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Two new annual killifishes from Amazonas Territory, Venezuela (Cyprinodontiformes: Rivulidae)

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Pterolebias xiphophorus, new species, and *Rivulus nicoi*, new species, were taken together in small isolated forest pools near the mainstream of the Rio Ventuari (Orinoco drainage), Amazon Federal Territory, Venezuela. *Pterolebias xiphophorus*, a small (males to 40-50 mm SL) slender annual species, is known from the Ventuari drainage, and several tributaries of the Orinoco north and south of Puerto Ayacucho in Venezuela. Females have three lateral longitudinal rows of dark dots and transparent fins; males have strong red and green markings on sides of head, three lateral longitudinal rows of orange to red dots, elongated pectoral, dorsal, anal, and caudal fins. A white to orange stripe extends from the ventral base of the caudal fin onto an elongated sword-like extension of the ventral caudal rays. *Rivulus nicoi*, known only from the type locality, is probably an annual species. Both sexes have elongated pectoral, anal, and dorsal fins, unusually large scales, and an ocellated rivulus spot on the caudal-fin base.

Se describen dos especies nuevas de peces de la familia Rivulidae, *Pterolebias xiphophorus* y *Rivulus nicoi* capturados de pozos aislados en el bosque de galería, cerca del canal principal del Río Ventuari (alto Río Orinoco), en el Territorio Federal Amazonas de Venezuela. *Pterolebias xiphophorus* es una especie pequeña (los machos alcanzan a 40-50 mm SL), delgada, anual con distribución en la cuenca del Ventuari y los afluentes del Río Orinoco al norte y al sur de Puerto Ayacucho en Venezuela. Las hembras tienen tres filas longitudinales de puntos oscuros en los costados y las aletas son transparentes; los machos tienen manchas intensas de color verde y rojo en los lados de la cabeza, tres filas longitudinales de puntos anaranjados o rojos, y aletas pectorales, dorsal, anal y caudal alargadas. Los radios ventrales de la aleta caudal en los machos están alargadas para formar una "espada", que tiene una franja blanca o anaranjada que extiende desde la base ventral en la aleta caudal hacia la punta de la espada. Se conoce *Rivulus nicoi* solo de la localidad típica. Es probablemente una especie anual. En ambos sexos las aletas pectorales, anal y dorsal están alargadas, las escamas son inusualmente grandes, y existe una mancha ocelada en la base dorsal de la aleta caudal.

Introduction

Occurrence and distribution of annual killifishes (Myers, 1952) in northern Venezuela is relatively well known. Six species occur in the Orinoco Llanos (Nico, Taphorn & Thomerson, 1987; Nico & Thomerson, 1989). Three of these species also live in the coastal Rio Unare drainage (Thomerson, Taphorn & Nico, 1990). Four additional species are distributed in the Lake Maracaibo basin and adjacent coastal deserts (Taphorn & Thomerson, 1978, 1989). We here describe two new rivulid species from Amazonas Federal Territory, Venezuela. The first is confirmed as an annual species by aquarium observation; and the second species is inferred to be an annual species based on its association with the first species.

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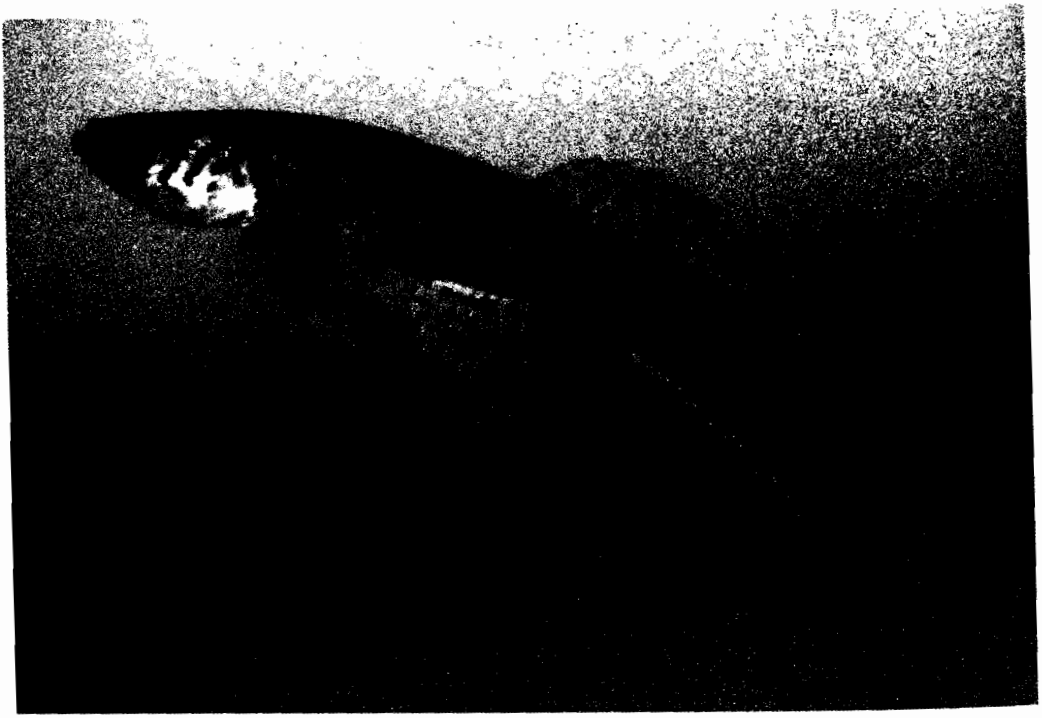

Fig. 1. *Pterolebias xiphophorus*, male, holotype, MCNG 23888, 26.7 mm SL.

Methods

Measurements were made with Helios dial calipers (under a dissecting microscope for *R. nicoi*). Counts and measurements follow Hoedeman (1959), with the exception that head depth, HD, was measured at the posterior margin of the preopercle. Measurements not taken by Hoedeman include prepelvic-fin insertion length, PP2L; snout length, SnL; orbit diameter, OD. Ratios are expressed in thousandths so that the reader can reconstruct measurements to the precision with which we recorded them. Fin ray counts were made on preserved specimens using a dissecting microscope with light transmitted through the fins, and include all discernible fin rays. Life color descriptions are based on field notes, color slides, and observation of wild-caught fish in the aquarium. Institutional abbreviations follow Leviton et al. (1985). MAC-PAY collections are deposited at the FONAIAP station in Pto. Ayacucho.

Pterolebias xiphophorus, new species
(Figs. 1-2)

Holotype. MCNG 23888, male, 26.7 mm SL, small forest pools about 500 m from right bank of Rio Ventuari, about 5.5 km upstream of Rio Yureba, 04°16'N 66°23'W, Orinoco drainage, Amazonas Federal Territory, Venezuela, 28 Sept 1989, L. Nico Field # LN 89-106.

Paratypes. MCNG 23889, female, 22.5 mm SL; MCNG 23890, 3, 23.3-21.1 mm SL. FMNH 100600, 2, 24.3-22.3 mm SL, taken with holotype. - MAC-PAY 0844, 4 females, 19.8-15.2 mm SL, Caño Parueña, Road between Pto. Ayacucho-El Burro, Dpto. Atures, 13 July 1984, J. Fernández et al. - MAC-PAY 01140, 1 male, 23.1 mm SL, Small creek flowing to Rio Orinoco below the airport at San Fernando de Atabapo, 3 July 1986, J. Fernández, A. Orozco, W. Sanchez.

Diagnosis. Differs from other described species of *Pterolebias* in the combination of: small adult size, 12 or 13 anal-fin rays, unique development of ventral caudal-fin sword in males, and male

Fig. 2. *Pterolebias xiphophorus*, female, paratype, MCNG 23889, 22.5 mm SL.

body color pattern of three rows of orange to red dots.

Description. A small species of *Pterolebias*; large adult male 40-50 mm SL, large adult female 25-30 mm SL. Body proportions and counts for the type series of three males and four females given in Table 1. Head long, approximately 30% SL, and flat, head width about 60% of head length, eye large, diameter of orbit about 35% HL. Body slender, greatest body depth about 20% SL. Dorsal fin long, but with only 8 or 9 fin rays, dorsal-fin length about 33% SL in males, 24% SL in females; anal fin long, its length more than 50% SL in well developed males, about 30% SL in females, but only 12 to 13 fin rays, anal-fin base short, approximately 15% in both sexes. Caudal fin long, up to 66% SL in males, approximately 37% SL in females. Pectoral fins long, approximately 32% SL in males, approximately 24% SL in females, with 15 fin rays. Pelvic fins relatively short, approximately 15% SL in males, 10% SL in females, only 7 pelvic-fin rays. Three individuals with undamaged head scales had e - e pattern.

Life colors. Male: Dorsum dark brown. Sides of head bright green, iris gold, vertical dark bar through pupil of eye, two inclined dark red bars behind eye, a third bar present on gill cover or broken up into several red spots. Body sides light green, three longitudinal rows of orange to blood-red dots on sides, rows regular to somewhat broken up anteriorly. Belly dusky rose-tan.

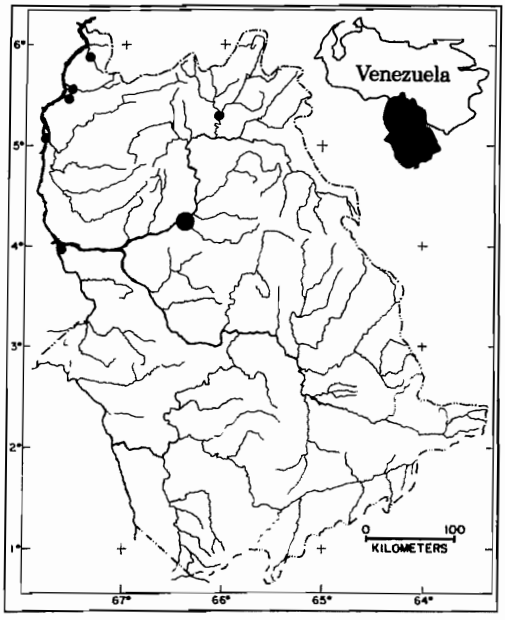

Fig. 3. Distribution of *Pterolebias xiphophorus* and *Rivulus nicoi* in Amazon Federal Territory, Venezuela. Type locality for both species (and only known locality for *R. nicoi*) marked with large circle.

Table 1. Body proportions and counts for the type series of *Pterolebias xiphophorus*. First male is the holotype.

Sex	Male	Male	Male	Female	Female	Female	Female	Female
SL mm	26.7	24.3	23.3	22.3	22.5	21.2	21.1	21.1
TL/SL	1.547	1.667	1.472	1.336	1.338	1.392	1.374	1.374
PDL/SL	0.704	0.737	0.721	0.726	0.733	0.736	0.720	0.720
PAL/SL	0.592	0.609	0.609	0.614	0.613	0.637	0.668	0.668
PP2L/SL	0.464	0.527	0.506	0.516	0.511	0.528	0.545	0.545
HL/SL	0.292	0.309	0.300	0.300	0.298	0.292	0.284	0.284
GBD/SL	0.206	0.222	0.202	0.179	0.191	0.170	0.171	0.171
BD/SL	0.184	0.193	0.193	0.166	0.169	0.156	0.161	0.161
CPD/SL	0.135	0.140	0.137	0.121	0.120	0.104	0.109	0.109
OD/HL	0.346	0.347	0.357	0.343	0.358	0.355	0.367	0.367
HW/HL	0.577	0.600	0.586	0.597	0.612	0.661	0.650	0.650
HD/HL	0.538	0.480	0.500	0.448	0.478	0.500	0.500	0.500
Sn/HL	0.154	0.160	0.129	0.119	0.119	0.113	0.150	0.150
P1L/SL	0.318	0.305	0.318	0.256	0.240	0.241	0.237	0.237
P2L/SL	0.150	0.144	0.120	0.121	0.116	0.113	0.100	0.100
DB/SL	0.112	0.111	0.094	0.112	0.111	0.104	0.090	0.090
DL/SL	0.333	0.321	0.322	0.256	0.249	0.255	0.232	0.232
AB/SL	0.157	0.160	0.163	0.157	0.142	0.151	0.166	0.166
AL/SL	0.528	0.391	0.348	0.224	0.262	0.307	0.303	0.303
Lat Sc	29	29	30	30	30	30	–	–
Tr Sc	8	7	9	8	8	8	8	8
D	9	9	8	9	9	9	9	9
A	12	12	12	13	13	13	13	13
P1	15	15	15	15	15	15	15	15
P2	7	7	7	7	7	7	7	7

Dorsal fin translucent, with greenish iridescence, five or six rows of orange to red spots in interradial membranes, anal fin similar. Caudal fin with red dots at base, dots join to form red lines along fin rays. Central fin rays longer than rays above or below. Lower caudal-fin rays elongated to form a regular sword, to more than 50% longer than the rest of the caudal fin, extending down at a slight angle to the axis of the fin. The lower margin of the sword is brown to black, the central portion white to light orange, sometimes with an irregular orange line down the center, the upper margin of the sword is red. Pectoral and pelvic fins are hyaline to translucent with slight greenish sheen. Female: Dorsum gray-brown with many scattered dark brown dots. Iris tan to silver, gill cover gray to silver, dark bar through pupil. Two or three dark grey-brown bars on gill cover. Sides of body grey-brown, darker on caudal peduncle, with three continuous longitudinal rows of dark grey-brown spots. Belly and lower part of head white. All fins hyaline, caudal fin with three or four irregular rows of poorly defined gray spots.

Etymology. *Xiphophorus*, from the Greek for sword bearer, refers to the sword-like lower extension of the male caudal fin.

Distribution. In addition to the localities listed for paratypes, *P. xiphophorus* has been collected at three localities south of Pto. Ayacucho, and one locality near San Juan de Manaupire NE of the type locality (Fig. 3).

Rivulus nicoi, new species
(Fig. 4)

Holotype. MCNG 23891, male, 19.1 mm SL, small forest pools about 500 m from rt. bank of Rio Ventuari, about 5.5 km upstream of confluence with Rio Yureba, 04°16'N 66°23'W, Orinoco drainage, Amazonas Federal Territory, Venezuela, 28 Sept 1989, L. Nico, Field # 89-106.

Paratypes. MCNG 23892, female, 18.2 mm SL; MCNG 23893, female, 14.7 mm SL; FMNH 100598, male and female, 17.2 and 17.1 mm SL, all collected with holotype.

Diagnosis. Differs from all other described

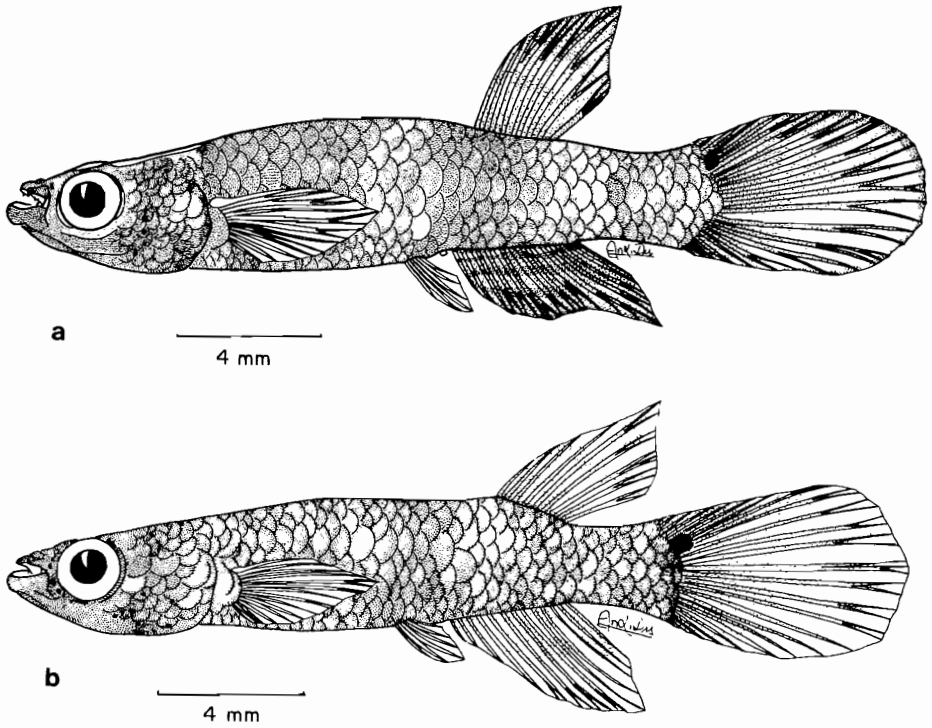

Fig. 4. *Rivulus nicoi*: **a,** male, holotype, MCNG 23891, 19.1 mm SL; **b,** female, paratype, MCNG 23892, 18.2 mm SL.

species of *Rivulus* in having elongated pectoral fins reaching to base of pelvic fins in both sexes, and in the combination of: dorsal and anal fin extending to or beyond base of caudal fin in both sexes, similar development of the rivulus spot in both sexes, elongated pelvic fins reaching beyond anal-fin origin in both sexes, and low number of scales in lateral series (26-29).

Description. Sexually differentiated at less than 20 mm SL, rivulus spot small, ocellated, on base of caudal fin, similar in both sexes. Head scalation usually e pattern. Body proportions and counts given in Table 2. Head relatively large, about 30% SL; eye large, about 31% HL, snout moderate, snout length about 16% HL; head much wider than deep, about 65% vs about 52% HL; body moderately slender, greatest body depth about 20% SL. Predorsal-fin length long in both sexes, about 74% SL, preanal-fin length similar in both sexes, about 65% SL. All fins well developed in both sexes: Pectoral fin extending to or past origin of pelvic fins, pectoral-fin length about 23% SL. Pelvic fins extending to or past origin of anal fin, pelvic-fin length probably greater in males. Dorsal fin extending to or past base of caudal fin in both sexes, dorsal-fin length about 28% SL. Anal fin extending past base of caudal fin in both sexes, anal-fin length about 32% SL. Caudal fin elliptical in both sexes, total length about 35% greater than SL.

Color in alcohol. Head and body, including belly, of both sexes dusky with minute melanophores, more uniformly distributed in males. Snout and upper lip lighter than rest of head; chin and corners of gape darker. Sides of head mottled in male, more uniform in female. Female with scattered dark dots on scale centers of dorsum and upper body sides, faint chevron pattern on sides, caudal peduncle with scattered unpigmented dots on scale centers. Male dorsal-fin dusky with two obscure darker bands; female dorsal-fin clear with four to five irregular dark bands. Male anal-fin uniformly dusky, darker distal margin and posterior tip; female anal-fin dusky with four or five irregular darker bands. Male caudal-fin uniformly dusky, rivulus spot

Table 2. Body proportions and counts for the type series of *Rivulus nicoi*. First male is holotype.

Sex	Male	Male	Female	Female	Female
SL	19.1	17.2	18.7	17.1	14.7
TL/SL	1.335	1.413	1.339	1.359	1.304
PDL/SL	0.733	0.756	0.726	0.762	0.725
PAL/SL	0.613	0.663	0.656	0.650	0.661
HL/SL	0.291	0.297	0.301	0.314	0.305
GBD/SL	0.209	0.211	0.188	0.195	0.205
CPD/SL	0.128	0.142	0.120	0.131	0.118
OD/HL	0.315	0.294	0.325	0.293	0.330
HW/HL	0.650	0.659	0.696	0.633	0.649
HD/HL	0.568	0.529	0.516	0.508	0.462
SnL/HL	0.182	0.135	0.129	0.161	0.169
P1L/SL	0.227	0.238	0.213	0.259	0.199
P2L/SL	0.121	0.113	0.111	0.078	0.083
DB/SL	0.121	0.122	0.113	0.114	0.099
DL/SL	0.280	0.331	0.278	0.289	0.228
AB/SL	0.186	0.195	0.172	0.150	0.156
AL/SL	0.329	0.376	0.290	0.341	0.249
Lat Sc	28	27	26	26	29
Tr Sc	8	8	9	9	8
D	8	8	9	9	8
A	14	12	13	13	12
P1	–	14	15	–	–
P2	6	6	6	–	–

overlapping two interradial spaces, only slightly ocellated; female caudal fin slightly less dusky than male, with three or four obscure darker bands, rivulus spot overlapping three interradial spaces, and preceded by a lighter area. Pectoral-fins clear with melanophores scattered along fin rays; male pectoral-fin with dusky ventral margin. Male pelvic-fins less dusky than unpaired fins; female pelvic-fins like pectoral-fins.

Etymology. Named in honor of the collector, Leo G. Nico, in recognition of the many contributions he has made to the study of Venezuelan fishes.

Comments. Nico's field notes mention blue markings. Maximum or usual adult size of *R. nicoi* is not known. Our specimens seem to be young adults. We have assigned *R. nicoi* to *Rivulus* without osteological analysis (due to availability of only five possibly immature specimens) based on general body form, 6 pelvic rays, and rivulus spot present in both sexes. Elongated pectoral-fins do not fit recent definitions of *Rivulus* (Parenti, 1981; Costa, 1990a, 1990b), but this may be a juvenile characteristic.

Discussion

Annual killifishes (Myers, 1952) have a suite of adaptations which allow them to inhabit seasonal waters. Their primary adaptation is a series of modifications of the general pattern of cyprinodontiform egg development, and includes one or several periods of diapause (Wourms, 1972a-c). We apply the terms 'confirmed annual' or 'confirmed non-annual' to species which have been bred in the aquarium, and whose eggs have been carried through complete development to successful hatching of normal-seeming fry. If the fish lays eggs which show an annual pattern of development, with periods of diapause which extend the period of time from fertilization to hatching over a period of months, we regard the species as a confirmed annual. If the fish's eggs show a normal course of development, without diapause, particularly when incubated on moist peatmoss rather than in water, we regard the species as a confirmed non-annual.

Our aquarium observations of *P. xiphophorus* confirm that it, like other *Pterolebias* species, is an annual fish. Eggs are 1.7-1.8 mm diameter, and, so far, minimum time to hatching has been more than seven months. Growth is relatively slow

and sexual maturity is reached some six weeks after hatching. The type locality was an isolated forest pool near the Rio Ventuari, but all other collections have come from connected backwaters of large clearwater or blackwater streams. There the fish were in forest-shaded areas, over leaf litter, in shallow areas along the shoreline, often within a few cm of flowing water. Temperatures ranged from 24 to 28°C, pH 4.5 to 5.0, and conductivity was 0.

Pterolebias zonatus Myers and *P. hoignei* Thomerson (Thomerson, 1974) of the Orinoco llanos, are greatly different from *P. xiphophorus* in color pattern, proportions, maximum size, and meristic characters. Two other species of *Pterolebias: P. staecki* Seegers 1987, described from the lower Rio Negro (Amazon drainage) in Brazil, and *P. rubricaudatus* Seegers 1984, described from southeastern Peru, are perhaps most similar to *P. xiphophorus* in general appearance. The former (Seegers, 1987) is a much larger species with a higher lateral scale count and body pattern of alternating dark and light stripes running the length of the body, and except for its elaborated fins, looks at first glance like any of several similarly patterned *Rivulus* species. Not only does *P. staecki* occur in the connected Rio Negro drainage in Brazil, to the southeast of the known range of *P. xiphophorus*, but it occurs to the northeast, in the lower Essequibo River drainage of Guyana (we have collected it at Gluck Island) and at Karanambu (BMNH 1974.5.22: 574-577) in the Rupununi River drainage. The color pattern (other than the caudal fin, which has equally developed dorsal and ventral stripes) of *P. rubrocaudatus* seems similar to that of *P. xiphophorus*, and Seegers (1984) reports it to be a small species.

Costa (1990b) lists two characteristics as diagnostic for *Pterolebias* Garman: (1) male caudal-fin length more than 45% SL, and (2) pelvic-fins with 8 fin rays. The first characteristic fits *P. xiphophorus* very well (although males of four of the ten species listed as *Pterolebias* species by Costa do not have caudal fins that long), but the second does not (the type series of *P. xiphophorus* all have 7 pelvic-fin rays). We do not accept 8 pelvic-fin rays to be diagnostic for *Pterolebias* because: (1) Individuals of some unequivocal *Rivulus* species have 8 pelvic-fin rays (Thomerson, Nico & Taphorn, 1991); (2) Thomerson (1984) synonymized *Rivulichthys luelingi* Meinken, 1969, which has 7 pelvic-fin rays, with *P. longipinnis* Garman, 1895, the type species of *Pterolebias*; (3) Thomerson (1974) reported that, of 10 fish in the type series of *P. hoignei*, two had 6, five had 7, and only three had 8 pelvic-fin rays (he also reported ten of ten *P. zonatus* with 8 pelvic-fin rays). Specimens of *P. xiphophorus* have been given to Dr. Ken Lazara for osteological examination.

Whether an unfamiliar rivulid species is an annual can be inferred from its occurrence in seasonal habitats vs. non-seasonal habitats, its association with confirmed annuals, and, to a lesser extent, its general morphology. In general, rivulid killifishes are either non-annual members of the morphologically conservative genus *Rivulus*, or belong to one of a dozen annual genera (Costa, 1990a-b). This distinction is blurred because two undescribed *Rivulus* species belonging to the "*rectocaudatus* species group" proposed by Thomerson, Nico & Taphorn (1992) have been confirmed as annual species.

We infer that *R. nicoi* is an annual species because of its association with *P. xiphophorus* in an annual habitat, but Costa & Brasil (1991) have reported a non-annual *Rivulus* species from an apparent annual habitat in Brasil, so our inference should not be accepted uncritically.

Acknowledgments

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