158442 (1, 70.3 mm SL) Gulf of Mexico, USA, Florida, NW of Key West, vessel Oregon, station 1026, 25°08'N and 84°19'W, 163 fms deep, 19 April 1954. USNM 184926 (1, 46.8 mm SL) Atlantic, off Brazil, vessel Oregon, station 2081, 01° 52'N and 46° 54'W, 175 fms deep, 17 Nov. 1957. USNM 266298 (1, 92.0 mm SL) Atlantic, New Jersey, USA, vessel Dolphin, 39°36'48"N and 72°24'18"W, 90 fms deep, 15 Aug. 1970. USNM 266304 (29, 42.1–138.2 mm SL) Caribbean Mexico, Campeche, vessel Silver Bay, station 1184, 23°56'N and 87°32'W, 150 fms deep, 05 June 1959.

*Physiculus karrerae*: USNM 266723 Paratype (1, 188.5 mm SL) Caribbean Mexico, Campeche, vessel Silver Bay, station 1184, 23°56'N and 87°32'W, 150 fms deep, 05 June 1959. USNM 337526 (1, 222.1 mm SL) Bermuda, 32°22'08"N and 64° 57'06"W, 400 fms deep, 12 Dec. 1990.

*Physiculus kaupi*: DBUFC 74 (originally CIDRO 86) (1, 275.3 mm SL) Aracati Oceanic Bank, Ceará, Brazil, 03°22'31" S 37°32'30" W, 263 m deep, Programa REVIZEE, oceanographic vessel "Professor Martins Filho", 31 March 2001. LABIPE 1232 (1, 135.7 mm SL), 30 miles off Porto do Mangue, Rio Grande do Norte, Rio Grande do Norte, Brazil, 180–211 m deep, LABIPE, 08 Dec. 2008. MCZ 39971 (3, 125.2–179.9 mm SL) off Brazil, vessel Oregon, 02°41'N and 47°48'W, 180 fms deep, 15 Nov. 1957. MNRJ 45301 (1, 183.1 mm SL) Western Atlantic, 23°41'84"S and 42°52'81"W, col. D.F. Moraes and R. Soares, 28 March 2015. MNRJ 49452 (1, 211.2 mm SL) off Praia do Forte, Mata de São João, Bahia, Brazil, -12.566667° and -38°, 500 m deep, col. Alfredo Carvalho Filho and Guy Marcovaldi, pot fishing, 19 April 2007. MZUSP 78279.0, (1, 19.9 mm SL) Western Atlantic Ocean, vessel N. Oc. Atlântico Sul, station PE01, -26.274723° and -45.77639°, 610m deep, col. REVIZEE team, 07 Oct. 1999. MZUSP 121511 (2, 211.2–245.0 mm SL), off Praia do Forte, Mata de São João, Bahia, Brazil; 12°35'00 S, 37°54'05"W, 350 m deep, col. Guy Marcovaldi, pot fishing, 17 May 2007; USNM 266300 (2, 138.4–159.6 mm SL) Atlantic, off Brazil, vessel Oregon, station 2081, 01° 52'N and 46° 54'W, 175 fms deep, 17 Nov. 1957; ZUEC 6319 (1, 252.4 mm SL), off Praia do Forte, Mata de São João, Bahia, Brazil, -12.566667° and -38°, 300 m deep, col. Alfredo Carvalho Filho and Guy Marcovaldi, hook and line, 21 May 2006. ZUEC 6320 (2, 177.3–192.4 mm SL), off Praia do Forte, Mata de São João, Bahia, Brazil, -12.566667° and -38°, 500 m deep, col. Alfredo Carvalho Filho and Guy Marcovaldi, pot fishing, 29 April 2007.

*Physiculus huloti*: USNM 266725 (1, 165.8 mm SL) Eastern Atlantic, Ghana, vessel La Rafale G.T.S I, station 7B Trans. 31, 05°06'N and 00°17'W, 260–265 m deep, 24 Sept. 1963.

*Physiculus microbarbata*: USNM 405226 (1, 195.3 mm SL) Cape Verde, vessel Dr. Friditof Nansen, station 36, 16°57'09"N and 25°04'42"W, 275–283 m deep, col. K. Wieber, 17 June 2011. USNM 405227 (1, 234.8 mm SL) Cape Verde, vessel Dr. Friditof Nansen, station 36, 16°57'09"N and 25°04'42"W, 275–283 m deep, col. K. Wieber, 17 June 2011.

### Key to Atlantic species of the genus *Physiculus*, including *P. natalensis* from Eastern South Africa

Based on Paulin, 1989; Paulin & Matallanas, 1990; Trunov, 1991; Anderson & Tweddle, 2002, and this study.

- 1a. Continuous tube of lateral line long, reaching caudal peduncle. . . . . *P. helenaensis*.
- 1b. Continuous tube of lateral line shorter, not reaching caudal peduncle. . . . . 2
- 2a. Distance from interventral line to anterior margin of light organ less than 15% InV-af. . . . . 3
- 2b. Distance from interventral line to anterior margin of light organ more than 15% InV-af. . . . . 7
- 3a. Scales in longitudinal series 100–110 . . . . . *P. natalensis*
- 4b. Scales in longitudinal series at least 119 . . . . . 5
- 5a. Scales in longitudinal series 119–126 . . . . . *P. dalwigki*
- 5b. Scales in longitudinal more than 130 . . . . . 6
- 6a. Scales in longitudinal series 134–160, no scales on snout . . . . . *P. karrerae*
- 6b. Scales in longitudinal series 156–189, scales present on snout . . . . . *P. cirm* n. sp.

7a.	Distance from interventral line to anterior margin of light organ more than 30% InV-af	8
7b.	Distance from interventral line to anterior margin of light organ less than 30% InV-af	10
8a.	Scales in longitudinal series about 90	<i>P. microbarbata</i>
8b.	Scales in longitudinal series more than 100	9
9a.	First dorsal-fin rays 8–9	<i>P. cyanostrophus</i>
9b.	First dorsal-fin rays 11–12	<i>P. maslowskii</i>
10a.	Scales in longitudinal series more than 110	11
10b.	Scales in longitudinal series less than 115	12
11a.	Scale rows between base of first dorsal and lateral line 12–14	<i>P. kaupi</i>
11b.	Scale rows between base of first dorsal and lateral line 8–9	<i>P. caboverdensis</i>
12a.	Scales in longitudinal series less than 90	<i>P. fulvus</i>
12b.	Scales in longitudinal series 90–110	13
13a.	Teeth in a graded series	<i>P. capensis</i>
13b.	Teeth not in a graded series	<i>P. huloti</i>

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