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The California Academy of Sciences Gulf of Guinea Expedition (2001) V. Multivariate Analysis of Sicydiines of São Tomé & Príncipe with Redescription of *Sicydium brevifile* and *S. bustamantei* (Teleostei: Gobiidae) and a Key to West African Sicydiines

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Freshwater fish collections made during the California Academy of Sciences 2001 Expedition to São Tomé and Príncipe in the Gulf of Guinea, West Africa, provided numerous specimens of *Sicydium* species. Our examination of these specimens indicates that two species were found on the islands. One species is *S. brevifile* Ogilvie-Grant, 1884, previously known only from the holotype and reported from the Cameroons. The other species is *S. bustamantei* Greeff, 1882. Both species were common in samples and were represented by a variety of size classes. Although the subject of much confusion historically, they are distinguished by squamation, jaw morphology, lip morphology, the number of premaxillary tooth rows, the number of premaxillary teeth, head size, length of first dorsal fin spines in males and pigmentation. Evidence is given indicating that one of the paralectotypes of *S. bustamantei* is a specimen of *S. brevifile*. The two species are redescribed and compared across life/size class stages. A key is provided for the three West African species of *Sicydium* and *Parasicydium bandama*.

Os peixes de água doce coletados durante a expedição de 2001 da California Academy of Sciences à São Tomé e Príncipe, no Golfo da Guinéa, África do Oeste, continham vários espécimes do tipo *Sicydium*. O exame desses espécimes indica que duas espécies são encontradas nas ilhas. Uma das espécies é *S. brevifile* Ogilvie-Grant, 1884, previamente conhecida somente pelo holotipo e por relatos de Cameroons. A outra especie é *S. bustamantei* Greeff, 1882. As duas espécies são muito comums nas amostras e são representadas por uma variedade de classes por tamanho. Historicamente, apesar de muita confusão acerca de suas características, as espécies podem ser diferenciadas pela disposição das escamas, morfologia da mandíbula, morfologia dos lábios, o número de camadas de dentes pré-maxilares, tamanho da cabeça, comprimento do espinho da primeira nadadeira dorsal nos machos e pigmentação. As evidências indicam que um dos paralectotipos de *S. bustamantei* é uma espécie de *S. brevifile*. As duas espécies foram redescritas e comparadas baseadas na relação de longevidade/tamanho. Uma chave de classificação para a identificacao dos três tipos das espécies do Oeste da Africa de *Sicydium* e *Parasicydium bandama* é fornecida.

The California Academy of Sciences (CAS) expedition to the Republic of São Tomé and Príncipe in 2001 (Drewes 2002) obtained many collections of fishes from freshwater streams of the islands. The islands are part of the Guinea Line, a volcanic line associated with the African Plate that extends for more than 1000 km from Pagalu (Annobón) Island to the Jos Plateau of Nigeria (Lee et al. 1994). São Tomé and Príncipe are tropical oceanic high islands receiving as much as 500 cm of rainfall annually on the southwestern slopes. São Tomé is younger (13+ my) and larger (836 km^2) than Príncipe (31+ my and 130 km^2), and its highest peak is greater than 2000 m, more than twice that of the highest peak on Príncipe. The islands are isolated from one another by 146 km, from the African coast by 220 km, and by depths greater than 3000 m. More information on the geology of the islands is given by Drewes and Wilkinson (2004).

The 2001 CAS freshwater collections included many specimens of the gobioid genus *Sicydium*. Identification of these specimens to species was initially problematic due to the great confusion surrounding the taxonomic status of nominal species described from the region. The nomenclatural confusion surrounding West African sicydiines was reviewed by Harrison (1993). He recognized four species from the region: *Parasicydium bandama* Risch 1980, *Sicydium brevifile* Ogilvie-Grant 1884, *S. bustamantei* Greeff 1882, and *S. crenilabrum* Harrison 1993. A summary of the taxonomic progression follows. Richard Greeff described *Gobius bustamantei* in 1882 based on specimens from São Tomé. In 1884, referring to the same specimens in a footnote, Greeff distinguished a larger species, which retained the name *G. bustamantei*, from a smaller species, which he called *Sicydium bustamantei*. Also in 1884, Ogilvie-Grant described *Sicydium brevifile* from a single specimen recorded from the "Cameroons," a name which at that time referred to the general region of the Gulf of Guinea south of Nigeria, including the islands. Boulenger (1916) regarded *S. bustamantei* Greeff 1884 as a *nomen nudum* and synonymized it with *Lentipes bustamantei* which he described from some small specimens from São Tomé. Thys van den Audenaerde (1967) recognized *S. brevifile*, *S. bustamantei* Greeff 1884 and *Lentipes bustamantei*, but Risch and Thys van den Audenaerde (1979) synonymized *Lentipes bustamantei* with *S. bustamantei* using ontogenetic information to show that *L. bustamantei* is simply the post-larval phase of *S. bustamantei*. In distinguishing *S. brevifile* from *S. bustamantei*, they stated that *S. brevifile* has a crenate upper lip. Additional material and closer inspection of the holotype of *Sicydium brevifile* led Harrison (1993) to redescribe *S. brevifile*, which does not have a crenate upper lip, and recognize a new continental West African sicydiine, *S. crenilabrum* — the species characterized by a crenate upper lip. Harrison distinguished *Sicydium brevifile* from *S. bustamantei* and *S. crenilabrum*, but his redescription of *S. brevifile* was limited to the holotype; no other specimens were identified. *Sicydium bustamantei* and *S. brevifile* were the only sicydiine species recognized by Harrison (1993) from the Gulf of Guinea islands, and as noted, *S. brevifile* was known only from the holotype.

The numerous *Sicydium* specimens of differing life stages provided by the 2001 CAS collections have allowed us to better distinguish sicydiine diversity of the islands. We concur with Harrison's (1993) recognition of three *Sicydium* species from West Africa. In this paper we report the collection of numerous specimens of *Sicydium brevifile* from São Tomé and Príncipe, redescribe the species and compare it to *S. bustamantei* of different sizes using both new and previously available material. We also demonstrate that one of the paralectotypes of *S. bustamantei* is actually a specimen of *S. brevifile*.

Materials and Methods

Counts and measurements follow Hubbs and Lagler (1958) except as noted. Lateral scale row counts were made from the upper pectoral fin axilla midlaterally to the base of the caudal fin and

do not include scales extending onto the caudal fin. Transverse row counts were made from the origin of the anal fin posterodorsally to the base of the second dorsal fin. Caudal peduncle row counts were made from the scale immediately above the terminus of the anal fin posterodorsally to the midline of the caudal peduncle. Head depth measurements were made perpendicular to the body axis at the preopercle. Premaxillary teeth were examined and counted (on one side only) with a dissecting microscope and photographed with a scanning electron microscope. Osteological information was obtained from radiographs and cleared and stained specimens. Pterygiophore insertion patterns are expressed following Birdsong et al. (1988). Cephalic lateralis pore terminology is given as described by Akihito et al. (1984). Museum acronyms follow Leviton et al. (1985), except for Staatliches Museum fur Tierkunde Dresden, which is given as MTDF.

Material Examined

Sicydium brevifile: BMNH 1866.6.26.10, holotype, Cameroons, A. Smith; AMNH 236489 (tissue REB 37) (2), Cameroon, Limbe River near botanical garden, 4°00′53.3″N, 9°11′53.7″E, R. Brummett, Nov. 2003; AMNH 236490 (tissue REB 38b) (1), Cameroon, Limbe River near botanical garden, 4°00′53.3″N, 9°11′ 53.7″E, R. Brummett, Nov. 2003; BMNH 1927.5.4.1 (1), Príncipe, Rowland Ward Ltd.; CAS 214398 (32), Príncipe, Água Maria Correia, main fork going into Baia das Agulhas about 300 m upstream from mouth, 1°36′5″N, 7°21′12″E, Iwamoto, Drewes and Cabral-Quade, 23 April 2001; CAS 214401 (42), Príncipe, Ribeira Chimboto, NE of Praia Seca and cove N of Neve Ferreira, small stream with mouth completely blocked by 2–5" dia. cobblestones, 1°33′14″N, 7°24′E, Iwamoto, Drewes and Cabral-Quade, 23 April 2001; CAS 214411 (23), São Tomé, R. Anambó, downstream from coast road about 50–150 m from ocean at monument to first village on São Tomé, 0°19′33″N, 6°30′30″E, Iwamoto, Cabral-Quade and Rosa-Delgado, 3 April 2001; MRAC 94-086-P-0038 (1), Annobón (originally incorrectly listed as Anabon, Gabon, in MRAC catalog), M. Levy, 1–12 January, 1994; NLU 78956 (3), São Tomé, Rio Maria Luisa at bridge crossing, 0°19′41″N, 6°30′44″E, Iwamoto, Cabral and Rosa-Delgado, 3 April 2001; NLU 78959 (20), São Tomé, Água Micondó, downstream of coastal hwy. to lagoon-like area, 0°10′18″N, 6°41′12″E, Iwamoto and Cabral-Quade, 4 April 2001; NLU 78961 (2), Rio Contador ca. 100 m from stream mouth to last pool before mouth, Iwamoto and Costa, 8 April 2001; NLU 78965 (5), Sao Tome, Áqua Azeitona below hwy. bridge, 0°6′15″N, 6°37′15″E, Iwamoto, Drewes and Cabral-Quade, 28 April 2001; MTDF 10000 (1), São Tomé, Rio Quija, Rio Xufe Xufe, Widmann, Fahr and Bruhl, March 1991; MCZ 13327 (5), Príncipe, collectors unknown, 1854; ZMH 8110 (former 19296) (1), syntype of *S. bustamantei*, São Tomé, Rio d'Ouro, Greeff, December 1879; ZSM 33222–23 (2), Cameroun (no further locality data), Glaser Imports, 2005.

Sicydium bustamantei: CAS 214407 (19), São Tomé, Rio do Ouro, at Angostino Neto (formerly Rio do Ouro plantation), 0°21′56″N, 6°38′42″E, Iwamoto, Cabral-Quade and Drewes, 13 April 2001; CAS 214410 (18), São Tomé, Rio Anambó downstream from coast road, 50–150 m from ocean at monument to first village on São Tomé, 0°19′33″N, 6°30′30″E, Iwamoto, Cabral-Quade and Rosa-Delgado, 3 April 2001; CAS 214658 (8), clear mountain stream, Roca Zampalma, B. Malkin, 1 August 1949; MRAC 142108–109 (2), Equatorial Guinea, Fernando Póo, Bach bei Basokoto an der Strasse nach St. Isabel, 3°35′N, 8°37′E, Eisentraut, 22 October 1962; MRAC 142110–111 (2), Equatorial Guinea, Fernando Póo, Lager I., 3°18′N, 8°10′E, Eisentraut, 6 December 1962; MRAC 143362 (1), Equatorial Guinea, Fernando Póo, Rio Ruma, at bridge on route to Conception, D. Thys v. d. Audenaerde, 13 December 1964; MRAC 143438–439 (2), Equatorial Guinea, Fernando Póo, Moca, mountainside stream, affl. of Rio Ilabyi (Ilachi), 3°20′N, 8°40′E, D. Thys van den Audenaerde, 15 December 1964; NLU 78957 (4), São Tomé, Rio Maria Luisa at bridge crossing, 0°19′41″N, 6°30′44″E, Iwamoto, Cabral-Quade and Rosa-Delgado, 3 April 2001; NLU 78960 (8), São Tomé, Água Micondó, downstream of coastal hwy. to lagoon-like area, 0°10′18″N, 6°41′12″E, Iwamoto and Cabral-Quade, 4 April 2001; NLU 78964 (6), São Tomé, Rio do Ouro, at Angostino Neto (formerly Rio do Ouro plantation), 0°21′56″N, 6°38′42″E, Iwamoto, Cabral-Quade and Drewes, 13 April 2001; NLU 79866 (20), São Tomé, Água Azeitona below hwy. bridge, 0°6′15″N, 6°37′15″E, Iwamoto, Drewes and Cabral-Quade, 28 April 2001; ZMH 8108, (former 19295) (1), lectotype of *S. bustamantei*, São Tomé, Água Grande, Greeff, 1 April 1880; ZMH 8109, (former 19295) (1), paralectotype of *S. bustamantei*, Água Grande, São Tomé, Greeff, 1 April,

1880; ZSM 27435 (3), São Tomé, Almerim, J. Haft, August 1989; ZSM 27616 (2), Equatorial Guinea, Bioko (Fernando Póo), Rio Ilady, above cascades near Moka village, U. Schliewen, February 1990; ZSM 28418 (3), São Tomé, Rio Quija ca. 800 m from sea, J. Haft, April 1992; MRAC 94-086-P-0039-44, Annobón (originally incorrectly listed as Anabon, Gabon, in MRAC catalog), M. Levy, 1–12 January, 1994; BMNH 1914.12.28:3-12 (6), syntypes of *Lentipes bustamantei*, São Tomé, Rio do Ouro, Henrique; MRAC 143154-162 (5), Fernando Póo, Rio Timbapé, D. Thys van den Audenaerde, 12 December, 1964; MRAC 143163-166 (3), Fernando Póo, Rio Timbapé, D. Thys van den Audenaerde, 12 December, 1964; MRAC 143264–362 (20), Fernando Póo, Rio Ruma, near to bridge on road to Conception, D. Thys van den Audenaerde, 13 December 1964; MRAC 78-46-P-262 (1), Fernando Póo, small stream just north of Conception, J.J. Scheel, 6 February 1968; MRAC 78-46-P-263 (1), Fernando Póo, mouth of Rio Timbapé up to 100 m above Rio Agua-Negreb, J.J. Scheel, 12 January 1969.

Sicydium crenilabrum: MNHN 1992–1234 (1), holotype, River Tabou at Yaka, Côte d'Ivoire, Tabou River, Yaka, 4°28′N, 7°23′W, G. Teugels, 8 April 1986; BMNH 1989.1.6.35 (1), Cameroon, River Lokunje and tributaries within 30 km of Bipindi, T. Roberts, 18–19 December 1987; MCZ 48156 (13), Cameroon, river Mboue at Edea, T. Roberts, 17 April 1971; MCZ 48157 (3), Cameroon, Sanaga river, rock pools on barrage at Edea, T. Roberts, 17 April 1971; MNHN 1987-703 (2), paratypes, Côte d'Ivoire, river Tabou at Yaka, G.G. Teugels, 8 April 1986; CU 90195 (2), Cameroon, Lobe River, Lobe rapids between ocean and bridge, 2.8782°N 9.8987°E, J.P. Friel and J.P. Sullivan, 15 February 2004. MRAC 75-56-P-1934 (1), paratype, Cameroon, Kribi, among rocks below bridge, D. Thys van den Audenaerde, 14 March 1975; MRAC 86-013-P-0717 (1), paratype, Côte d'Ivoire, on the road between San Pedro and Tabou, G. Teugels, 7 April 1986; MRAC 86-013-P-0720-0723 (4), Côte d'Ivoire, Tabou River, Yaka, 4°28′N, 7°23′W, G. Teugels, 8 April 1986; MRAC P173337-338 (2), paratypes, Equatorial Guinea, Rio Benito, Puente de Senye, 1°34′N, 9°50′E, B. Roman, 12 August 1966; MRAC 90-57-P-2435-2437 (3), labeled as *Sicyopterus imitoratus*, Congo Brazzaville, river Mombi, affluent of River Kouilou, road from Kakamoeka to Sounda, 500m from Sounda bridge, G. Teugels, L. DeVos, and J. Snoeks, 11 October, 1990; MRAC 95-30-P-2367-2369 (3), labelled as paratypes of *Sicyopterus imitoratus* Cameroon, river Bongolo en aval 56-77 ??, 2°26′N 9°57′E, A. Kamden-Toham; MRAC 95-034-P-0001-002 (2), Cameroon, Lobe River about 500 m from sea just below water falls, 2°52′N, 9°54′E, Univ. Saarbrucken, 1–30 September 1993; MRAC 95-034-P-0006, Cameroon, Lobe River about 500 m from sea just below water falls, 2°52′N, 9°54′E, Univ. Saarbrucken, 1–30 September 1993.

Parasicydium bandama: MNHN 1979-152 (1) holotype, Côte d'Ivoire, Bandama River, Tiassalé, C. Leveque and D. Paugy; BMNH 1989.1.6.36 (1), Cameroon, River Lokunje and tributaries within 30 km of Bipindi, T. Roberts, 18–19 December, 1987; CU 90920 (1), Cameroon, Lobe River, Lobe rapids between ocean and bridge, 2.8782°N, 9.8987°E, J.P. Friel and J.P. Sullivan, 15 February 2004; CU 90226 (1), Cameroon, Lobe River, Lobe rapids between ocean and bridge, 2.8782°N, 9.8987°E, J.P. Friel and J.P. Sullivan, 15 February 2004; MRAC 80-48-P-1-2 (2), paratypes, Côte d'Ivoire, Bandama River, Tiassalé, C. Leveque and D. Paugy; MRAC 90-57-P-2438-2451 (14), Congo Brazzaville, river Mombi, affluent of River Kouilou, road from Kakamoeka to Sounda, 500m from Sounda bridge, G. Teugels, L. DeVos, and J. Snoeks, 11 October 1990; MRAC 90-57-P-2452-2454 (3), Congo Brazzaville, river Mboulou, affluent of River Douvolo, affluent of river Loulimba, road from Bena I to Kakamoeka, approximately 2 km from Kakamoelka, 4°07′N, 12°13′E, G. Teugels, L. DeVos, and J. Snoeks, 12 October, 1990; MNHN 1979-152 (3) paratypes, Côte d'Ivoire, Bandama River, Tiassalé, C. Leveque and D. Paugy.

Results

Two distinctive *Sicydium* morphotypes are distinguishable among the specimens taken during the CAS 2001 expedition to São Tomé and Príncipe. They differ in squamation, jaw morphology, lip morphology, the number of premaxillary tooth rows and teeth, head size, the length of first dorsal fin spines in adult males, and pigmentation.

Of the 11 meristic features examined, eight were distinctive for the two forms (Appendix Table 1). The number of premaxillary teeth most clearly distinguishes the two forms. One set of specimens, which includes the lectotype of *S. bustamantei*, has fewer than 50 premaxillary teeth; these

specimens are hereafter referred to that species (Fig. 1). The other group, which includes the holotype of *S. brevifile*, has more than 60 teeth, often to more than 100 (Fig.1), and they are identified herein as that species. Specimens of *S. brevifile* usually have alternate teeth staggered in two rows visible above the gum. Only one exposed row is apparent in *S. bustamantei*. For both species we observed an increase in premaxillary tooth number with increasing size, the increase being most pronounced in *S. brevifile* between 20–40 mm SL and more gradual over the size range of *S. bustamantei* (Fig. 1). Although there was overlap for scale counts and the number of pectoral fin rays (e.g., lateral scale rows, Fig. 2), a principal components analysis using meristic characters other than number of premaxillary teeth or premaxillary tooth rows gave clear separation of the two species on PC 1 (Fig. 3 and Appendix Table 2). Scale variables were the most important contributors to specimen scores along the PC 1 axis. *Sicydium brevifile* has smaller scales than *S. bustamantei* as demonstrated in the higher mean scale numbers (Appendix Table 1).

The two species also differ in morphometry (Appendix Table 3). As observed by Harrison (1993), *Sicydium brevifile* has a larger jaw that extends to the posterior margin of the orbit or beyond (Figs. 4–6). Other obvious differences of oral morphology include the presence of a medial notch in the upper lip of *S. brevifile* (Fig. 7), which is lacking in *S. bustamantei*, and the presence of a prominent median fleshy tubercle separating the premaxillary tooth rows in *S. bustamantei*, which *S. brevifile* lacks or has only weakly developed in smaller individuals. A principal compo-

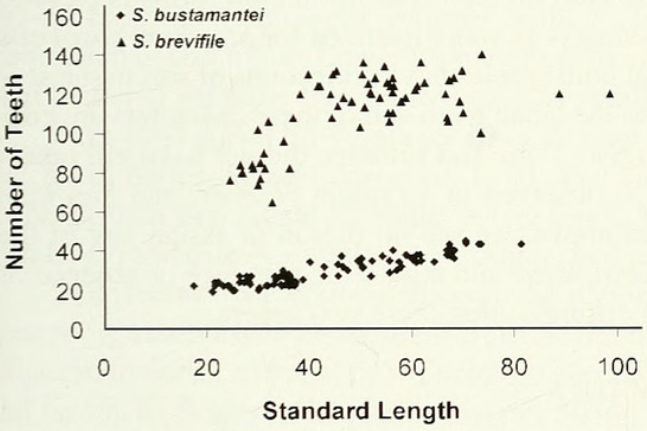

FIGURE 1. Comparison of premaxillary tooth counts of *Sicydium brevifile* and *S. bustamantei* at different standard lengths.

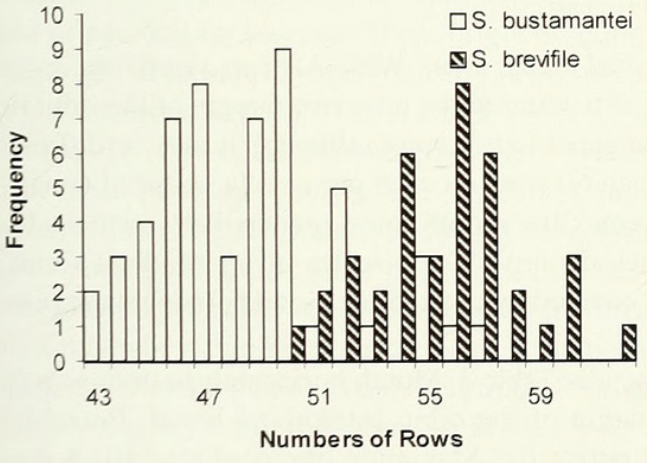

FIGURE 2. Frequency distribution of lateral scale row number.

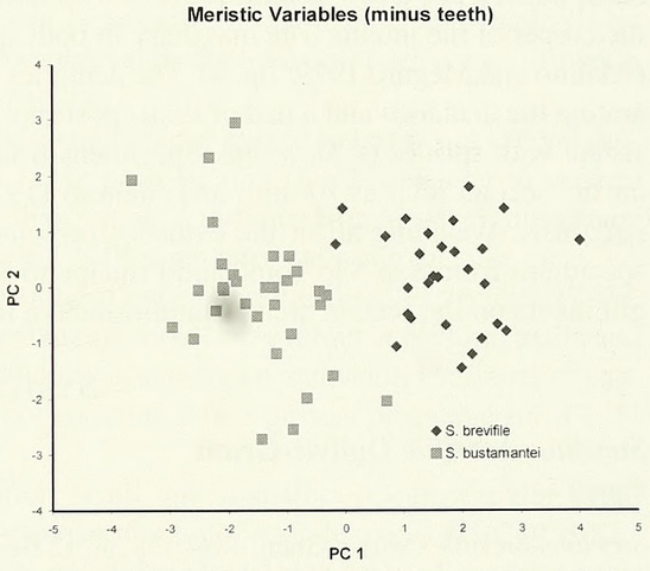

FIGURE 3. Principal components analysis of meristic features not including teeth or tooth row number.

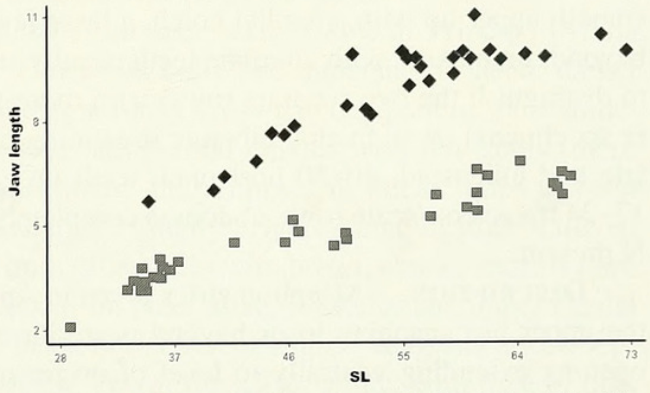

FIGURE 4. Upper jaw length vs. SL for *S. brevifile* (diamonds) and *S. bustamantei* (squares).

nents analysis of morphometric characters also separated the species (Fig. 8 and Appendix, Table 4) when PC 1 was plotted against PC 3. In addition to jaw length, head size and second dorsal fin and anal fin length differences contributed substantially to the distinction of the taxa (Appendix Table 3 and Fig. 9). Variance on PC 2 reflected size differences and sexual dimorphism for first dorsal fin length.

Discussion

Although *Sicydium* is the only sicydiine genus reported from islands in the Gulf of Guinea, some specimens borrowed from MRAC had labels indicating a proposed manuscript name that would assign one of the island forms to *Sicyopterus*. Other specimens from the mainland of Africa in some MRAC collections, MRAC 90-57-P-2435-2437 and MRAC 95-30-P-2367-2369, were assigned to the *nomen nudum Sicyopterus imitoratus* by R. Watson (Toham and Teugels 1997). Watson (2000) commented that Harrison (1993) had described *Sicydium crenilabrum* from specimens of two different genera in reference to some of the MRAC material he identified as *Sicyopterus*. Specimens of *Sicydium brevifile* and *S. bustamantei* obtained in the CAS 2001 expedition were examined for characters used to distinguish *Sicydium* and *Sicyopterus* proposed by Akihito and Meguro (1979: table 3). The premaxillary teeth of both species have long tips (exceeding half the length of the basal portion) that are sharply bent inwards to form about a 90° angle. The basal portion has a low inward process. The lateral cleft on the upper lip in both forms is close to the corner of the mouth. The maxillary in both species is as was illustrated for *Sicydium cocoensis* (Akihito and Meguro 1979: fig. 4). The dentaries of both species have projections of soft tissue separating the dentaries and a pad of tissue posterior to the labial teeth. All of these characters are consistent with species of *Sicydium*. Specimens from São Tomé and Príncipe did not have gill rakers on the second arch as Akihito and Meguro (1979) observed in *Sicydium plumieri* and *Sicydium cocoensis*. Weighing all of the evidence presented above, we see no reason to assign any of the specimens from Sao São Tomé and Príncipe to *Sicyopterus* and regard the presence or absence of gill rakers on the second arch as uninformative in distinguishing these two genera.

Systematics

Sicydium brevifile Ogilvie-Grant

Figure 5.

Sicydium brevifile Ogilvie-Grant, 1884:158, pl. 12 fig. 1. Type locality "Cameroons."
Sicydium bustamantei (not Greeff), Harrison, 1993:213 (in part).

Diagnosis.— A *Sicydium* species distinguished from other West African sicydiines by a smooth upper lip with a medial notch, a large jaw extending to the posterior margin of the orbit or beyond, premaxilla with alternate teeth usually staggered in two rows (although it may be difficult to distinguish the two separate rows) with more than 60 teeth on each premaxilla, reduced (smaller specimens) or no medial tubercle separating premaxillary tooth rows, premaxillary teeth spatulate and unicuspid, 40–50 horizontal teeth on each dentary, 50–64 scales in longitudinal series, 17–24 transverse scale rows, abdomen completely covered by cycloid scales, and preopercular pore N present.

Description.— Morphometrics given in Appendix Table 3. Mouth horizontal; posterior tip of the upper jaw reaching to or beyond posterior margin of the orbit. Interorbital broad. Branchial opening extending ventrally to level of origin of pelvic fin. Maximum observed size 103.6 mm SL,128.7 mm TL [ZSM 33223].

Lips and jaws. Upper jaw prominent. Lips relatively thick, width at median notch ½–⅔ eye

FIGURE 5. *Sicydium brevifile*. CAS 214659 (91.8 mm SL) from Ribeira Chimboto, Príncipe. Photograph by J.D. Fong.

diameter. Upper lip smooth with median notch, lateral clefts and longitudinal furrow between outer lip and tooth row. No medial tubercle separating premaxillary tooth rows. Each premaxilla with 63–136 long, slender setiform teeth, unicuspid and spatulate (Fig. 10), with alternate teeth usually staggered in two rows (although it may be difficult to distinguish two separate rows because they are positioned very close to each other). Each dentary with a row of (3, rarely [eg. ZSM 33223]) 4–9 caniniform teeth, more or less equal in size, with anterior one or two slightly inclined laterally. A single specimen (ZMH 8110) with apparently 2 caniniform teeth and 35 labial teeth on the dentary has been observed, however, this specimen is atypical and poorly preserved and is not included as representative for the species, as noted below. Ventrally each dentary with a row of 40–50 horizontal, unicuspid setiform teeth, separated broadly from one another at symphysis by protrusion of soft tissue. Lower lip smooth with a dorsolateral fleshy lobe near each corner of mouth and bordered ventrally by a narrow band of small papillae.

FINS. First dorsal fin VI, spines III or IV may be elongate, may extend to last ray of second dorsal fin in males. Second dorsal fin I, 10; anal fin I, 10; pectoral fins 18–21, reaching to vertical beneath sixth first dorsal fin spine; pelvic fins I, 5, disk length ⅓ distance from disk origin to anus; caudal fin truncate or rounded, 11–15 branched rays, 17–18 segmented rays in total.

SQUAMATION. Suborbital and opercular regions of head naked. Predorsal scales cycloid, 17–25, extending anteriorly to above preopercle. Scales on flanks ctenoid, but cycloid at pectoral axilla and adjacent to dorsal and anal fins. Cycloid scales on abdomen, and dorsal and ventral surfaces of caudal peduncle. Scales in longitudinal series 50–64, not counting 2 or 3 present on caudal fin; 17–24 transverse rows.

CEPHALIC LATERALIS SYSTEM. Canal pores often small and indistinct. Oculoscapular canal extending from vicinity of anterior naris posteriorly to rear margin of opercle, pores A'BCDFH/KL' present (Fig. 11). Preopercular canal with three pores, M' and N placed high on head, between midline of pectoral fin base and upper origin of axilla, O' placed ventrally near horizontal through ventral origin of axilla (Fig. 12). Sensory neuromasts as illustrated (Figs. 11–12).

PIGMENTATION (in life).— Color notes of adults from specimens taken in Príncipe (Maria Correa: TI-2001-028). Ground color olive-brown with white belly and underside of head; darker over head. Margins of scales on body darker, producing a finely cross-hatched pattern. Fins somewhat yellowish, but first dorsal fin rays blackish; first and second dorsals with few spots (these spots sometimes much more prominent in other specimens and arranged in linear series to form irregular stripes). Anal fin with a thin white distal margin (usually bright orange in life) bordered proximally by a thin black stripe (some specimens from other areas with broad, almost entirely dark margin and much paler proximal portion of fin). Caudal fin paler along posterior and upper caudal margin (usually somewhat orangish in life), with a black horizontal or slightly diagonal streak separating pale upper caudal margin from remainder of fin. Pelvic fins clear, white, with base of disk blood red, owing to blood vessels coursing close to surface of translucent fin membranes. In the

juveniles from this collection, the caudal fin had prominent, narrow black bands separated by clear areas, with the interspace between the penultimate and ultimate band bright reddish.

Pigmentation (in alcohol).— Postlarvae and early juveniles. Head tan, evenly pigmented dorsally and laterally, with thin suborbital bar from eye to upper jaw, no spots; mental and branchial regions also pigmented. Occipital region and dorsum often with seven faint bars weakly contrasted with light tan ground color; when present bars extend ventrally nearly full depth of the flank (Fig. 13a). Narrow basicaudal bar continuous ventrally and dorsally. First dorsal fin with dark broad submarginal band on dusky background, second dorsal fin dusky with dark ray tips. Caudal fin with spot confluent with basicaudal bar on trunk, underlying thin line of dark melanophores edging hypural; thin dark bar crossing caudal rays from dorsal to ventral margin just beyond base, second thin dark bar present midway between previous bar and end of fin; larger specimens with thin medial vertical bar and broad, dark distal margin, or dark submarginal distal band with anterodorsal and ventral extensions. Pectoral fins and anal fins unpigmented in smallest specimens, anal fin acquiring dark submarginal band in larger specimens.

Late juveniles and adults. Head and snout dusky, sometimes with broad dusky band on snout above upper jaw; cheek and opercle with many small speckles and some striations, sometimes including thin suborbital bar from eye to jaw; lighter ventrally. Dorsum and flanks with or without bars, when present seven dark dorsal bars may be very faint or, if more distinct they may have a vermiculated appearance dorsally, fading midlaterally on flanks. Flanks have freckled appearance, spots not evenly distributed except below midline over anal fin and on caudal peduncle. Barred pattern generally faded in larger specimens, but fine speckles on head still apparent. No basicaudal spot, caudal fin dusky, with dark diagonal submarginal band dorsally. First and second dorsal fins dusky, heavily speckled on and between fin rays. Anal fin dusky with dark submarginal band in females, dark margin in males. Pectoral fins dusky with spots on base and lighter near distal tips of rays. Pelvic disk unpigmented but with dark margin or spot on interspinal membrane in some specimens.

Remarks.— Harrison (1993) did not include the *S. bustamantei* paralectotype ZMH 8110 in his redescription of *S. bustamantei* because it seemed aberrant. We reexamined the specimen and have determined it to be a specimen of *S. brevifile*. One of Harrison's concerns was the length of the jaw compared to the holotype. This difference is simply explained by the differences in the SL of the two specimens (Fig. 4). Some of the difficulties encountered assessing the condition of the oral morphology are due to the poor condition of the specimen.

Distribution.— Found in rivers of the islands of São Tomé, Príncipe, and Pagalu (Annobón) in the Gulf of Guinea. Also collected from continental western central Africa at Limbe in Cameroon, and imported by aquarist dealers from Cameroon (no locality reported).

Sicydium bustamantei Greeff

Figure 6.

Gobius bustamantei Greeff, 1882:37 (in part). Type locality Rio d'Ouro and Agoa Grande, São Tomé.
Sicydium bustamantei Greeff, 1884:50
Sicydium plumieri (not Bloch, 1786): Osorio, 1895:62,64.
Sycidium plumieri (not Bloch, 1786): Osorio, 1895: 62; 1898:202.
Lentipes bustamantaei Boulenger, 1916:46.
?*Sicydium brevifile* (not Ogilvie-Grant, 1884):Monod, 1927:727 (in part); 1928:116 (in part).
Sicydium sp. (aff. brefifilis Ogilv., 1884): Thys van den Audenaerde, 1965:317.
Sicydium brevifile (not Ogilvie-Grant, 1884): Blache, 1962:73(in part); Blanc et al., 1968:251.

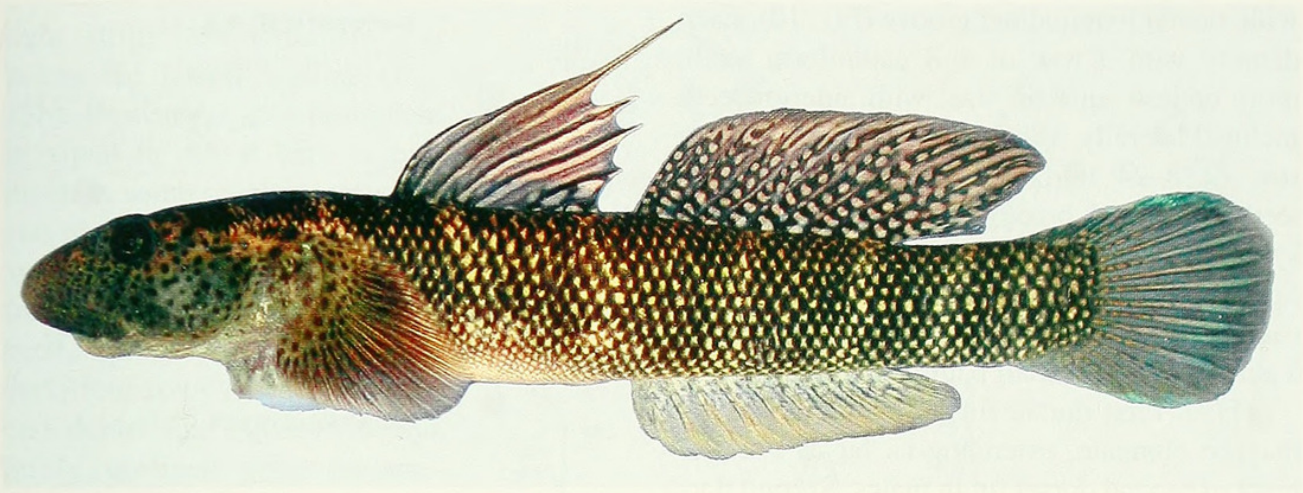

FIGURE 6. *Sicydium bustamantei*. CAS 214415 (49.4 mm SL) from Agua Micondó, São Tomé. Photograph by R. C. Drewes.

DIAGNOSIS.— A *Sicydium* species distinguished from other West African sicydiines by a smooth upper lip with no medial notch, posterior tip of upper jaw extending to below anterior third or middle of orbit, one visible row of teeth on the premaxilla with fewer than 50 teeth on each side, premaxillary tooth rows separated by a fleshy medial tubercle, premaxillary teeth unicuspid with a medial longitudinal groove on a rounded anterior surface, 8–24 horizontal teeth on each dentary, 43–57 scales in longitudinal series, 13–20 transverse scale rows, abdomen entirely or almost entirely covered by cycloid scales (scales sometimes absent immediately adjacent to ventral midline), and preopercular pore N usually present.

DESCRIPTION.— Morphometrics given in Table 3. Mouth horizontal; posterior tip of the upper jaw extending to below anterior third or middle of orbit. Interorbital broad. Branchial opening extending ventrally to level of origin of pelvic fin. Maximum observed size 100 mm SL, 101.7 mm TL.

LIPS AND JAWS. Upper jaw prominent. Lips relatively thick, width at median notch ½–⅔ eye diameter. Upper lip smooth and lacking prominent medial notch, if notch present, very light; lateral clefts and longitudinal furrow between outer lip and tooth row present. Fleshy medial tubercle separating premaxillary tooth rows. Each premaxilla with 19–49 long, slender setiform teeth, unicuspid and rounded anterior surface

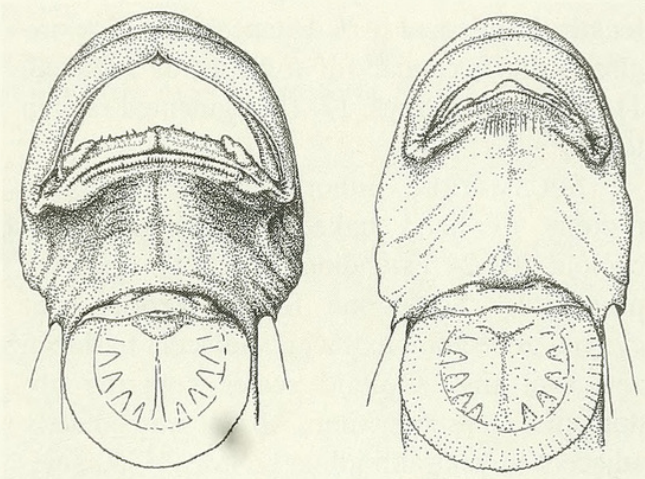

FIGURE 7. Ventral view of *S. brevifile* (left) and *S. bustamantei* (right).

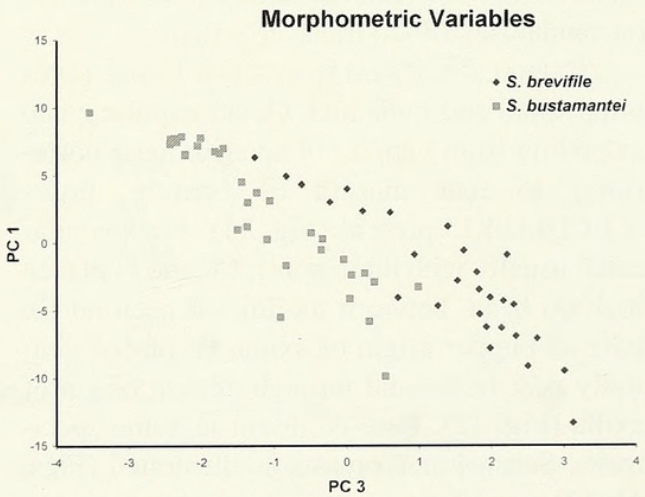

FIGURE 8. Principal components analysis of morphometric data plotting PC 1 and PC 3.

with medial longitudinal groove (Fig. 10). Each dentary with a row of 1–8 caniniform teeth, more or less equal in size, with anterior teeth inclined laterally. Ventrally each dentary with a row of 8–24 horizontal, unicuspid setiform teeth, separated broadly from one another at symphysis by protrusion of soft tissue. Lower lip smooth with a dorsolateral fleshy lobe near each corner of mouth and bordered ventrally by a narrow band of small papillae.

FINS. First dorsal fin VI, spines III or IV may be elongate, extending as far as 9th element of second dorsal fin in males. Second dorsal fin I, 9–10; anal fin I, 9–10; pectoral fins 17–20, reaching to vertical beneath fourth to sixth first dorsal fin spine; pelvic fins I, 5, disk length about equal to ⅓ distance from disk origin to anus; caudal fin truncate or rounded, 11–15 branched rays, 17–18 segmented rays in total.

SQUAMATION. Suborbital and opercular regions of head naked. Predorsal scales cycloid, 10–24 extending anteriorly to above preopercle. Scales on flanks ctenoid, but cycloid at pectoral axilla and adjacent to dorsal and anal fins. Cycloid scales covering abdomen, except sometimes absent immediately adjacent to ventral midline [ZSM 27435 specimens], cycloid scales on dorsal and ventral surfaces of caudal peduncle. Scale rows in longitudinal series 43–57, not counting 2 or 3 present on caudal fin; 13–20 transverse rows.

CEPHALIC LATERALIS SYSTEM. Canal pores often small and indistinct. Oculoscapular canal extending from vicinity of anterior naris posteriorly to rear margin of opercle, pores A'BCDFH/KL' present (Fig. 11). Preopercular canal usually with three pores, M' and N placed high on head, between midline of pectoral fin base and upper origin of axilla, O' placed ventrally near horizontal through ventral origin of axilla (Fig. 12). Pore N absent in some specimens. Sensory neuromasts as illustrated (Figs. 11–12).

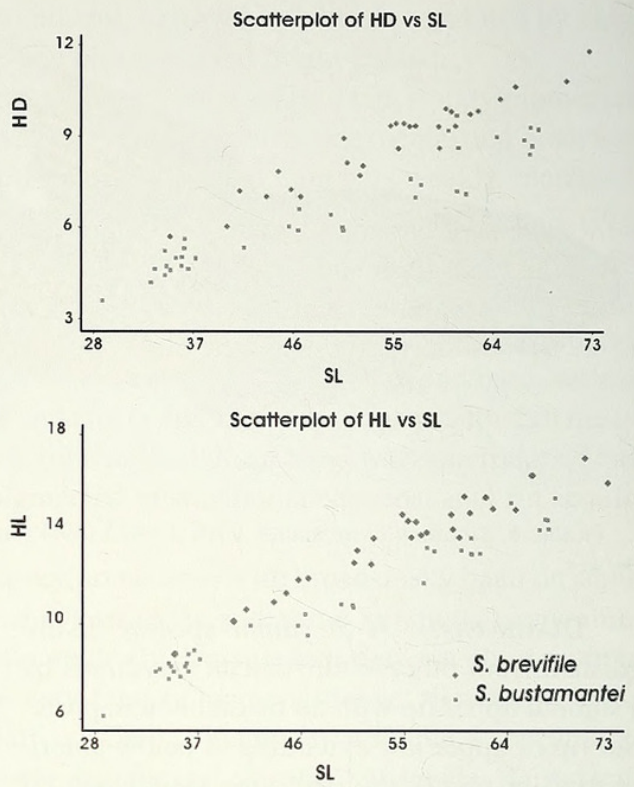

FIGURE 9 Head depth and head length vs. SL for *S. brevifile* (diamonds) and *S. bustamantei* (squares).

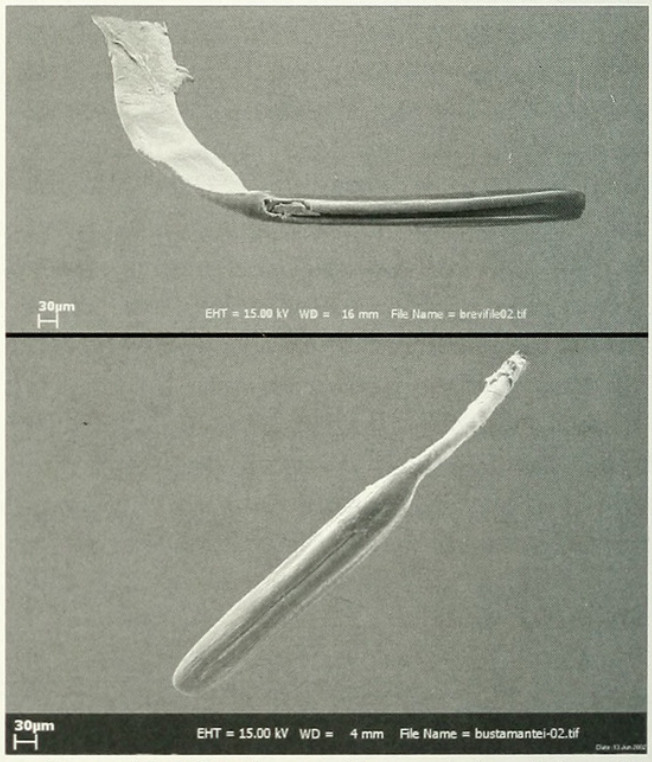

FIGURE 10. SEM of premaxillary teeth from *S. brevifile* (top) and *S. bustamantei* (bottom).

PIGMENTATION (in alcohol).— POSTLARVAE AND EARLY JUVENILES. Spots develop on the cheek and opercle, and later pectoral fin base. Occipital region and dorsum with seven dark bars highly contrasted with light tan ground color; each anterior bar usually divided dorsoventrally by a thin

light strip; bars terminate just below the lateral midline (Fig. 13b). Basicaudal spot prominent or equal to dorsal bars in pigment. In some specimens midlateral pigment of bars may darken, and with the basicaudal spot, form a horizontal midlateral band. Spines of first dorsal fin dark, four rows of spots on second dorsal fin. Caudal fin rays thinly outlined with melanophores, no vertical bars present. Pectoral fins and anal fins unpigmented in smallest specimens.

LATE JUVENILES AND ADULTS. Head dark above and before eyes, many small dark spots running obliquely across cheek and opercle, unpigmented ventrally. Seven dark dorsal bars fading ventrally on flanks to light ground color. Flanks have checkerboard appearance, each scale having darkest pigment on posterior field, lighter or no pigment on anterior field. Barred pattern tends to fade in larger specimens, leaving no checkerboard appearance, but spotting on head still apparent. Basicaudal spot prominent, caudal fin rays pigmented, interradial membrane becoming dusky with lighter distal margin in males, interradial membranes mostly clear in small females. First dorsal fin dusky, with darkest pigment on spines, and sixth ray sometimes with three white spots. Second dorsal fin in males with four (to ten?) rows of light spots and a light submarginal band offset against dark background membrane; in females with five rows of dark spots paralleling slope of fin margin. Pectoral fins dusky towards base, lighter distally, with spots on base. Anal fin weakly pigment-

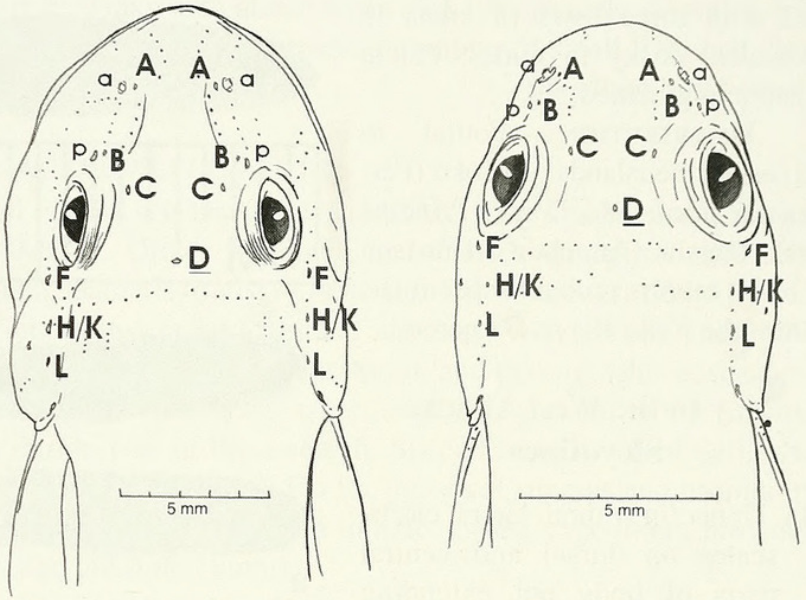

FIGURE 11. Dorsal view of cephalic lateralis oculoscapular canal pores and dorsal sensory neuromasts of *S. brevifile* (left) and *S. bustamantei* (right). Anterior nares (a) and posterior nares (b) also shown.

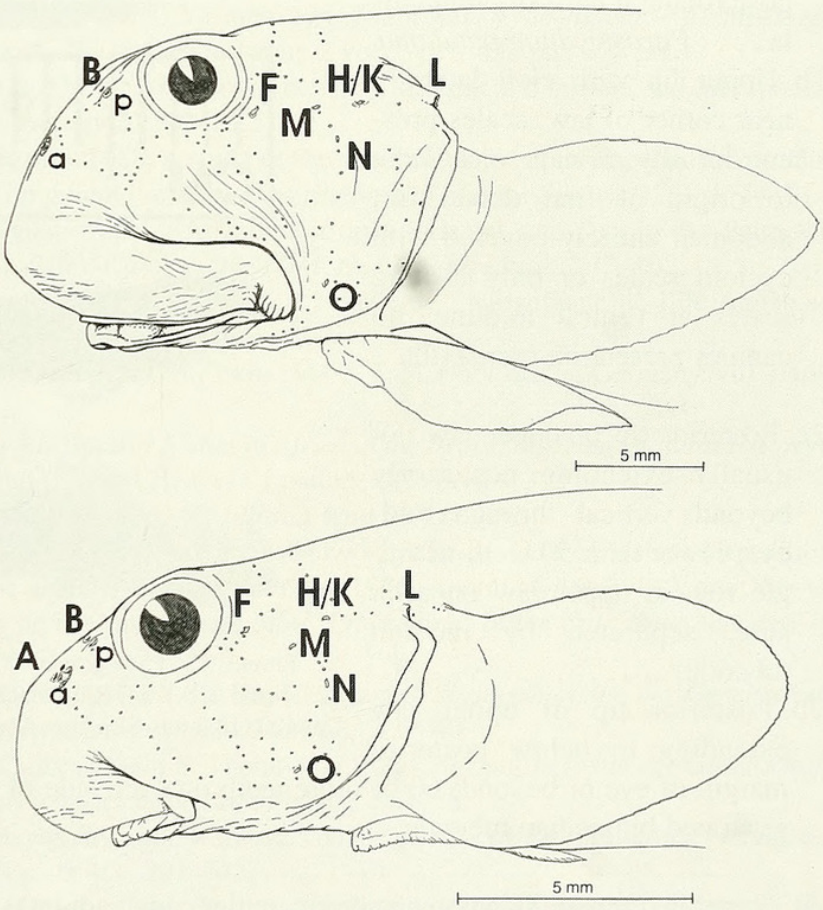

FIGURE 12. Lateral view of cephalic lateralis preopercular canal pores, visible oculoscapular canal pores and sensory neuromasts of *S. brevifile* (top) and *S. bustamantei* (bottom). Anterior nares (a) and posterior nares (b) also shown.

ed with three rows of spots in females, dusky in males. Pelvic disk unpigmented.

Distribution.— Found in rivers of the islands of Bioko (Fernando Póo), São Tomé, Príncipe and Pagalu (Annobón). Harrison (1993) reports probable specimens from the Kribi River, Cameroon.

Key to the West African Sicydiines

1a. Upper lip without lateral clefts; scales on dorsal and ventral parts of body not extending anteriorly beyond origin of second dorsal and anal fins respectively; males with canines on posterolateral parts of premaxilla . . . . *Parasicydium bandama*

1b. Upper lip with cleft laterally near corner of jaw; scales present dorsally on nape or at least to origin of first dorsal fin; abdomen entirely covered with cycloid scales or only lacking scales at ventral midline; no canines present on premaxilla 2

2a. Posterior tip of upper jaw not usually extending posteriorly beyond vertical through mid-eye; fewer than 50 teeth in single row in upper jaw on each side, separated by median tubercle. 3

2b. Posterior tip of upper jaw extending to below posterior margin of eye or beyond; 60 or more teeth on each side of upper jaw, usually in two rows, not separated by median tubercle . . . . . *Sicydium brevifile*

3a. Upper lip crenate; two pores in preopercular canal; adults with 2 or 3 suborbital bands of brownish-black pigmentation; adults with small dark spots on anterior of flanks, and 5–6 broad, vertical dark bands on flanks between first dorsal fin and caudal peduncle . . . . . *Sicydium crenilabrum*

3b. Upper lip smooth; usually three pores in preopercular canal; head dark in adults, with numer-

Figure 13. Photographs of postlarval of (a) *S. brevifile*, CAS 214657 (23.2 mm SL) from Rio Angobó, São Tomé, and (b) *S. bustamantei*, CAS 214420 (18.0 mm SL) from Agua Maria Correia, São Tomé.

ous dark spots over cheek and opercle; flanks with about seven dark bars in early juveniles, but in adults the bars are less distinct and flanks have a chessboard pattern of small light and dark patches ..... *Sicydium bustamantei*

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Appendix
Tables 1–4

TABLE 1. Mean and range (in parentheses) of meristic characters for *Sicydium* from Príncipe and Saõ Tomé.

	S. brevifile			*S. bustamantei*		
	Mean and range	SD	n	Mean and range	SD	n
1st dorsal spines	6	0	38	6	0	56
2nd dorsal elements	11	0.00	37	11(10-11)	0.13	56
anal fin elements	11(10-11)	0.16	37	11(10-11)	0.13	56
pectoral fin rays	19.8(18-21)	0.95	38	18.9(17-20)	0.62	56
branched caudal rays	13.2(11-15)	0.58	44	13.3(12-15)	0.93	34
longitudinal scale rows	55.5(50-62)	2.74	38	48.6(43-57)	3.32	55
transverse scale rows	20.3(17-24)	1.64	37	16(13-20)	1.58	54
caudal peduncle scale rows	18.3(16-20)	1.12	30	14(12-15)	0.76	42
predorsal scale rows	20.6 (17-25)	2.20	37	18.5 (10-24)	2.44	53
exposed premaxillary tooth rows	2 (1-2)	0.28	37	1	0	59
premaxillary teeth	115.4 (76-136)	15.27	34	29.1 (20-41)	7.04	58

TABLE 2. Eigenvalues and factor scores for six meristic characters used in principal components analysis.

PC	Eigenvalues	Percent of variance	Cumulative percent of variance
1	3.30239	55	55
2	1.21526	20.3	75.3
3	0.68654	11.4	86.7
4	0.42811	7.1	93.9
5	0.19747	3.3	97.2
6	0.17023	2.8	100

Factor	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
Longitudinal scales	0.5093	-0.0455	0.039	-0.1989	0.3947	-0.7361
transverse scales	0.4895	0.1539	-0.249	-0.1365	-0.8061	-0.0792
branched caudal rays	0.1845	-0.716	0.5754	-0.2467	-0.1776	0.1728
caudal peduncle scales	0.4862	0.1608	-0.192	-0.3896	0.3893	0.6305
predorsal scales	0.3987	-0.3658	-0.2529	0.7846	0.1049	0.1289
pectoral fin rays	0.2676	0.5496	0.7103	0.337	-0.0178	0.089

TABLE 3. Morphometric proportions. All measurements expressed as proportions of standard length or head length if denoted with /HL.

	S. brevifile				*S. bustamantei*			
	N	mean	range	SD	N	mean	min	SD
anal fin length	28	0.32	(0.25-0.37)	0.04	34	0.28	(0.22-0.39)	0.05
body depth	28	0.19	(0.17-0.21)	0.01	35	0.17	(0.15-0.19)	0.01
caudal fin length	28	0.22	(0.17-0.25)	0.02	34	0.20	(0.18-0.23)	0.01
caudal peduncle depth	28	0.13	(0.11-0.14)	0.01	34	0.12	(0.11-0.15)	0.01
caudal peduncle length	28	0.19	(0.14-0.22)	0.02	34	0.21	(0.18-0.23)	0.01
first dorsal fin length	28	0.33	(0.19-0.48)	0.09	35	0.22	(0.14-0.46)	0.08
second dorsal fin length	28	0.39	(0.30-0.46)	0.05	35	0.33	(0.27-0.47)	0.08
head depth/HL	28	0.65	(0.59-0.74)	0.05	35	0.60	(0.52-0.75)	0.07
head length	28	0.25	(0.22-0.27)	0.01	35	0.22	(0.20-0.24)	0.01
interorbital width/HL	28	0.38	(0.29-0.43)	0.04	34	0.36	(0.25-0.44)	0.05
upper jaw length/HL	28	0.66	(0.60-0.76)	0.06	34	0.44	(0.33-0.51)	0.04
orbit/HL	28	0.22	(0.16-0.26)	0.02	34	0.23	(0.17-0.31)	0.04
pectoral fin length	28	0.19	(0.16-0.22)	0.01	34	0.18	(0.16-0.20)	0.01
pelvic fin length	28	0.13	(0.11-0.16)	0.02	34	0.12	(0.09-0.15)	0.01
snout length/HL	28	0.48	(0.41-0.54)	0.03	33	0.48	(0.39-0.58)	0.05

TABLE 4. Eigenvalues and factor scores for principal components analysis of sixteen morphometic characters.

PC	Eigenvalues	Percent of variance	Cumulative percent of variance		
1	294.417	91.7			91.7
2	17.601	5.5			97.2
3	4.31	1.3			98.5
4	2.33	0.7			99.2
Factor		PC 1	PC 2	PC 3	PC 4
SL		0.676	0.563	0.015	-0.28
head length		0.151	0.067	0.338	0.094
head depth		0.108	0.006	0.304	0.094
jaw length		0.109	-0.152	0.64	0.361
orbit length		0.019	-0.001	0.075	0.059
snout length		0.075	0.039	0.188	0.028
interorbital width		0.073	0.04	0.098	0.095
body depth		0.12	0.05	0.125	0.099
caudal peduncle depth		0.099	0.105	-0.035	0.022
caudal peduncle length		0.129	0.168	-0.119	-0.195
pectoral fin length		0.146	-0.021	0.021	0.042
pelvic fin length		0.069	0.033	0.231	0.081
caudal fin length		0.18	-0.046	0.015	0.033
1st dorsal fin length		0.387	-0.735	0.078	-0.527
2nd dorsal fin length		0.381	-0.223	-0.325	0.446
anal fin length		0.301	-0.132	-0.368	0.475