STUDIES ON THE FAUNA OF CURAÇAO AND OTHER CARIBBEAN ISLANDS: No. 32.

RIVULID FISHES OF THE ANTILLES

by

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The present paper is chiefly based on the Rivulid fishes collected by Dr. P. WAGENAAR HUMMELINCK in the Antilles during the years 1930, 1936, 1937, and 1955, and in addition on some specimens collected by various other investigators at earlier dates. Some of the specimens, in particular those belonging to *Rivulus marmoratus* have been recorded before by WAGENAAR HUMMELINCK (1933, 1940), SANDERS (1936), and DE BEAUFORT (1940). With the aid of HUMMELINCK's field notes and water analyses, some further information could be given on the habitat and salt tolerance of the island Rivulids, cf. table 3.

I wish to express my sincere thanks to Dr. K. H. VOOUS, Curator of Birds of the Zoological Museum of Amsterdam, and Professor of Zoogeography at the Free University of Amsterdam, for his aid and advice; to Dr. ETHELWYNN TREWAVAS, Curator of Fishes of the British Museum (Natural History), London, for her kind coöperation in taking counts and measurements on ten of BOULENGER's types of *Rivulus harti*, and for sending me in exchange four topotypical specimens of *Rivulus harti*; to Dr. LEONARD P. SCHULTZ, Curator of Fishes of the Smithsonian Institution, Washington, for sending me additional material from Margarita; to Dr. M. BOESEMAN, Curator of Fishes of the State Museum of Natural History, Leiden, who lent me two specimens of *Rivulus marmoratus* from Curaçao; and finally to Dr. P. WAGENAAR HUMMELINCK, Zoological Laboratory, Utrecht, for putting his Rivulid material at my disposal, and for his kindness and friendly suggestions.

In the LIST OF MATERIAL, given below, the initials ZMA refer to samples from the collections in the Zoölogisch Museum, Amsterdam, and RML refer to those in the Rijksmuseum van Natuurlijke Historie, Leiden.

Rivulus marmoratus

Curaçao. Pool of the RIFWATER, W. of Willemstad, 25.IV.1949, W. Holleman coll., 1 ♀ (ZMA 100380). CURAÇAO, 3.IX.1904, J. Boeke coll., 1 ♂ 1 ♀ (ZMA 100384); 5.III.1905, J. Boeke coll., 2 ♀♀ (RML 9308).

Bonaire. LANSBERG PUTTEN (most southern Pos Lansberg), near Zuidpunt, Sta. 60a, 8.VI.1930, 6 shriveled specimens (ZMA 100387, 100388); Sta. 60, 26.III.1937, 1 ♀ (ZMA 100429). Pos JATOE LARGOE, Lima, Sta. s.n., 29.VIII.1930, 3 shriveled spec. (ZMA 100429). Pos GUAJAKÁ, Lima, Sta. s.n. 29.VIII.1930, 2 shriveled spec. (ZMA 100432). Pos DI PEPE, Lima, Sta. s.n., 29.VIII.1930, 4 ♂♂ 2 ♀♀ (ZMA 100437). Pos FRANCÉS, W of Lima, Sta. 58a, 3.IX.1930, 1 ♂ 1 ♀ (ZMA 100385). Pos DI HOOP, S of Salinja Martinus, 23.IX.1930, 1 ♂ 2 ♀♀ (ZMA 100386). Pos SALINJA MARTINUS, S of Kralendijk, 27.IX.1930, 1 ♂ (ZMA 100389).

Los Roques. GRAN ROQUE, POZO DE LA CABECERA, Sta. 42, 26.VII.1936, 1 ♂ (ZMA 100433). GRAN ROQUE, northern part, 12.IV.1954, Dr. F. Martin (Caracas) coll., 3 juv. (ZMA 100404).

Barbuda. BULL HOLE, River Quarter, Sta. 667, 9.VII.1955, 1 ♂ (ZMA 100403). LOW POND, N of Codrington Village, Sta. 674, 5.VII.1955, 1 ♂ shriveled (ZMA 101055).

St. Martin. DEVILS HOLE, at cave entrance, E of Simson Bay, Sta. 541a, 26.VII.1955, 7 juv. (ZMA 101056).

Rivulus cylindraceus

Cuba. Hill stream at about 600 m altitude, 1939, van Oers leg., 1 ♂ (ZMA 100427). CUBA, aquarium importat, 1956, Oskam leg., 1 ♂ (ZMA 101006); offshoot from aquarium importats, 1956, 9 ♂♂ 21 ♀♀ 71 juv. (ZMA 101017).

Rivulus harti

Margarita. MANANTIAL DEL GÜIRI, San Antonio, Sta. 15, 13.VII.1936, 1 ♂ 2 juv. (ZMA 100362). MANANTIAL DE LAS AGUAS SALADAS, San Juan, Sta. 16, 11.VIII.1936, 6 ♂♂ 3 ♀♀ (ZMA 100383). TOMA DE AGUA DEL ENCAÑADO, Sta. 17, 13.VII.1936, 1 ♂ 2 ♀♀ 1 juv. (ZMA 100487). RIO ASUNCIÓN, Toma de Agua, Sta. 21, 6.VII.1936, 2 ♂♂ 4 ♀♀ (ZMA 100379); W of La Asunción, Sta. 22, 3.VII.1936, 1 ♂ (ZMA 100377); Puente de La Asunción, Sta. 23, 11.V.1936, 2 ♂♂ 2 ♀♀ (ZMA (100378). RIO DEL VALLE (= Rio Porlamar), Toma de Agua del Valle, Sta. 26, 4.VII.1936, 1 ♂ 2 ♀♀ (ZMA 100382); Casa de Agua del Valle, Sta. 27, 4.VII.1936, 4 ♂♂ 3 ♀♀ 8 juv. (ZMA 100376); Rio Porlamar, at El Valle, 1. IV, 1939, F. F. Bond coll., 4 ♂♂ 2 ♀♀ (ZMA 100463).

Trinidad. BAMBOO GROVE, Fish Exp. Sta. Control Pond, Sta. 653, 29.I.1955, 2 ♀♀ (RML). BARATARIA, in cress bed, I.1955, Senior White coll., exchange British

TABLE 3.

List of localities in which HUMMELINCK's material of *Rivulus marmoratus* and *Rivulus harti* was collected, and supposed conditions on Cuba.

sta. locality	water body in m	water movement flowing	water movement stagnant	bottom	vegetation	°C	mg Cl'/l
Rivulus marmoratus							
Barbuda:							
667 Bull Hole	20×20×0.3		×	muddy	many algae	30–32	2,200
674 Low Pond	20×15×1		×	muddy	many algae	30–32	2,650
St. Martin:							
541a Devils Hole	1.5×1×0.3		×	muddy	very few algae	26-30	8,800
Cuba: (supposed conditions)		×	×				± 1,000
Curaçao:							
Rifwater, pool	10×5×0.5		×	muddy	many algae	28–32	±20,000
Bonaire:							
60a Lansberg Putten	1.5×1×0.25		×	muddy	many algae	29–35	400
60 Lansberg Putten	0.75×0.75×0.2		×	muddy	many algae	29–33	370
s.n. Pos Jatoe Largoe	6×5×1		×	rock, mud	few algae	29–33	360
s.n. Pos Guajaká	2×2×1 (−5)		×	rock, mud	few algae	28–30	480
s.n. Pos di Pepe	4×2.5×1		×	rock, mud	many algae	28–32	± 500
58a Pos Francés	2×1×0.25		×	muddy	few algae	28–32	± 600
Pos di Hoop	15×10×0.3		×	muddy	few algae	30–35	± 6,000
Pos Salinja Martinus	1×0.3×0.3		×	muddy	few algae	28–30	± 5,000
Gran Roque:							
42 Pozo de la Cabecera	1×0.3×0.5		×	rock, mud	almost none	28–30	3,650
Rivulus harti							
Margarita:							
15 Manatial del Guïri	1.5×0.25	×		rock, sand, mud	algae, mosses	26	80
16 Manatial de la Aguas Saladas	1×0.25	×		rock, sand, mud	algae. mosses	29	4,400
17 Toma del Encañado	1.5×0.25	×		sand, leaf decay	some algae	28	270
21 Toma de la Asunción	0.5×0.25	×		rock, decay	few algae	25	50
22 Rio Asunción	2.0×0.5	×		sand, mud	some algae	26–28	120
23 Puente de la Asunción	1.0×0.25	×		rock, mud	almost none	26–29	390
26 Toma del Valle	3.0×0.5	×		rock, mud	algae	25–26	60
27 Casa de Agua del Valle	0.5×1.0	×		sandy clay	algae, grasses	26–28	± 60
Trinidad:							
653 Bamboo Grove	80×30×1		×	mud	algae	26–28	135
Tobago:							
656 Lambeau River	2×0.2	×		debris, mud	many algae	27	170

Museum, 1 ♂ 2 ♀♀ (ZMA 101047). NEW LA PAILLE, in cress bed, I.1955, Senior White coll., exch. Brit. Mus., 1 ♂ (ZMA 101048).

Tobago. LAMBEAU RIVER, at Stock Farm bridge, Sta. 656, 15.I.1955, 1 ♀ (ZMA 100402).

Some ecological data are to be found in the *List of Localities* (table 3).

HUMMELINCK's stations 1930–1937 have already been described in the 1st and 4th papers of this series (*Studies 1*, p. 5–28; *2*, p. 1–21). Sta. 60, Lansberg Putten, has been illustrated in Studies 2, plate IIa; Pos Jatoe Largoe in *Studies 1*, plate Va, and a picture of the Toma del Valle, Sta. 26, is to be found in *Studies 1*, plate IIa. Other localities will be described, and illustrated, in a forthcoming "Third List of Localities".

TABLE 4.

Counts and proportion rates in 1000ths of the standard length of *Rivulus cylindraceus* and *Rivulus marmoratus*. Data from the typical specimens have been included for the sake of comparison.

Abbreviations: st.l. = standard length (snout to caudal root), D = dorsal fin, A = anal fin, prdl = predorsal length, pral = preanal length, dpth = greatest depth of body, dcp = least depth of caudal peduncle, snt = snout length, iob = interorbital width, trans. = transverse scale rows, prd = number of predorsal scales, cpcf = number of caudal peduncle circumference scales.

	mm st.l.	sex	D	A	prdl	pral	head	dpth	dcp	snt	eye	iob	scales		
													lateral/trans.	prd	cpcf
cylindraceus:															
Cuba:															
RIVAS, 1945			8	12	720–750	670–700	300	210		110	80		36+?/?		
ZMA 100427	34.1	♂	9	12	750	692	292	235	147	79	88	170	36+4/9	21	16
ZMA 101006	63.4	♂	9	12	734	685	289	238	139	84	92	159	35+6/9	22	16
marmoratus															
Cuba:															
RIVAS 1945	46.5		8	10	740	650	280	200	140	80	45	127	46–48/13	33	18
Curaçao:															
RML 9308	35.9	♀	10	11	756	635	275	208	142	47	83	126	45+3/13	35	18
	22.6	♀	9	11	752	647	275	202	129	40	75	141	46+3/13	35	18
ZMA 100380	32.7	♀	9	11	785	652	268	199	125	49	74	141	49+6/14	36	19
ZMA 100384	42.3	♂	9	12	786	670	300	203	135	67	85	144	48+3/13	35	18
Bonaire:															
ZMA 100385	44.9	♀	9	11	762	650	263	187	131	56	65	125	44+3/13	34	18
	26.9	♂	9	11	770	635	271	194	—	—	—	—	44+3/13	33	18
ZMA 100386	47.8	♂	10	11	751	606	263	196	128	59	63	124	48+?/14	36	18
	32.1	♀	9	11	780	630	261	218	137	62	84	140	47+?/14	35	18
	24.1	♀	9	11	766	617	268	207	122	56	79	137	46+3/13	32	18
ZMA 100389	29.2	♂	9	10	805	660	288	200	138	62	86	130	47+5/14	38	20
ZMA 100429	24.3	♀	8	10	800	650	263	230	143	58	87	140	44+6/12	33	18
ZMA 100436	42.9	♂	8	11	755	655	310	200	133	65	84	144	47+4/14	34	18
	38.8	♀	8	11	746	636	292	182	129	67	92	143	46+4/14	33	18
	28.9	♂	8	11	747	637	312	208	135	73	98	142	46+3/14	34	18
ZMA 100437	39.6	♀	8	11	743	643	305	182	136	68	86	134	44+5/14	35	18
	34.2	♂	8	11	745	630	292	190	135	57	84	129	46+3/14	33	18
	28.5	♂	8	11	739	626	289	187	140	60	85	130	45+4/14	34	18
Los Roques:															
ZMA 100404	25.1	♂	8	11	758	630	291	—	—	56	83	125	46+4/14	36	22
	20.0	juv	8	11	—	—	—	—	—	—	—	—	47+4/—	—	—
	19.6	juv	—	—	—	—	—	—	—	—	—	—	45+6/—	—	—
ZMA 100433	23.3	♂	8	12	763	630	303	—	—	43	82	129	47+5/14	36	20
Barbuda:															
ZMA 101055	36.2	♂	9	—	735	650	—	—	—	—	—	—	50+2/14	37	20
ZMA 100403	34.0	♂	9	11	804	685	241	—	—	53	59	123	45+3/13	36	20
St. Martin:															
ZMA 101056	12.9	juv	9	12	760	642	302	—	—	39	116	—	47+3/13	32	20
	12.3	juv	9	14	755	640	296	—	—	49	106	—	47+3/13	34	20

and five specimens of from 10.0 to 12.0 mm st.l.

Rivulus marmoratus Poey, 1880

Quite recently RIVAS (1945) has shown that the two Cuban species names *cylindraceus* and *marmoratus* are not synonymous, as has been supposed since GARMAN's (1895) monumental review of the *Cyprinodontiformes*. Both species were described by POEY, who established the genus *Rivulus* (1861) for the Cuban *cylindraceus*,

and recorded a second species of this genus (1880) which he named *marmoratus*. The two Cuban forms do indeed differ markedly from each other in several respects (cf. figs. 17 and 18), most strikingly as regards the pattern of frontal scalation. In order to show the significance of this frontal pattern, which is presumed to be of clear specific distinctness (at least within the genus *Rivulus*), the essential differences in the FRONTAL SCALATION PATTERNS of *cylindraceus* and *marmoratus* and in the genus in general, will first be discussed here.

The scales on the body of *Rivulus* are very regularly arranged. They are rather large, smaller on the caudal and belly, but usually greatly enlarged on top of the head. These enlarged frontal scales are grouped around a central scale marked *a* in the sketches, which covers the pineal organ. Behind this central scale, in the midrow, is a scale *b*, and in front in the midrow a scale *g*. To the left and right of the midrow of scales the lateral pairs *cc'*, *dd'*, *ee'*, and *ff'* are found. Of these lateral pairs one is fully exposed, and lies over the others, either completely uncovered or covered by the other scale of the pair for only a small portion of the dorsolateral margin. This pattern is constant throughout the series of specimens studied, including those of the mainland forms not reported on here.

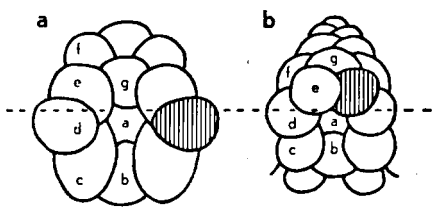

Fig. 17. Outline drawings of the frontal scalation patterns of *Rivulus*: a = *cylindraceus*, and b = *marmoratus*; the first after Cuban, the second after Bonaire specimens. — The horizontal broken line is the connection of the verticals from the rear margins of the orbits.

The two patterns in fig. 17 represent two evolutionary lines in the genus. In the first, the *cylindraceus* type, the pair of scales *dd'* is fully exposed (*d*-type pattern), and in the second, the *marmoratus* type, the scales *ee'* are fully exposed (except for the small portion of *e'* covered by *e*); this is called the *e*-type pattern. There are moreover some other differences, viz. in *cylindraceus* there is an uninterrupted midrow of scales, with three rows up to the snout, whereas in *marmoratus* only two rows are found in front of the most anterior midrow scale *g*. Posteriorly the midrow scale *b* underlies the occipital pair in *cylindraceus*, and it overlies this pair in *marmoratus*. For the rest, the arrangement of these principal scales is essentially alike in both species.

All the present samples referred to *marmoratus* here, except those from Curaçao, have been recorded as *cylindraceus*. This misidentification was obviously the result of comparison with Cuban material (cf. SANDERS, 1936, p. 452) ranged under *cylindraceus* (cf. MYERS, 1927, p. 121). It is evident now that the two Cuban forms are specifically distinct (cf. RIVAS, 1945). Comparison of specimens referable to both species (cf. list of material), especially with respect to the frontal scalation pattern, leaves no room for doubt.

All the above-mentioned specimens of *marmoratus*, originating from the islands of Curaçao, Bonaire, Los Roques, Barbuda, and St. Martin, perfectly agree with the re-description of that species given by RIVAS (1945). The characters in which these samples differ from the typical Cuban form are:

(a) the greater predorsal length, 739 to 805, as against 731 to 745 in the Cuban form,
(b) the shorter snout, 40 to 73, as against about 80,
(c) the higher circumpeduncular scale counts, 18 to 20, as against 18,
(d) the larger eye, 70 to 98, as against 65, and
(e) one more ray in the anal fin in nearly all specimens.

The number of dorsal rays in the Curaçao specimens and in some of the Bonaire specimens is 9 (seldom 10), as against 8 in the Cuban form and in some of the Bonaire and Los Roques specimens. In colour the material agrees perfectly with the general description given by RIVAS of the types from Cuba, except as regards two specimens from Curaçao (ZMA 100384). In these two specimens, a male and a female, no trace of the remarkable humeral fleck could be found. The males are generally more pigmented than the females, showing somewhat darker and more prominent markings on the flanks and in the vertical fins. There appears to be a rather great variation in the inter-dorsal/anal space, i.e. it is about 120 (1000ths of the standard length), as against about 80 in Cuban *marmoratus*.

The samples under discussion, originating from Curaçao, Bonaire, and Los Roques, represent a distinct subspecies, which I have named after the island of Bonaire, whence the finest specimens (type material) came. The specimens from Barbuda and St. Martin, though definitely *marmoratus* according to the frontal pattern, have not been included in this new subspecies, because it was impossible to take precise counts and measurements on the two Barbuda specimens and on the very small (young) specimens from St. Martin.

Rivulus marmoratus bonairensis nov. subsp.

Rivulus cylindraceus, HUMMELINCK, 1933, p. 321; SANDERS, 1933, p. 452; HUMMELINCK, 1940a, p. 114; DE BEAUFORT, 1940, p. 109.

Holotype: ZMA 100436, Pos di Pepe, Bonaire, ♂, 42.9 mm standard length; plate XVIIa. Paratypes: all other specimens from Curaçao, Bonaire and Los Roques in the list of material.

The following description is based on the holotype, and on all paratypes, the extremes of which are given in parentheses.

Dorsal rays 8 (8–10), anal rays 12 (10–12), with normally two unbranched rays in each fin included; pectoral rays 14–14 (14–15), ventral rays 7–7 (7–7), in both one unbranched ray included. Scales from upper edge of opercle to the end of the hypural 47, plus 4 more on the base of the caudal fin (44–49 + 3–6); scales from the base of the first dorsal rays obliquely downward and forward to the base of the anal fin 14 (12–14); predorsal scales

from occiput to the base of the first dorsal ray, not including scales of the frontal pattern, 34 (32–39); scales in a zigzag row around the narrowest part of the caudal peduncle 18 (18–20).

Body cylindrical, head slightly depressed, caudal compressed posteriorly; the greatest depth of the body 200 (187–250), head 318 (261–312); margin of the eye not free, eye 84 (63–98), snout 68 (40–68), interorbital width 144 (120–144), predorsal length 775 (739–805), preanal length 655 (606–670).

In life the sexes of Cuban *marmoratus* are of a similar colour, and in this respect *marmoratus* looks much like *cylindraceus*, in which latter species, however, the males do NOT show a caudal ocellus, and sexual dimorphism is more obvious. The ground colour in typical *marmoratus* is olive-brown, the back dark greenish, and the belly olive yellow to bright orange in the males (especially during mating); the vertical fins are greenish translucent, more yellowish in the females, and with narrow dark edges in the males. The ventrals are yellow in both sexes, the pectorals colourless. The sexes can be distinguished a little more easily in living specimens than in preserved ones, but there is still only very slight dimorphism. Our new subspecies (according to field notes by HUMMELINCK on material from Pos Lansberg) is slightly different, having a greenish-grey ground colour with greenish-brown flecks and speckles, and minute black stipples. The back is greyish-brown with blackish flecks, giving the impression of dirty sand. Belly silver-greyish with violet sheen. The caudal ocellus is black in a greenish-yellow field. The humeral spot is dark on a brownish-grey background.

In alcohol the coloration of the holotype (male) consists of a brownish background with prominent marbling (plate XVIIa), distributed in a band along the midaxis of the body, from a dark humeral fleck, breaking up into a series of dark and lighter blotches, and confluent with a dark fleck at the base of the caudal. From each dark blotch of the lateral series, rather dark streaks run obliquely upward and downward; a perfect ocellated black caudal spot is present in the upper half of the caudal root. All fins are practically hyaline, with only traces of bars in the dorsal, anal, and caudal at the bases of these fins. Outer margins of dorsal, anal, and caudal have narrow blackish edges. The other males are similar, the females somewhat duller, but with the same markings, including the caudal ocellus, which is thus present in both sexes. However, neither the females nor the young males have the dark edges to the fins. Accordingly there is hardly any sexual dimorphism in coloration, at least when compared with the other forms of the genus.

The frontal scalation pattern, which is thought to be of specific distinctness, at least in the genus *Rivulus*, consists, as mentioned before, of a number of enlarged scales, and in our new subspecies they are arranged in a kind of rosette around scale *a*. Some of the patterns in our specimens are illustrated in plate XVII. The pattern is constant, despite the minor deviations from the normal regular pattern as given in fig. 17b. Unless otherwise stated, all specimens referred to our new subspecies *Rivulus marmoratus bonairensis* show a pattern like the one in plate XVIIb. There is a light deviation in the specimens from Curaçao (ZMA 100380); in them the scales are strongly imbricated and covered with a tight slimy

skin, and do not show ridges at the margins of the exposed portions of the scales, but merely narrow furrows, which give the pattern a slightly different appearance. The scales are, however, arranged in the same manner as in the other specimens. Perhaps this deviation points to a marine habitat. The Bonaire specimens, except those represented in plate XVII, are similar. In one specimen (ZMA 100433) from Los Roques the central scale *a* posteriorly overlies scale *b*, instead of underlying it as in the other specimens.

Morphological characters: The values which have been found in the samples under discussion, and which are enumerated in table 4, have again been expressed in the diagrams of figs. 18 and 19.

As the samples are but small it was not thought warranted to consider variation among the island populations, but merely variation from the Cuban form. The means from the types of subspecies *bonairensis* have been added, together with the ranges of the allied species *myersi* from Yucatan and *ocellatus* from the State of Rio de Janeiro.

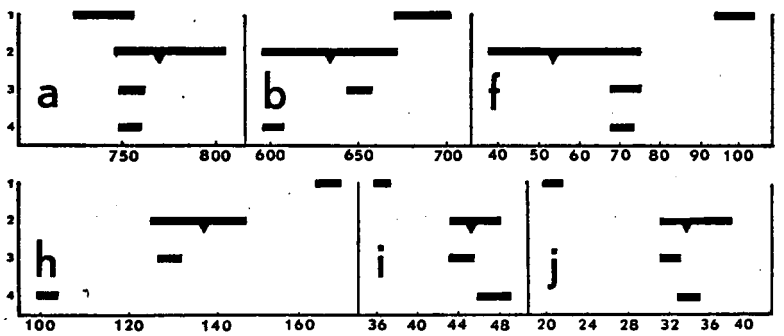

Fig. 18. Diagrams of the range of a number of morphological characters which distinguish *Rivulus cylindraceus* (1 in diagram) from the forms of *R. marmoratus*, viz. *m. marmoratus* (2), and means of *m. bonairensis*, black triangle below abscissas; *myersi* (3), and *ocellatus* (4). — In this and all other diagrams, a stands for predorsal length, b = preanal length, c = length of head, d = greatest depth of body, e = least depth of caudal peduncle, f = length of snout, g = diameter of eye, h = interorbital width, i = number of lateral scales, and j = number of predorsal scales. Proportion rates in 1000ths of the standard length.

The above diagrams (fig. 18) show the range of the principal morphological characters of *cylindraceus*, *marmoratus*, and the allied species *myersi*, and *ocellatus*. The considerable morphological difference between *cylindraceus* and the three species thought to represent the *marmoratus* superspecies is evident. These three forms remain within the morphological limits of *marmoratus* s.s., while only *ocellatus* differs in its very narrow interorbital width.

The diagrams (fig. 19) show that the new subspecies readily falls within the limits of *marmoratus marmoratus*. Only in one feature, the diameter of the eye

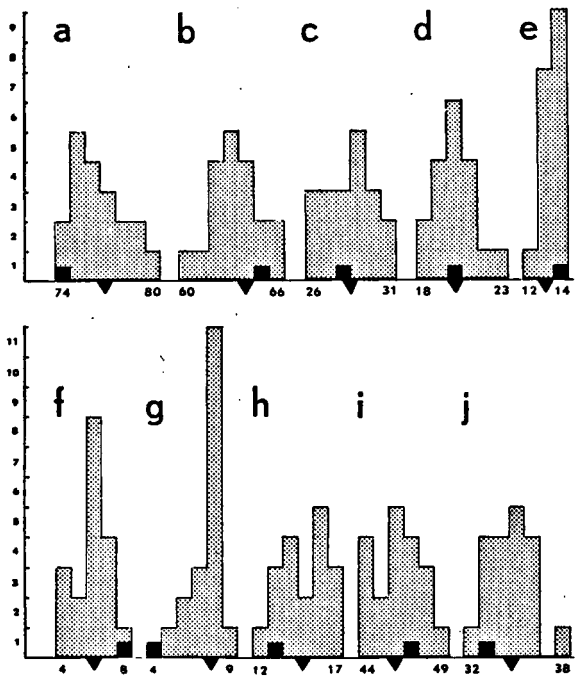

Fig. 19. Diagrams of the values found in *Rivulus marmoratus bonairensis* n. ssp.; axis of ordinates = number of specimens; axis of abscissas = proportion rates of the characters as enumerated in fig. 18 in 1000ths of the standard length. Solid black block = means of the types of typical *marmoratus* after RIVAS, 1945, and triangle = means of the diagrams.

(cf. fig. 19g), does there seem to be a rather important variation from the mean in *bonairensis*. The diagrams f, h, and i (fig. 19) show remarkable notches, but I do not think that they can be ascribed to anything other than the low number of specimens on which they are based. At first sight there seems to be a sexual variation in these characters. More specimens will have to be studied in order to confirm this probability.

According to HUMMELINCK's field notes *Rivulus marmoratus bonairensis* may be considered to be a decidedly euryhaline subspecies, with some preference for small, muddy, brackish ponds. On the other hand, it is necessary to accept its occurrence in the shallow marine pools of the Rifwater on Curaçao, in which the salinity of the water is usually about the same as that of the surrounding sea, or even somewhat higher. Here there would appear to be no good reason for discounting the information given by local people, who are convinced that *Rivulus* breeds in these pools.

TABLE 5.

Counts and proportion rates in 1000ths of the standard length of *Rivulus harti*, including those from ten of the types.

	mm st.l.	sex	D	A	prdl	pral	head	dpth	dcp	snt	eye	iob	scales		
													lateral/tr	prd	cpcf
Trinidad:	63.0	♂	10	16	—	—	278	200	—	80	71	118	41/10	—	—
types, data supplied by Dr. TREWAVAS in litt. October 1953	56.0	♀	10	—	—	—	275	198	—	87	72	—	41/11	—	—
	54.5	♂	10	16	—	—	285	238	—	83	74	110	36/9	—	—
	53.0	♂	10	17	—	—	274	208	—	85	75	130	41/11	—	—
	52.5	♀	9	16	—	—	265	178	—	77	77	115	42/9	—	—
	47.5	♂	10	17	—	—	292	210	—	—	63	116	38/9	—	—
	47.5	♂	9	16	—	—	253	200	—	74	74	116	?/9	—	—
	47.0	♀	9	16	—	—	255	192	—	—	75	118	39/10	—	—
	45.5	♂	10	17	—	—	286	160	—	86	88	110	35/11	—	—
	45.0	?	9	16	—	—	256	200	—	—	78	111	38/10	—	—
ZMA 101047	40.0	♂	9	15	758	625	255	195	135	68	75	135	38+5/10	27	17
	35.3	♀	8	14	765	626	250	207	131	56	71	136	38+5/10	27	18
	30.7	♀	8	14	746	619	277	205	135	68	80	127	36+4/10	26	18
ZMA 101048	34.6	♂	8	15	760	636	270	188	144	64	86	115	38+5/10	28	18
RML no number	36.8	♀	8	15	755	628	250	204	141	41	73	120	37+3/10	27	16
	27.1	♀	8	15	762	633	248	198	137	45	91	111	38+4/10	26	16
Tobago:															
ZMA 100402	52.7	♀	10	17	750	645	240	275	145	47	70	138	40+5/11	31	18
Margarita:															
Rio Asunción:															
ZMA 100377	62.6	♂	8	15	732	623	275	211	157	78	71	153	37+4/9	28	16
ZMA 100378	64.0	♂	9	17	766	283	270	239	159	67	75	130	37+4/10	28	16
	39.4	♀	9	16	792	604	264	204	140	65	77	137	38+3/9	27	16
	34.8	♀	9	16	770	608	262	198	142	64	66	142	38+3/10	27	16
	33.9	♂	8	15	787	619	255	243	139	65	78	129	38+4/10	28	16
ZMA 100379	64.2	♀	9	16	778	632	283	216	148	65	74	148	38+5/9	27	17
	61.0	♂	9	16	751	616	287	206	146	72	71	164	36+4/9	26	16
	59.5	♂	9	15	766	606	272	244	163	72	76	143	37+4/10	26	16
	52.3	♀	9	16	745	608	304	234	142	85	78	139	38+6/10	28	16
	49.1	♀	9	16	772	610	272	214	139	63	79	145	37+5/9	27	16
	24.4	♀	8	15	741	588	282	193	123	49	91	123	40+3/9	27	16
Rio del Valle:															
ZMA 100463	69.5	♂	9	17	756	606	248	211	119	71	70	137	40+3/11	27	17
	67.2	♀	9	17	743	602	243	209	117	80	73	141	38+4/10	29	17
	65.2	♂	9	17	747	580	238	203	114	73	70	140	39+3/10	28	18
	43.6	♀	8	18	758	578	282	202	121	75	72	139	37+5/11	27	17
	42.8	♂	9	17	734	589	279	213	143	81	76	142	38+3/11	29	17
	35.4	♂	9	18	727	604	269	189	150	69	65	148	40+4/10	29	17
ZMA 100376	51.3	♀	10	17	730	582	270	175	125	66	57	117	38+5/10	32	18
	47.8	♀	9	17	723	580	262	184	126	63	58	130	39+6/11	32	18
	39.4	♂	10	17	738	582	271	200	146	62	61	128	37+4/10	28	18
	34.1	♂	10	18	722	576	242	195	128	72	68	132	38+5/10	28	17
	32.4	♂	9	17	712	569	258	186	129	57	74	133	39+4/10	28	18
	32.0	♀	10	18	743	594	250	187	131	56	73	128	37+6/10	28	18
	18.0	♂	10	18	730	590	273	164	117	56	83	122	40+3/11	30	18
ZMA 100382	56.6	♀	10	17	744	580	240	217	141	53	65	115	36+3/11	27	18
	42.7	♂	10	18	730	571	250	195	150	59	70	133	40+5/11	31	18
	33.0	♀	10	17	736	610	270	188	139	55	73	106	36+4/11	26	18
San Antonio:															
ZMA 100362	33.7	♂	9	16	789	634	304	204	124	62	60	119	37+4/11	28	17
	19.4	juv	9	16	773	620	286	173	131	63	60	122	39+3/11	29	18
	15.8	juv	9	15	802	665	267	192	129	68	65	124	39+2/10	31	17
San Juan:															
ZMA 100383	67.2	♂	10	17	744	596	257	216	144	68	66	132	39+6/11	25	18
	65.0	♀	10	17	734	602	256	230	152	57	66	147	37+5/10	25	17
	56.4	♂	10	16	746	601	241	212	131	53	64	134	39+4/10	25	18
	55.6	♀	10	16	750	607	257	197	137	69	71	133	38+4/10	26	18
	53.6	♂	10	17	737	598	252	219	145	61	69	141	38+4/10	25	18
	31.7	♂	10	17	732	622	256	199	137	63	72	140	38+3/10	26	18
	30.2	♂	10	17	728	620	243	201	126	68	70	132	39+3/10	26	18
	23.7	♀	10	17	754	603	257	197	134	73	66	134	40+4/10	25	18
	14.9	♂	10	17	748	600	257	202	124	59	64	128	39+4/10	26	18
ZMA 100487	70.6	♀	9	16	755	610	265	219	153	66	68	157	41+4/11	26	18
	59.0	♂	9	16	773	618	274	212	136	62	64	139	40+6/11	26	17
	55.6	♀	9	17	754	613	284	216	140	67	68	151	38+5/11	26	17
	32.7	juv	9	16	764	612	287	204	134	71	86	133	37+4/10	24	16

Rivulus harti (Boulenger)

Haplochilus hartii BOULENGER, 1890, p. 190 (Trinidad). *Rivulus harti*, DE BEAUFORT, 1940, p. 110 (Margarita). *Rivulus holmiae*, SCHULTZ, 1949, p. 90 (Margarita).

In table 5 meristicals are given of the *harti* specimens originating from the islands of Margarita, Trinidad, and Tobago, next to data from the types of *harti*.

The variation in the frontal scalation pattern of *harti* is very slight (cf. plate XVII d to g), and the picture, which is most constant in the entire series studied (including the mainland samples, not recorded here), looks much like that presented by *cylindraceus* (cf. fig. 17a). The major difference of the *harti* pattern from that of *cylindraceus* is that the entire lateral series of scale pairs, *cc'*, *dd'*, *ee'*, and *ff'* overlies the midrow series *g*, *a*, and *b*. In *cylindraceus* the lateral pair *ff'* underlies the posterior scales. Both *harti* and *cylindraceus* are of the *d*-type.

Just as in *marmoratus*, there is a noticeable difference in the slime skin; the mainland specimens exhibit hardly any slimy layer covering the scales, whereas the island specimens have rather thick slimy layers covering these scales, forming ridges at the margins of the exposed parts. As the present writer has found in other fish, this may be caused by the salinity and the rapid flow of the waters they inhabit.

From the samples studied it must be concluded that on Trinidad island there are at least two populations, more or less isolated from each other, one with dorsal rays 8–9, and anal 14–15, the other with dorsal rays 9–10, and anal rays 16–17. The differences in proportion rates of these two island races have been worked out in a diagram (figs. 20 and 21).

The *harti* samples from Margarita also belong to two different populations, which was probably the reason why SCHULTZ (1949, p. 90) misidentified his "*holmiae*" material from Margarita. None of the samples can be referred to any other species but *harti*, at least as far as the frontal pattern is concerned. Furthermore, they agree with the diagnosis of that species, and disagree with *holmiae*, particularly in the longer head, the lower scale counts, and the greater predorsal length. The first population from Margarita can be recognized from their having dorsal rays 8–9, anal rays 15–17, and circumpeduncular scales 16–17 (Rio Asunción, cf. table 5), and the second population from their having dorsal rays 9, or mostly 10, anal rays 17–18, and circumpeduncular scales 17–18 (Rio del Valle = Rio Porlamar, San Antonio and San Juan, cf. table 4). All localities are at about the same elevation (from 100 to 200 feet) above sea level, and so the differences can hardly be due to ecological circumstances. It is possible that these two populations on the islands of Margarita and Trinidad are offshoots from two isolated mainland populations.

It is remarkable that in the Margarita specimens of up to about 35 mm st.l. the males still show the caudal ocellus (a juvenile and female character), which is even present as a lighter fleck in some of the larger males too. In other Rivulids in which only the females exhibit this character permanently, the ocellus fades away much earlier in the males. There can be hardly any doubt regarding sex in this species, as the females have a light-spotted caudal fin, often with a narrow dark outer margin, whereas in the males this fin is dark and the upper and lower rays are pale.

In the diagrams (figs. 22 to 25) the range and means of the important morphological characters of each of the Margarita populations represented in the samples studied are compared. From fig. 22 it can be seen that the populations of *harti* generally have 9 dorsal rays, except the types from Trinidad, which most frequently

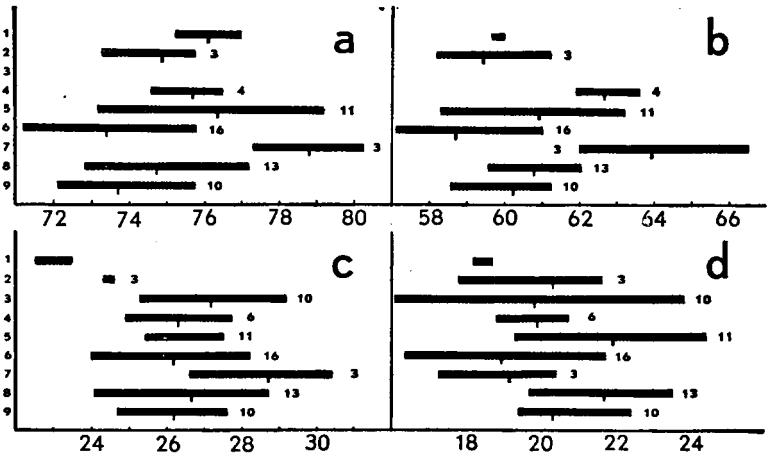

Fig. 20. Range and means of predorsal length, preanal length, length of head and depth of body of *Rivulus harti*, compared with data from *R. micropus* and *holmiae*. Ordinates: 1 = *micropus* from type + specimen ZMA 100381; 2 = *harti*, mainland; 3 = *harti*, types from Trinidad; 4 = *harti*, Trinidad, Bamboo Grove + Barataria + New la Paille samples; 5–8 = *harti* from Margarita island, 5 = Rio Asunción, 6 = Rio del Valle, 7 = San Antonio, 8 = San Juan; 9 = *holmiae* from Surinam samples, not recorded here. The figures at the end of each black bar indicate the number of specimens in the samples.

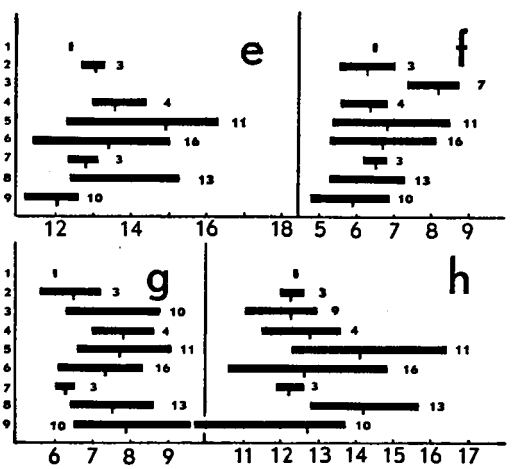

Fig. 21. Range and means of the caudal peduncle depth, the length of the snout, the diameter of the eye, and the interorbital width. Same samples as in fig. 20.

have 8 rays, and the San Antonio and Rio del Valle specimens, which most frequently have 10 rays. The Rio del Valle specimens, however, have an about equal distribution of 9 and 10 rays, and are thus intermediate in this respect.

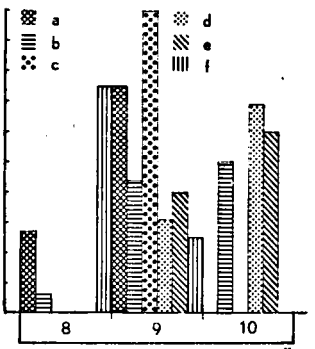

Fig. 22

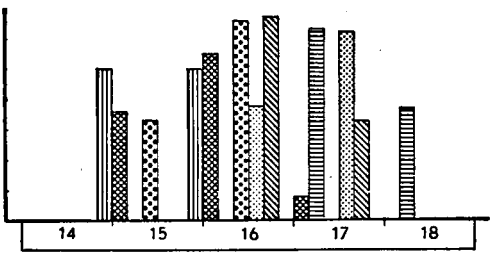

Fig 23

Fig. 22. Percentage frequencies of the numbers of dorsal rays in *Rivulus harti* specimens from Margarita island, and comparative data from the types and another sample from Trinidad. *a* = Rio Asunción; b = Rio del Valle; c = San Antonio; d = San Juan; e = Trinidad, types; f = Trinidad.
The samples are those enumerated in table 5.

Fig. 23. Percentage frequencies of the numbers of anal rays in *Rivulus harti*. Same samples as in fig. 22.

The number of anal rays gives a similar picture, though the variation is a little greater, the frequencies being distributed over five numbers. The Trinidad types correspond with the majority of the other samples in having a 16-rayed anal fin, but in the other Trinidad specimens 14 and 15-rayed fins are equally distributed. The extremes from fig. 22 fall within the average in fig. 23; the characters are therefore mixed, and show no points of correlation with a probable isolation for long periods. Gene flow is obviously possible from time to time, the barriers not being permanent.

The number of predorsal scales, a character of specific distinction within the genus, again gives a picture similar to that presented by the dorsal and anal fin

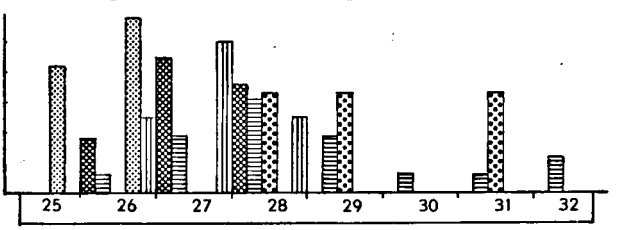

Fig. 24. Percentage frequencies of the number of predorsal scales in *Rivulus harti*. Same samples as in fig. 22.

characters. The greatest variation was found in the Rio del Valle specimens (the largest number of specimens available from one river system). The equal distribution of 28, 29, and 31 scales in the San Antonio sample (cf. fig. 24) says little, as only three specimens were available. But the San Juan population can certainly be distinguished by its relatively low number of scales (25 or 26).

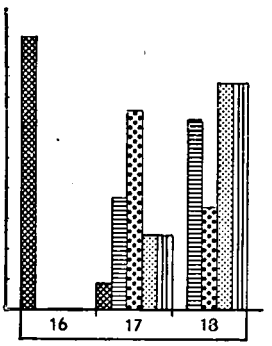

Fig. 25. Percentage frequencies of the numbers of circumpeduncular scales in *Rivulus harti*. Same samples as in fig. 22.

Finally, the number of circumpeduncular scales (fig. 25) at once differentiates the Rio Asunción population from all the others on account of the very low number (16) found in this population. The other specimens (omitting the three San Antonio specimens) most frequently have 18 scales.

From the above it is obvious that the Margarita populations all belong to the same species, *harti*, and that the differences in some characters between the populations from the various drainage systems, and even from each niche, are the result of incomplete isolation. Together with *cylindraceus* from Cuban hill streams, these species form a natural assemblage all showing the *d*-type pattern of frontal scalation (cf. fig. 26). In both *cylindraceus* (fig. 26a) and *micropus* (fig. 26b), the lateral pair *dd'* is not in contact with the exposed portion of central scale *a*, as is the picture in *holmiae* (fig. 26c), and *harti* (fig. 26d). The pattern of *holmiae* is essentially the same as that of *cylindraceus*, and the minor differences are merely caused by the slightly different shape of the anterior pairs *ee'* and *ff'*, whereas the

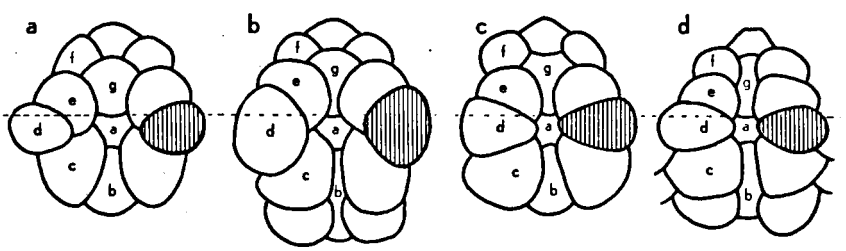

Fig. 26. Outline drawings of the frontal scalation patterns in the *cylindraceus* series; a = *cylindraceus* (Cuba); b = *micropus* (Rio Negro); c = *holmiae* (Guiana plat); d = *harti* (mainland and islands of Margarita, Trinidad and Tobago). — The broken horizontal line connects the verticals from the rear margins of the orbits.

scale anterior to *g* in the midrow lies over this scale in *holmiae* and under it in *cylindraceus*. *Rivulus harti* (fig. 26d) is virtually the same as *micropus* with respect to the pattern, but anteriorly the lateral pair *ff'* lies over *g* instead of under it, whereas posteriorly the scales adjoining the *cc'* and occipital pairs cover the left and right margins; each of the scales is therefore covered by two other scales. In all three of the forms *cylindraceus*, *micropus*, and *holmiae* the lateral scales are only covered by one other scale, except of course the fully exposed pair *dd'*.

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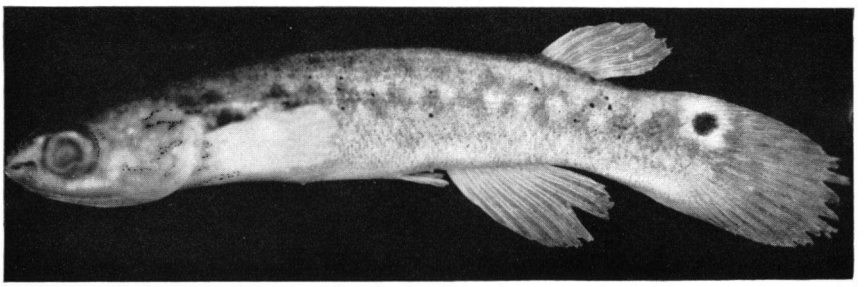
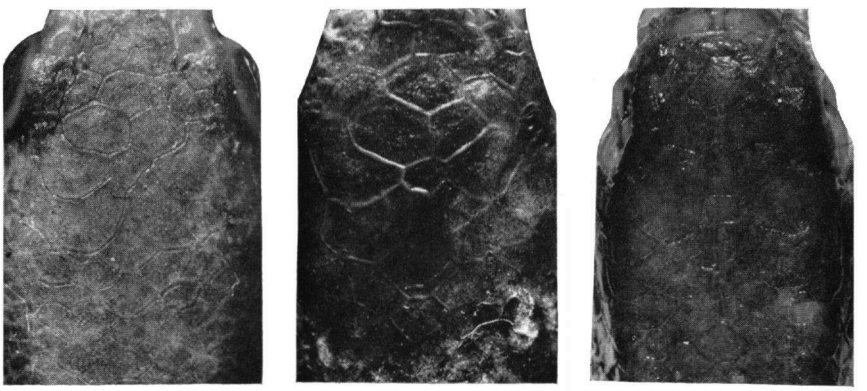
PLATE XVII



a



b c d

e f g

XVII. *Rivulus marmoratus bonairensis* n. subsp., male holotype from the island of Bonaire. – Frontal scalation patterns (upper and lower row, left to right) from *Rivulus marmoratus bonairensis* ♀, 32.7 mm (Curaçao), ♀, 44.9 mm (Bonaire); *R. harti* ♂, 34.6 mm (Trinidad), ♂, 64.0 mm (Margarita, Rio Asunción), ♂, 39.4 mm (Margarita, Rio del Valle), ♀, 56.6 mm (Margarita, Rio del Valle).