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Identification of West African Rivulins

For many years I have been faced with the problems concerning identification of live or preserved individuals belonging to West African Rivulins. As you may know, there are about one hundred and twenty nominal species (including subspecies) in this group in Rivulinae. The last review concerning all (or most) known forms was published back in 1915 by Boulenger. Up to that time only 36 nominal species had been described by zoologists. All the remaining more than eighty species descriptions for this reason are to be found here and there in numerous articles in the zoological and aquaristic literature.

The problem of identification starts when you receive some live or preserved individuals belonging to this group of Rivulins. If you are not familiar with this form you need a "name" to place on these fish. You now may look up one description of one of the West African Rivulins in literature and compare the data (measurements and counts, colors, color patterns etc.) of your sample with those of the description. Very often you will realize that your individuals are in rather fine agreement with the data of the description and you may identify your fish as belonging to that particular species. Well, sometimes you are not quite sure that this "identification" was good enough and you look up a second description in literature and also in this case you often will find rather fine agreements between your data and those of the description. Indeed sometimes you may find that your material corresponds to up to seventy different descriptions of West African Rivulins. It all depends on the variation of morphological characters found in your analysis of your material and those published for the nominal species.

You may indeed try to solve your problem in the way that you compare your material with the standard for various species in question. These standards are the "types" which are stored in zoological museums. These standards however are not to be seen in a single museum. They are scattered all over the zoological Museums of the Old and the New World. As these standards normally are not sent out of museums you have to go to see the types where they are stored. Sometimes your consultation of the type will solve your problem, but very often you will realize that the types themselves are not very informative because through time and the frequent use for identification they have lost most scales and fin rays and also rather often their original colors and color patterns are no longer visible. Also it may be that the types -and in particular the older ones- appear rather badly deformed from improper conservation or by shrinkage. Some liquids used for preservation deform the material more than other liquids. As the oldest types have been preserved in 70% alcohol, they will be more deformed than those preserved in formole or 30-40% isopropanole. Preservation in formole however will destroy all red and yellow

pigments and also may develop black color patterns that will not develop during preservation in alcohol. Individuals preserved in isopropanole will be "flabby" and difficult to handle without damage to the type. If identification has to be based too often on the type material we soon will have no informative type material left.

This situation demands that descriptions of West African Rivulins should be prepared in such a way that they can be used as standards for identification. For the present, most descriptions of these fishes do not at all fulfill this claim as they can not be used for identification. A revision of all descriptions and redescriptions is badly needed. This however claims that recollection at the type localities (if known!!) is needed to prepare an analysis of the "characters" used in descriptions. Some of the about one hundred and twenty forms have been described as subspecies or "varieties". For the present time some of the nominal subspecies apparently are representing good species, whereas some of the nominal species indeed may represent subspecies. For this reason I will consider all names so far created for West African Rivulins as representing nominal species. Also forms which have been placed as synonyms for other names will here be treated as nominal species because at least some of the synonyms are not correct. All these nominal species have been placed in several genera and most have been placed in the genera Epiplatys and Aphyosemion. These groupings may prove to be correct for most forms, however in the following analysis of characters, there is no need to consider genera as it is impossible for the present to place all forms under consideration in known genera.

The group "West African Rivulins" has been used here in a rather wide sense. The group here studied contains nominal species found in the Senegal, the Niger, the Congo River drainages and in the smaller river systems west of these major river systems. Also the Chad drainage is taken into consideration. This geographical limitation excludes most forms in Nothobranchius and all forms in Pachypanchax.

All information on these forms has been collected on loose leaves for each nominal form. To this information from the original descriptions I have added reliable data from other publications concerning these forms and my own measurements and counts on my own material and material which I had the opportunity to inspect. When this has been done it is possible to study each character used in the ordinary description of a West African Rivulin and to calculate the "value" of each character in taxonomy. As these characters have been used to demonstrate differences between a "new species" and older ones, the value of the character will depend on the ability to fulfill this claim. This value again will depend on the variation of that character within a single species, compared with the total variation for the whole group plus the distribution of the data for each species within the total range of variation. If the specific variation (species variation) is great compared with the group variation, the "value" of that character will be low and in particular if the data for most species are heaping up near the average value for variation.

Before such comparisons are made the morphological characters should be studied in order to see if the data have been collected in just the same way by different authors. Various zoologists however use various methods for counting and measurements. When counting fin rays some count all rays which stand isolated from other rays at the root of the fin. Other zoologists do not consider "small rays" and often the two last rays of the fin are considered as a single ray ("branched ray"). These differences in methods may render differences of up to three or four rays when the methods are used on just the same material. Also when counting scales different methods are in use (have been in use) and the same is true

for most measurements of body proportions.

Some species have been redescribed by zoologists. Redescriptions based on the type material have disclosed gross inconsistencies in the original descriptions. As an example I should like to give the data that Ahl (author) and Holly published for some of the types of Ahl's West African Rivulins.

Species	**Ahl**		**Holly**	
	D	A	D	A
Fundulus beauforti (1924)	9	12	12	16
Fundulus riggenbachi (1924)	11-13	11-13	13-15	13-14
Panchax elberti (1924)	6-7	11-12	11-12	16-17
Fundulus tessmanni (1924)	8	15	12	17
Fundulus normani (1928)	6-7	11-12	11-12	16-17

These differences however probably are not the result of different methods used for these counts, as Holly (1930) found himself in agreement with the corresponding counts for other species described by Ahl from 1924-28. Holly's corrections of Ahl's type descriptions not only concern counts, but also various measurements of body proportions. Such disagreements between the data published by different zoologists for the same material are not only found in Ahl's descriptions and Holly's redescriptions, but occur -less marked- when Meinken's and Boulenger's data were studied.

Often redescriptions include new material, identified as belonging to the form in question. Some of these redescriptions however published data concerning two different species. Boulenger's data for SEX (Catalogue III/1915) contain data (and individuals) of CHA. His description of CHA probably is based mostly on individuals belonging to DAG etc. I have not used such redescriptions for the analysis.

The data for body proportions sometimes are given with more accuracy than measurements are able to render. For example Meinken in his description of MUC was using live individuals. However, for these individuals he gave data with an accuracy of 1/4 millimeter (on up to 13 mm, that is "13 1/4 mm"), whereas for his preserved material he had an accuracy of 1/8 mm. Such accuracy indeed appears to be beyond what can be obtained.

Other data are given with less accuracy than easily could be obtained from the material. For the position of the anterior-most dorsal fin ray in proportion to the anal fin, the description often says that the first dorsal fin rays stand above the middle of the anal fin, regardless that it is evident that the author did not

think of the geometrical center of the root for that fin.

Most descriptions of new species (names) have been published without any picture showing the type. Such pictures indeed are valuable for identification if they have been prepared on fresh material. A good picture indeed may give away more information than pages of written descriptions.

Most new species have been based on a very limited material. About 27% of the species have been based on a single individual only. About 18% have been based on two individuals, about 11% on three individuals, and about 13% on four. This means that almost 70% of these nominal species have been based on less than five individuals. Also about 70% of the nominal species have never been recaptured in nature!!!

As you will realize in the section dealing with the crossings, Rivulins are indeed rather variable fish in measurements and in counts. A few individuals, often from a single deme (local population) will not give any idea of the true variation of data. As most of these fish live in small, often more or less isolated bodies of water, the exchange of genes between these micropopulations will not be absolutely free and local differences may accumulate. Also there are reasons to believe that some of ...(can not read the last line of page 181!!!) ... important to the fish itself and not the object for severe selection, as conspicuous variation is found even within the deme. Such characters indeed are not very important in taxonomy.

All nominal species have been based on differences from other known species only. However, apparently no attempt has been made to calculate the degree of differences that would support such claimed "differences" between two forms. Generally the "differences" which have been used for the separation of two or more forms are smaller (often much smaller) than the real differences between two individuals belonging to a single deme of a single species. Also differences in color patterns have been used to support the creation of new species. However the nature of the different color patterns and color markings within these Rivulins has not been discussed. As measurements and counts are highly variable even on demes' level, also the color patterns undergo variation if many individuals are compared. The use of differences in these characters should be based on a study of this type of variation also. Many of these species are polymorphic in males ("yellow" and "blue" males, etc.). About 1924-30 the collections of West African Rivulins in the largest museums permitted a study of the variation within species, but apparently no such study has been prepared.

Within Europe, the descriptions of new West African Rivulins have been rather standardized within this century. Most zoologists used the characters used by Boulenger. At the time when this system of Boulenger was prepared, only about twelve different species belonging to this group were known. Boulenger's system indeed is capable to contain much more than a hundred species, sufficiently separated in morphology from each others, by at least one character.

Fowler used a somewhat different system for his descriptions of West African Rivulins. This system contains more characters than Boulenger's system. It is however difficult to compare Fowler's descriptions with those prepared by the Boulenger system because Fowler's new characters are not known for the whole lot of forms described in Europe and also Fowler expresses his findings in measurements and counts in a somewhat different way which makes comparisons difficult.

Boulenger used the following factors suited for a statistic study:

1) the standard length of the body/the greatest depth of the body
2) the standard length of the body/the length of the head
3) the diameter of the eye/the length of the snout
4) the length of the head/the diameter of the eye
5) the interorbital width/the diameter of the eye
6) the number of dorsal fin rays
7) the number of anal fin rays
8) the position of the dorsal fin to the anal fin
9) the least length of the caudal peduncle/the least depth of the caudal peduncle
10) the number of scales in a longitudinal series
11) the number of scales around the body in front of the ventrals
12) the maximum length of the body (without caudal)

Further characters used by Boulenger and others will be considered later on in this report.

1) Standard length/greatest depth of body

The data for this character normally will be given as two numbers indicating the variation found by the author. Many descriptions, however, have been based on semiadults and juveniles and for this reason the variation might be considerable and not very useful for use in taxonomy. For my own measurements I have used well fed, full grown individuals only. These fish have been kept for some time in aquarium so that they should be able to develop full length of fins etc. All measurements are taken from close up photos, prepared in the way that the fish stands at a right angle to the optical axis. Also these measurements show much variation, depending on the sex of the individual, the number of eggs in females and individual variation probably of genetic origin. Individuals which have been preserved in formole normally will not deform much, whereas those preserved in alcohol often will be badly deformed by shrinking. For comparison I prefer the maximum value for this characteristic, thus taking only in consideration the individual which shows the greatest depth of the body. For newly hatched fry from most (all?) forms and for very small juveniles this character is rather constant and value 4.8-5.3. Here are the minimum values for the forms under consideration:

- 5.8: MAG
- 5.5: LIB
- 5.4: GER
- 5.0: BEL, BUA, CAS, CHA, DUB, FLV, MAE, MEI, TAE, UNC
- 4.9:
- 4.8: CHI, FAL, MIC, NII, ORN, PRE
- 4.7: ACU
- 4.6: SPM
- 4.5: ANN, AUS, BAT, BIT, CAM, CAR, ELB, ELE, ESC, INF, LOB, LOL, MAT, NIG, NOR, OBS, PAP, PAS, PET, POL, SAN, SIN, SUP

- 4.4: COG, LAB
- 4.3: BAU, GUI, LON, MAR, MEL, NDE, NYO, OGO, RUS, VEX
- 4.2: DAG, MAC, ZEN, ZIM
- 4.1: BEA, HOL, SRE
- 4.0: ANS, BIF, BRU, CHE, CHR, CIN, DEF, DOR, EXI, GAR, JAC, JAU, LOE, LOU, LUJ, MUC, MUF, NIG, NIM, LOB, RIG, ROL, RUF, SEX, SJO, SPP, SPL, SPU, STR, TES, UNS
- 3.9: GRA, LAM, SEN, SHE
- 3.8: BOU, CAB, FAS, CUS, KIY
- 3.7: ARN, BIV, DEC
- 3.6: WAL
- 3.5: AHL, CAL, GUL
- 3.4:
- 3.3: COE, GAM, THI
- 3.2: FIL
- 2.6: RUR

Fowler probably used not the standard length, but the total length for his measurements on MAG type. The published data do not correspond to the figure.

The descriptions cannot be used for a judgment of the specific variation (variation within a well known species). My own measurements however indicate that a specific variation of 1.1 is natural (well fed individuals of adult size differed from 0.7 to 2.2 "units"). If a "separation value" of 1.1 is used for separation of two forms we might have 711 different separations from this character. As about 7000 separations are needed, if all forms should be "separated" by a single morphological character, this character gave about 10% of the separations that are needed. As the ratio of the group variation to the specific variation is 3.3/1.1 = 3, the efficiency of this character is rather low, also because most forms are heaping near the center of variation 79% of all forms are concentrated within the specific variation.

2) Standard length/length of head

This character is highly variable. The group variation 2.6 (between 2.8 and 5.3).
The specific variation for the best known forms are:
- CAL: 3.3-5.3 = 2.1
- GRA: 3.0-4.8 = 1.9
- CIN: 3.3-5.0 = 1.8
- BIV: 3.0-4.6 = 1.7
- SHE: 3.2-4.8 = 1.7
- BOU: 3.0-4.5 = 1.6 (types)
- ROL: 3.5-5.0 = 1.6
- FAS: 3.0-4.4 = 1.5
- NIG: 3.2-4.6 = 1.5
- SEX: 3.3-4.6 = 1.4

I assume that the specific variation will be 1.7 at least. This means that the ratio of group variation to specific variation is 2.6/1.7 = 1.5 and we will not expect a high number of "separations". I found a total

of 280 separations. This means that this character is not very useful in taxonomy indeed. For this reason I will only give the distribution of the forms near the extremes of the group variation:

- 5.3: CAL
- 5.2: CAL, GER
- 5.1: CAL, GER
- 5.0: CAL, CHR, CIN, GER, ROL
- 4.9: CAL, CHR, CIN, GER, ROL
- 4.8: CAL, CHR, CIN, COG, GER, GRA, ROL, SHE
- 4.7: AUS, CAL, CHR, CIN, COG, GER, GRA, POL, ROL, SHE
- 2.9: ARN, DEF, NDE
- 2.8: DEF

3) Diameter of eye/length of snout

Most descriptions do not publish exact information on this ratio. It is said " that the snout is longer (equal to or shorter) than the eye". For 31 different species that I kept alive in my tanks I calculated this character. The group variation was 0.8-2.5 and I found these specific variations:

- BIF: 1.0-2.0 = 1.1
- BIV: 1.2-2.2 = 1.1
- SEN: 1.0-2.0 = 1.1
- SEX: 0.9-1.8 = 1.0
- LUJ: 1.6-2.5 = 1.0
- CHR: 1.4-2.2 = 0.9
- COG: 1.4-2.2 = 0.9
- FIL: 1.2-2.0 = 0.9

Three more species had a variation of 0.8 and five more species had 0.7. As my material was rather limited, I assume that the specific variation will be 1.0 or 1.1. As the group variation was only 1.8, it is evident that also this character cannot be of any importance in taxonomy. Not even a differentiation between nominal Aphyosemion and nominal Epiplatys was noticed.

4) Head/eye

From what has already been said about the variation of the eye and of the length of the head, it is likely that also this character will not be important in systematics of West African Rivulins. The group variation is 2.5-4.7 = 2.3 only. The specific variation could be calculated from these data:

- ARN: 2.5-4.5 = 2.1
- RUR: 2.6-4.4 = 1.9
- COE: 3.1-4.7 = 1.7
- BIF: 2.5-4.0 = 1.6
- SHE: 2.9-4.3 = 1.5
- GRA: 2.5-3.8 = 1.4

Apparently the "Nothobranchius-Fundulopanchax-like" forms differ more than Epiplatys and the usual Aphyosemion forms. For this reason I assume that the specific variation could be 1.4, more or less. However, this specific variation gives only 209 separations. If a specific variation of 1.5 had been used,

the number of separations would be 100 only. A specific variation of 1.6 only gives 72 separations. The grouping of nominal species near the extremes for the group variation:

- 4.7: COE
- 4.6: COE
- 4.5: ARN, COE, GAM, GUI
- 4.4: ARN, COE, GAM, GUI, ROL, RUR
- 4.3: ARN, COE, GAM, GUI, ROL, RUR, SHE
- 4.2: ARN, COE, GAM, GUI, NIG, ROL, RUR, SJO, SHE
- 2.7: ANN, ARN, BIF, BIV, DUB, GRA, RUR
- 2.6: ARN, BIF, BIV, GRA, RUR
- 2.5: ARN, BIF, GRA

5) Interorbital width/diameter of eye

I did not measure these data on my own material. Descriptions give data that can be used in statistics.

- RUR: 1.1-2.8 = 1.8
- FIL: 1.2-2.0 = 0.9
- GER: 1.2-2.0 = 0.9
- GUI: 1.7-2.4 = 0.8
- PET: 1.4-2.0 = 0.7
- BIV: 1.3-1.8 = 0.6
- BOU: 1.0-1.5 = 0.6
- CAM: 1.5-2.0 = 0.6
- ESC: 1.5-2.0 = 0.6

I assume that the specific variation will be 0.8, but it is likely that a study on more material will raise this value considerably. The distribution of the forms near the extremes of the group variation is:

- 2.8: RUR
- 2.7: RUR
- 2.6: RUR
- 2.5: RUR
- 2.4: GUI, RUR
- 2.3: GUI, RUR
- 2.2: GUI, RUR
- 2.1: GUI, RUR
- 1.2: ARN, BIT, BOU, FIL, GER, GUS, RUR, RUS, THI
- 1.1: BIT, BOU, RUR, THI
- 1.0: BIT, BOU, THI

This grouping shows that almost all forms are heaping within the range from 1.3 to 2.0 = the specific variation. The number of separations for this reason is very low: 151 separations only and also most of these "separations" come from RUR. This character probably is without any importance in systematics.

6) Number of dorsal fin rays

Apparently this character has been considered as very important in taxonomy of West African Rivulins

and indeed this character gives many more separations than any of the previously mentioned characters. The group variation runs between 6 and 22 dorsal fin rays. The specific variation however is larger than estimated in descriptions. Using my own counts on more than 3000 individuals and the reliable data from descriptions and redescriptions the following specific variations were found:

- FAS: 10-15 = 6
- BIF: 06-10 = 5
- BIV: 09-13 = 5
- COE: 14-18 = 5
- NIG: 12-16 = 5
- ROL: 11-15 = 5
- RUR: 16-20 = 5
- WAL: 12-16 = 5
- AUS: 09-12 = 4
- ARN: 15-18 = 4
- CAB: 09-12 = 4
- CHE: 07-10 = 4
- CHR: 08-11 = 4
- FIL: 14-17 = 4
- GRA: 07-10 = 4
- GUL: 15-18 = 4
- LAM: 10-13 = 4
- LON: 07-10 = 4
- MUF: 08-11 = 4
- NIC: 07-10 = 4
- PET: 07-10 = 4
- SCH: 08-11 = 4
- SEN: 09-12 = 4
- SEX: 09-12 = 4
- SHE: 10-13 = 4
- SJO: 19-22 = 4

I assume that the specific value of variation will be "5 rays". This specific variation will give 1798 "separations" if the total variation within each species is taken into consideration. If only the data published in descriptions are used the number of separations will be 1242. I found this grouping of the forms along the axis of variation:

- 22: SJO
- 21: SJO
- 20: RUR, SJO
- 19: RUR, SJO
- 18: ARN, COE, GUL, RUR, SJO
- 17: ARN, COE, FIL, GUL, RUR, SJO, SPL
- 16: ARN, COE, FIL, GAM, GUL, GUS, NIG, RUR, SRE, SPL, SPU, WAL
- 15: ARN, BAT, BEA, CIN, COE, FIL, FAS, GAM, GER, GUL, GUS, KIY, NIG, RIG, ROL, SPL, SRE, SPU, WAL

- 14: BAT, CIN, COE, DOR, FAL, FAS, FIL, GER, GUI, KIY, LAB, NIG, RIG, ROL, SPU, WAL
- 13: BIV, BRU, CIN, FAL, FAS, GAR, GER, GUI, HOL, KIY, LAB, LAM, NIG, RIG, ROL, SEX, SHE, SPU, WAL
- 12: AUS, BEL, BIV, BRU, CAB, CAM, ELB, ESC, FAS, GAR, GUI, HOL, LAB, LAM, LOE, MEI, NIG, NOR, OLB, PAP, PAS, ROL, RUF, SEX, SHE, THI, WAL, ZIM
- 11: ANS, AUS, BEL, BIV, BOU, BUA, CAB, CAM, CAR, CHR, DAG, ELB, ESC, FAS, HOL, INF, LAM, LIB, LOE, LOU, LUJ, MAE, MAC, MIC, MUF, NII, OBS, OGO, OLB, PAS, POL, PRE, ROL, RUF, RUS, SCH, SEN, SEX, SHE, SPI, SPP, STR, TES, THI, UNS, ZIM
- 10: ACU, AHL, AUS, BIF, BIT, BIV, BOU, CAB, CAL, CHE, CHR, CON, DAG, DUB, FAS, FER, GRA, LAM, LON, LUJ, MAC, MAG, MUC, MUF, NDE, NIG, OGO, OLB, PET, POL, RUF, RUS, SCH, SEN, SEX, SHE, SPI, SPM, STR, UNS, COG
- 09: ACU, AHL, AUS, BIF, BIT, BIV, BOU, CAB, CAL, CHE, CHR, COG, CON, DAG, DEC, DUB, GRA, JAU, LOL, LON, MAC, MAT, MUF, NIC, NIM, ORN, PET, SAN, SCH, SEN, SEX, SIN, STR, TAE, UNC, VEX, ZEN
- 08: BAU, BIF, CAL, CAS, CHE, CHI, CHR, COG, DEF, DEC, ELE, EXI, GRA, LOB, LOL, LON, MAC, MAR, MAT, MUF, NIC, NYO, PET, SCH, SEN, SIN, TAE
- 07: ANN, BIF, CHA, CHE, DEF, FLV, GRA, LON, MAR, MEL, NIC, PET, SEN, SUP, TAE,
- 06: BIF, JAC

There are two maxima. One large maximum is found at 10 dorsal fin rays. 46 nominal species -at least- may develop this number of dorsal fin rays. There is a smaller maximum at 15 dorsal fin rays, produced by Callopanchax, Fundulopanchax and Nothobranchius.

7) Number of anal fin rays

The group variation of this character is more narrow than found for the dorsal fin. The variation goes from 10 to 20 fin rays. The specific variation however reaches just the same magnitude as found for the dorsal fin. For this reason we should expect less separations from this character.

- BIF:
- FAS: 14-19 = 6
- SEX: 15-20 = 6
- WAL: 14-19 = 6
- BIV: 14-19 = 6
- GRA: 11-15 = 5
- NIG: 14-18 = 5
- ROL: 14-18 = 5
- RUR: 16-20 = 5
- SEN: 15-19 = 5
- SHE: 14-18 = 5
- ARN: 15-18 = 4
- BOU: 14-17 = 4
- CAM: 14-17 = 4
- CHE: 13-16 = 4
- COE: 16-19 = 4

- DAG: 14-17 = 4
- FIL: 14-17 = 4
- GUI: 14-17 = 4
- GUL: 16-19 = 4
- LAB: 14-17 = 4
- LAM: 14-17 = 4
- LON: 15-18 = 4
- MAC: 15-18 = 4
- MUF: 14-17 = 4
- NIC: 13-16 = 4

I assume that the specific variation will be "5 rays". This value however gives only 497 separations. The reason for this poor result is found in the distribution of the nominal species around the mean value for anal fin rays. 63 nominal species may develop 15 anal fin rays and 56 and 57 nominal species may develop 14 or 16 anal fin rays. For this reason I only give the distribution of species near the extremes of the group variation:

- 20: FAS, RUR
- 19: BIF, COE, FAS, GRA, GUL, RUR, SEN, SEX, SJO, WAL
- 18: ARN, BIF, COE, DOR, FAS, GRA, GUL, LON, MAC, NDE, NIG, ROL, SRE, SEN, SEX, SHE, SJO, WAL
- 12: AHL, BIT, BIV, CAL, EXI, JAC, LOE, RUS, UNC
- 11: BIV, JAC, RUS
- 10: MEL, RUS

8) Position of the anteriormost dorsal fin ray

I have already mentioned that this important character normally is not published with sufficient accuracy in descriptions. In my opinion it is evident that this particular character is the most important in the systematics of West African Rivulilns. The group variation of this character covers 19 fin rays (measured on the anal fin base) and thus exceeds the group variation of the dorsal fin rays by two rays. However, in this character the distribution of the nominal species is more even within the whole range of variation thus indicating that many "separations" are possible.

Not very much information on the specific variation can be harvested from descriptions and redescriptions. For this reason I prepared my own measurements on my close-up photos and on preserved material. I project the base of the anterior-most dorsal fin ray -along scale rows- to the base of the anal fin. I then find the anal fin ray that comes closest and count "backwards" to the anterior-most anal fin ray. In case that the anterior-most dorsal fin ray stands in front of the anterior-most anal fin ray (ARN, FIL, GAM, SJO, KIY, RUR) I project the latter on the dorsal fin base and give the value in "negative anal fin rays".

On my material I found these specific variations:

- COE: 01-06 = 6 rays
- DAG: 06-11 = 6 rays

- FAS: 08-13 = 6 rays
- ARN: 01-05 = 5 rays
- BIV: 02-06 = 5 rays
- FIL: 01-05 = 5 rays
- NIG: 03-07 = 5 rays
- ROL: 04-08 = 5 rays
- SEX: 08-12 = 5 rays
- SHE: 06-10 = 5 rays

I assume that the specific variation will be 5 (or 6) rays. I count this grouping of the nominal forms along the axis of....(?)

- 15: ORN
- 14: GRA, ORN, PET
- 13: BOU, FAS, GRA, NIM, PET, SEN, SIN, SUP
- 12: BOU, CHE, CHR, DAG, FAS, GRA, LON, MAC, MUF, PET, SEN, SEX, SIN, TAE
- 11: ACU, BAU, BIF, BOU, CHA, CHE, CHI, CHR, DAG, FAS, GRA, LON, MAC, MUF, PET, SEN, SEX, ZEN
- 10: ACU, BAU, BIF, BOU, CHE, CHR, COG, CON, DAG, FAS, MAR, MUF, NIC, PET, SAN, SEN, SEX, SHE, ZEN
- 09: AUS, BIF, CAL, CHR, COG, CON, DAG, DEF, DUB, ELB, FAS, JAC, LAM, MAR, MUF, NDE, NOR, PET, SEX, SHE, VEX
- 08: ANN, AUS, CAL, CAM, CAR, CAS, CHR, COG, CON, DAG, DUB, ELB, ELE, FAS, JAC, LAB, LAM, LOB, LOL, LUJ, MAE, MUF, NOR, NYO, OBS, OLB, PET, ROL, RUF, SEX, SHE, SPI, SPM, VEX
- 07: AHL, AUS, CAB, CAL, CAM, CAS, CHR, DAG, DOR, DUB, ELE, FER, FLV, INF, JAU, LAB, LAM, LOB, LOL, LOU, LUJ, MAE, MAT, MAG, MIC, NIG, OBS, OGO, OLB, ROL, SHE, SPI, SPM, STR
- 06: AHL, BIV, CAB, CIN, COE, DAG, EXI, FER, GUI, LAB, MAT, MAG, NIG, OGO, OLB, PAS, ROL, SHE, STR, UNC
- 05: BEL, BIV, BRU, BUA, CAR, CIN, COE, DAG, ESC, GUI, LAB, LIB, MEI, MEL, NIG, OGO, PAS, PRE, ROL, STR, TES
- 04: BEL, BIV, BRU, CIN, COE, GER, LIB, NIG, ROL
- 03: BIT, BIV, COE, HOL, NIG, NII, SPP
- 02: BEA, BIT, BIV, COE, GAR, MUC, NII, RUS, SRE, SJO, SPL, SPU, WAL
- 01: ARN, BAT, COE, FAL, FIL, GUL, GUS, LOE, PAP, RIG, RUR, SJO, SPL, THI, UNS, ZIM
- -2: ARN, FIL, GUL, KIY, RUR, SJO
- -3: ARN, FIL, GUL, SJO
- -4: ARN, FIL, GUL, SJO
- -5: ARN, FIL, GAM, SJO

On this base 2963 different separations between nominal species were prepared. This amount of "separations" however would increase if more information on the specific variation had been published. Indeed this character gives more separations than any other purely morphological character. The

distribution of the nominal species along the axis of variation develops two distinct maxima. One large maximum is seen at D/A=7-8 anal finrays and a smaller one as D/A=1 anal fin ray. There might be a third maximum near D/A=10-12 also.

These maxima indeed indicate a grouping in taxonomy that probably corresponds to the Fundulopanchax (including however also species in Callopanchax and Fundulosoma plus Nothobranchius) and a certain group in Epiplatys (D/A=10-12 A).

9) Ratio of measurements for the caudal peduncle

Most descriptions do not publish exact values for this character. It is said that the caudal peduncle is (much) longer (shorter) than deep. From my own measurements on close-up photos of adult well fed individuals I realized that the specific variation of this character is rather limited compared to the characters previously mentioned. Indeed this specific variation includes also the slight differences in this character sometimes found between the two sexes.

- BIV: 1.4-2.0 = 0.7
- ROL: 1.3-1.9 = 0.7
- RUR: 1.1-1.7 = 0.7
- SHE: 0.9-1.4 = 0.6
- SPL: 1.5-2.0 = 0.6
- AUS: 1.3-1.7 = 0.5
- CAL: 1.3-1.7 = 0.5
- ARN: 1.7-2.2 = 0.6
- GAB: 1.7-2.2 = 0.6
- CAM: 1.5-2.0 = 0.6
- CIN: 1.7-2.1 = 0.5
- DUB: 1.4-1.8 = 0.5
- FIL: 1.3-1.7 = 0.5
- GRA: 1.2-1.6 = 0.5
- CHR: 1.5-2.0 = 0.5
- COG: 1.3-1.8 = 0.6
- GAM: 1.0-1.5 = 0.6
- GUI: 1.0-1.4 = 0.5
- NIG: 1.5-1.9 = 0.5
- SEX: 1.0-1.4 = 0.5

I assume a specific variation of 0.6 units. A study of more material probably will raise this figure to 0.7. The group variation runs from 0.9 to 2.2 = 1.4 units.

- 2.2: ARN, CAB
- 2.1: ARN, CAB, CIN
- 2.0: ARN, BEL, BIV, CAB, CAM, CHR, CIN, CON, ESC, LIB, LOU, LUJ, MEI, MIC, SRE, SPL,
- 1.9: ARN, BEL, BIV, CAB, CAM, CHR, CIN, CON, ELE, ESC, LOE, LUJ, MIC, NIG, NOR, ROL, SPL, ZIM
- 1.8: ARN, BEL, BIV, CAB, CAM, CHR, CIN, COE, COG, CON, DUB, ELB, ESC, GER, LOU, LUJ, MIC, NIG, NYO, ROL, SAN, SPL

- 1.7: ANN, ARN, AUS, BIV, CAB, CAL, CAM, CAR, CAS, CHR, CIN, COE, COG, DUB, FER, FIL, GER, GUS, JAC, JAU, LOU, LUJ, MAE, NIG, OBS, POL, PRE, ROL, RUR, SPP, SPL
- 1.6: AUS, BIF, BIV, CAL, CAM, CHR, COE, COG, DUB, FIL, GER, GRA, GUL, LAB, NIG, POL, ROL, RUR, SPP, SPL
- 1.5: AHL, AUS, BEA, BIF, BIT, BIV, BRU, CAL, CAM, CHI, CHR, COG, DEC, DUB, EXI, FIL, FLV, GAM, GER, GRA, HOL, LAB, LOB, LOL, MUC, NIG, NIM, PAP, PAS, POL, ROL, RUF, RUR, SJO, SPP, SPL, SUP, TES, UNC, UNS
- 1.4: AHL, AUS, BIF, BIV, CAL, CHE, COG, DUB, FAS, FIL, GAM, GRA, GUI, ROL, RUR, SEX, SHE, SJO,
- 1.3: AHL, AUS, BAT, BIF, CAL, CHE, COG, DAG, FAS, FIL, GAM, GRA, GUI, LAM, MAC, MIC, ORN, RIG, ROL, RUR, RUS, SEX, SHE, SJO, STR, WAL
- 1.2: DAG, FAS, GAM, GRA, GUI, LAM, LON, NIC, RUR, SEN, SEX, SHE, WAL
- 1.1: BOU, DAG, FAS, GAM, GUI, LAM, LON, NIC, RUR, SEN, SEX, SHE, SPU, WAL
- 1.0: ACU, ANS, BAU, DAG, DEF, DOR, FAL, GAM, GAR, GUI, KIY, LAM, MAR, MUF, NII, NIC, OLB, PET, SEN, SEX, SHE, SIN, SPI, TAE, THI, ZEN
- 0.9: SHE

The four maxima (0.1-1.3-1.5-1.7) do not indicate taxonomic units. They are produced by the inaccuracy of the data of descriptions (1-1 1/4-1 1/2-1 3/4 or 1 2/3). The species in nominal Aphyosemion are concentrated at the higher values, whereas the species in nominal Epiplatys are concentrated at lower values. Among nominal Epiplatys only GRA reaches the value of 1.6 (DUB is not a true Epiplatys). From this distribution and a specific variation of 0.6 I had 1617 separations. This result indicates that this character should be taken into consideration in the systematics of this group of Rivulins.

10) Scales in a longitudinal series I am not quite sure that the data published for scales in a longitudinal series in various descriptions and redescriptions are comparable as this character can be counted in different ways. If scales situated on the caudal fin are not taken into consideration, differences between the different methods should be not be important. For my own counts of scales I start from the scale that is situated just above the upper part of the root of the pectoral fin and count in a median series (usually the row which has pits, if pits are present). I always count both sides in order to have an idea of the individual variation of this character.

The specific variation given on the next page is based on my own counts for most species. The variation found in COE and GUL is very large, probably because in these species the development of the scales often is very irregular and small and larger scales occur on the body sides. The variation found in GUL is that of a single deme from Ago-Iwoye of SW Nigeria. The data for CAM, RUR (types only), BEL (types only), BRU and GAR have taken from literature.

- COE: 31-37 = 7
- GUL: 29-35 = 7
- ARN: 24-29 = 6
- BIV: 24-29 = 6
- CAM: 29-34 = 6
- CHA: 25-30 = 6
- NIG: 29-34 = 6

- RUR: 29-34 = 6
- SEX: 27-32 = 6
- SHE: 25-30 = 6
- BEL: 30-34 = 5
- BIF: 25-29 = 5
- BRU: 30-34 = 5
- CAL: 27-31 = 5
- CHE: 27-31 = 5
- DAG: 25-29 = 5
- DEC: 28-32 = 5
- FAS: 27-31 = 5
- FIL: 24-28 = 5
- GAR: 28-32 = 5 GRA: 26-30 = 5

The specific variation for GUI, LAM, LON, LUJ, SPM also reaches 5 scales. The specific variation probably will not be below 6 scales. This value gives 1366 separations. A specific variation of 5 scales only (which I assumed one year ago) would give 2181 separations.

The following distribution of species was found:
- 37: COE, SPL
- 36: BEA, COE, GUS, SPL
- 35: BAT, COE, GUL, GUS, SRE, SJO, SPL
- 34: BAT, BEL, BRU, CAM, COE, FAL, GER, GUI, GUL, GUS, MEI, NIG, RUR, SRE, SJO, SPL
- 33: BAT, BEL, BRU, CAM, CIN, COE, GER, GUI, GUL, LIB, NIG, POL, RUR, SRE, SJO, SPL
- 32: AUS, BEL, BRU, BUA, CAM, CIN, COE, DEF, ELE, ESC, FER, GAM, GAR, GER, GUI, GUL, LAB, LAM, LIB, LUJ, MIC, NIG, PET, POL, ROL, RUR, SEX, SJO, SPU, VEX, ZIM
- 31: ANS, AUS, BEL, BRU, CAL, CAM, CHE, CHR, CIN, COE, COG, CON, DEC, ELB, ELE, ESC, FAS, FER, GAM, GAR, GER, GUI, GUL, LAB, LAM, LOU, LUJ, MIC, NIG, OBS, OGO, PAS, PET, POL, ROL, RUR, SAN, SEX, SPU, STR, ZIM
- 30: AHL, ANS, AUS, BEL, BRU, CAB, CAL, CAM, CAR, CAS, CHA, CHE, CHR, CIN, COG, CON, DEC, ELB, ELE, ESC, FAS, FER, GAM, GAR, GRA, GUI, GUL, JAU, LAB, LAM, LUJ, MAC, MAE, MAT, MEL, MUF, NIG, NII, NIC, NIM, NOR, OGO, OLB, PAS, PET, PRE, ROL, RUF, RUR, SCH, SEX, SHE, SPL, SPU, STR, TES, WAL, ZEN, ZIM
- 29: ACU, AHL, ANN, AUS, BIF, BIV, BOU, CAL, CAM, CHA, CHE, CHR, COG, CON, DAG, DEF, DEC, ELB, ELE, FAS, FLV, GAR, GRA, GUL, HOL, LAM, LON, LUJ, MAC, MAT, MEL, MUF, NIG, NIC, NIM, OGO, OLB, ORN, RIG, ROL, RUF, RUR, SCH, SEN, SEX, SHE, SPM, SPU, TAE, WAL, ZEN
- 28: ACU, ANN, BIF, BIT, BIV, BOU, CAL, CHA, CHE, CHR, DAG, DEF, DEC, DOR, EXI, FAS, FIL, GAR, GRA, HOL, INF, JAC, LAM, LOE, LON, LUJ, MAC, MAR, MAT, MUF, NIC, NYO, OLB, RIG, RUF, RUS, SCH, SEN, SEX, SHE, SIN, SPM, TAE, WAL
- 27: ACU, ANN, BIF, BIT, BIV, CAL, CHA, CHE, CHI, DAG, FAS, FIL, GRA, JAC, LOB, LOE, LOL, LON, MAC, MAR, MUF, NDE, NIC, RUF, RUS, SEN, SEX, SHE, SIN, SPI, SPM, SPP, SUP, TAE, THI, UNS, WAL

- 26: ACU, ARN, BIF, BIV, CHA, DAG, DUB, FIL, GRA, KIY, LOE, LOL, LON, MAG, MUC, NDE, PAP, RUS, SEN, SHE, SPI, SPM, SPP, THI, UNC, UNS
- 25: ARN, BAU, BIF, BIV, CHA, DAG, DUB, FIL, LOL, LON, MAG, SHE, UNS
- 24: ARN, BIV, FIL A very marked maximum occurs at 29-30 scales. 59 different nominal species may develop 30 scales. The Fundulopanchax species group is concentrated at values for high scale counts, except for the small ARN-FIL group that reaches the minimum values of this character. The variation for nominal Epiplatys is smaller ranging from 25 to 31 (32) scales. Statistics for this character are given in the section on crossings for species of which many individuals have been to my disposal.

11) Scales round the body in front of ventrals Boulenger counted scales round the body in front of the ventrals and so did most zoologists of his time. Other zoologists counted scales in transverse series, e.g. from the first dorsal fin ray to the first anal fin ray. I have not been able to convert (some of these) counts into the system used by Boulenger. In Boulenger's system I found a variation from 16 to 34 scales. In other systems the group variation was 6 to 12 scales. Species described after Boulenger's system are heaping near the variation of 20 to 22 scales. 46 species might develop 20 such scales and 52 species develop 22 scales. I have not prepares such counts of scales around the body myself and I have to base my idea on the specific variation on information in literature:
- RUR: 24-30 scales = 7
- SPL: 28-34 scales = 7
- BIV: 20-24 scales = 5
- CAM: 20-24 scales = 5
- GAR: 22-26 scales = 5
- WAL: 20-24 scales = 5

The species described in accordance with Boulenger are distributed like this:
- 34: SRE, SPL
- 33: SRE, SPL
- 32: GUS, SRE, SPL
- 31: GUS, SRE, SPL
- 30: BEA, COE, FAL, GUS, MEI, RUR, SPL
- 29: COE, FAL, GUS, RUR, SPL
- 28: COE, FAL, GUI, RUR, SPL
- 27: GUI, RUR
- 26: BAT, BRU, GAR, GUI, NII, RUR, SPU
- 25: BAT, BRU, CHR, GAR, RUR, SPU
- 24: BAT, BEL, BIT, BIV, BRU, CAM, CAR, CHR, CON, ELB, GAM, GAR, HOL, JAU, KIY, LAB, MIC, MUC, OGO, RUR, RUS, SCH, SPU, TES, WAL, VEX, ZIM
- 19: DAG, MAC, MAR
- 18: ANS, BAU, BIF, DUB, MAC, MAR, SPM
- 17: BIF
- 16: BIF A specific variation of 6 scales will give 789 separations. If this character (scales round the body in front of ventrals) was known for all nominal species, indeed the number of separations would increase considerably.

For various nominal species these counts of scale rows were published:

- 12: DEC
- 11: DEC, SJO
- 10: RUF
- 09: RUF
- 08: MAT, MEL
- 07: MEL, NDE
- 06: MAG, MEL A specific variation of 6/2 = 3 scales will give 9 separations and the total number of separations produced by this character will be 789+9 = 798.

The study of the eleven characters of Boulenger's "standard description" gave these results:

- 1) SL/max depth of body 711 separations (10.2%)
- 2) SL/length of head 280 separations (4.0%)
- 3) eye/snout few separations
- 4) head/eye 209 separations (3.0%)
- 5) interorbital width/eye 151 separations (2.2%)
- 6) dorsal fin count 1798 separations (25.7%)
- 7) anal fin count 497 separations (7.1%)
- 8) D/A ratio 2963 separations (42.4%)
- 9) caudal peduncle ratio 1617 separations (23.1%)
- 10) scales long 1366 separations (19.5%)
- 11) scales trans 798 separations (11.4%)

10390 149%

If about 7000 of these 10390 separations (one species from another) all were different then each nominal species would be sufficiently (?) separated from all other nominal species by at least one morphological character. Much less than 7000 different types of separations were harvested from this analysis, as some form (RUR, ARN, GUS, PET, etc) were separated from most nominal species by eight characters -more or less- whereas other forms (SCH, INF, TES, PAS, etc. etc.) could not be separated from very many nominal species by a single character.

When this analysis was prepared some years ago, I prepared an analysis of the 10648 different separations that I had at that time (the "scales long" gave 1744 separations at that time because I calculated the specific variation to be 5 scales only). This analysis gave the following result: the figure given for each species or group of species indicates the number of nominal species from which that species (or group of species) could not be separated:

- 00: RUR
- 01: ARN
- 04: GUS, PET
- 05: FIL, GUI, SPL
- 06: COE, FAL, GAM
- 07: SRE, SJO
- 08: BEA, BIV, FAS
- 10: GUL, KIY

- 11: GRA, LAM, THI
- 12: CAL, WAL
- 13: ZIM
- 14: MEI
- 15: BAT
- 18: NIG, LOE, GAR
- 19: GER, MAG, UNS
- 21: BOU
- 22: AUS, ORN, RIG, RUS
- 23: LIB
- 24: PAP
- 25: CAB, DUB, ROL
- 26: BIT, SEN
- 27: DOR, SHE
- 29: LAB, NII, SIN, SPU
- 30: BEL, CAM, MUC, SEX
- 31: CIN
- 32: MUF
- 34: BAU, BIF, TAE
- 35: LOL, SUP
- 36: SPP
- 37: BRU, CHR
- 38: DEC, MAC
- 39: LON, NIM
- 40: JAC, MEL
- 41: ACU, OLB
- 42: ESC, LUJ, SPI, ZEN
- 43: AHL, CHA, LON, NIC
- 44: MAR
- 45: ANS
- 48: DEF, ELE, MIC
- 49: LOU
- 50: ANN, NYO
- 52: CAS, ELB, HOL
- 53: POL
- 54: FER
- 56: MAE
- 57: NOR, OBS
- 59: COG
- 60: CAR, CHE, CHI, JAU, UNC
- 61: OGO
- 62: MAT, PRE
- 63: LOB, NDE, STR

- 64: BUA
- 66: EXI
- 67: RUF, SPM
- 68: VEX
- 69: FLV
- 72: PAS
- 74: TES
- 79: INF
- 80: SCH

This means that TES cannot be separated from 74 different nominal species by one single of the eleven morphological characters studied above. Only RUR (Nothobranchius) can be separated from all nominal species at least by one character. There are three major reasons why a certain nominal species cannot be separated from other nominal species by morphological characters:

1) All characters for this particular species group near the center of variation for the group variation for these characters. This is the "average" species (for example TES)

b) The description for that particular species has been based on a single individual or on a few individuals only. For this reason the specific variation of the characters is low (for example TES)

c) The description does not correspond to "Boulenger's standard" description and the data of the description cannot be compared with data for species described after Boulenger's system. Or the description lacks important data (for example RUF).

Boulenger's "standard description" contains data which are not suited for a statistical analysis. These data however can be used for certain separations.

Position of the dorsal fin

Most descriptions publish data for the position of the dorsal fin. This character is related to the "D/A ratio" (dorsal fin/anal fin ratio = no. 8) and in some way also to the "number of dorsal fin rays". This character however may be calculated in different ways that makes comparisons difficult or even impossible.

Boulenger, Pellegrin, Ahl and others used to express this character in this way: first the distance between the anterior-most dorsal fin ray and the root of the caudal fin is taken as a unit of measurement. Then the "position of the dorsal fin" is published as the "number of times" that this unit of measurement reaches from the first dorsal fin ray to some point of the anterior part of the fish. This point of measurement may be the end of the snout, the anterior, central or posterior part of the eye, the end of the head or the root of the pectoral fin. Such a system is suited for identifications, but not for comparison and statistics as the various points of measurements of the head vary in individuals in relation to the standard length.

Poll uses a somewhat different system. He uses the distance between the anterior-most dorsal fin ray and

the root of the caudal fin as a unit of measurement as in Boulenger's system. Poll however fixes a certain point of measurement on the head (the end of the head) and for this reason his figures for this character normally are not whole numbers but a fraction. As the length of the head varies, these data cannot easily be converted into measurements that use the standard length as unit.

Lambert uses the same system as Poll. Lambert's fixed point of the head however is not the end of the head but the end of the snout. For this reason his data are easily converted into data which use the standard length as a unit. Also Ahl used this system for his description of ROL, whereas for other species he used Boulenger's system.

Fowler used a different system. He said that the first dorsal fin ray was situated above some fraction of the standard length. His data are easily converted into percent of SL, measured from the end of the snout.

I use to project the root of the anterior-most dorsal fin ray -along scale rows- on the central line through the median body side and to express the position of that dorsal fin ray in percents of the standard length measured from the end of the snout. For these measurements close-up photos of live or preserved individuals are used. In order to convert the data given by Boulenger, Poll etc. into percents of SL, calculations have to be used. The following formulae can be used:
R: is the number of times (whole number or fraction) that the distance from the first dorsal fin ray to the root of the caudal fin reaches into the distance from the first dorsal ray to "the point of measurement on the anterior part of the fish". Normally R = 1 or 2 or 3.
b: is the standard length of the body divided by the length of the head.
c: is the length of the head divided by the diameter of the eye.
d: is the diameter of the eye divided by the length of the snout.

%SL = 1/R+1 . (100.R) for "end of snout"
%SL = 1/R+1 . (100.R + 100/b.c.d) - "anterior border of eye"
%SL = 1/R+1 . (100.R + 100/b.c.d + 50/b.c) for "center of eye"
%SL = 1/R+1 . (100.R + 100/b.c.d + 100/b.c) for "posterior border of eye"
%SL = 1/R+1 . (100.R + 100/b) for "end of head"

When the "point of measurement" is the root of the pectoral fin, it is impossible to calculate the position of the first dorsal fin ray, as the position of the pectoral fin is not given in descriptions.

"b", "c" and "d" are not constant figures as these characters vary in descriptions. For this reason mean values were calculated, as only the extremes were published. Also R varies in Poll's system.

I admit that such calculations are complicated, but I found no other way to evaluate the data of descriptions, but to calculate in accordance to the formula. I had these results:

- 84%: DAG
- 83%: DAG, SHE
- 82%: DUB, SHE
- 81%: DUB
- 80%: DUB

- 79%: CHE, DUB, NIM
- 78%: NIM, ORN
- 77%: ACU, BIF, CHI, LON, MUF, NIC, SEN, TAE, ZEN
- 76%: ACU, BAU, JAC, MAC, MUF, SAN
- 75%: JAC, JAU, MAT, SUP
- 73%: BOU, NYO, SPI
- 72%: ANN, FAS, MAR, NIC, NOR, OLB
- 71%: AHL, ANS, CON, DEF, EXI, GRA, LOB, OBS, PET, SIN, STR, VEX
- 70%: DOR, ELE, MAE, PAS, PET, POL, UNC
- 69%: AUS, CAL, CAM, CAR, CHR, COG, DEC, FLV, LON, LOU, LUJ, MEI, MIC, PRE, STR
- 67%: BRU, GAR
- 66%: BRU, BUA, CAB, CAS, DOR, ELB, GAR, MEL, ROL
- 65%: BEA, BRU, GAR, GUL, HOL, MUC, NII, ROL, SPP, SPU, UNS
- 64%: BIT, FAL, GAR, GUL, HOL, MUC, ROL, SPP, SPU
- 63%: BIT, FAL, GAR, GUL, HOL, SPU
- 62%: GUL
- 56%: BAT, BIV, GER, LOE, PAP, RIG
- 55%: BIF, BIV, RIG
- 54%: ARN, BIV, FIL, RIG, SPL
- 53%: BIV, CHA, FIL
- 52%: BIV, FIL
- 51%: BIV, FIL
- 50%: BIV, FIL

The distribution of the nominal species is not even within the range of variation for the whole group. The reason for this grouping may reflect certain taxonomic units or that the different systems used to publish this character are not sufficiently exact and favor certain figures. From my close-up photos up to spring 1964 I had these data:

- 79%: SEN
- 78%: LON, SEN
- 77%: LON, SEN, SEX
- 76%: BIF, DAG, GRA, LON, SEN, SEX
- 75%: BIF, CHE, DAG, FAS, GRA, LON, MAC, SEN, SEX, SHE
- 74%: BIF, DAG, FAS, LON, SEN, SEX, SHE
- 73%: BIF, FAS, LAM, OLB, SEN, SEX, SHE
- 72%: BIF, CHR, FAS, LAM, OLB, SEX, SHE
- 71%: BIF, CHR, FAS, LAM, SEX, SHE
- 70%: BIF, CAL, CHR, FAS, LAM, SEX, SHE
- 69%: CAL, FAS, SEX, SHE
- 68%: AUS, CAL, COG, FAS, ROL, SEX, SHE
- 67%: CAL, COG, FAS, ROL
- 66%: COE, COG, LAB, NIG, ROL
- 65%: COE, COG, DUB, LAB, NIG, ROL

- 64%: BIV, CIN, COE, LAB, NIG, ROL, STR
- 63%: BIV, CIN, COE, NDI, NIG, ROL, STR
- 62%: BIV, CAB, CIN, COE, NDI, NIG, ROL, STR
- 61%: BIV, CAB, CIN, COE, NDI, NIG, ROL
- 60%: BIV, CIN, COE, GUL, NDI
- 59%: BIV, COE, FIL, GUL
- 58%: ARN, BIV, COE, FIL, GUL, SJO
- 57%: ARN, BIV, COE, FIL, SJO
- 56%: ARN, FIL, SJO
- 55%: ARN, FIL, SJO
- 54%: ARN, FIL, SJO
- 53%: ARN, SJO

Also this distribution of the nominal species shows some maxima. However, different taxonomic groups grade one into the other. DUB (65%) is separated from the main lot of Epiplatys (67-79%) which grades into the Aphyosemion subgenus (62-72%). The true Fundulopanchax exceeds between 53 and 66%, whereas the Callopanchax range from 53 to 68%.

The distribution of nominal species as calculated from descriptions had no species corresponding to the range 57-61% of standard length. The distribution of species according to my own measurements does not show any such extreme minimum at these figures. The reason for the uneven distribution from 57 to 61% SL probably is caused by the fact that the distance between the end of the head and the posterior border of the eye is rather large in most species and the individual variation of the length of the head is not able to "compensate" for this. The specific variation of this character probably will be 8 to 10 units. As the group variation is 27units (32 units according to descriptions) rather many "separations" will be possible if this character is used in systematics of West African Rivulins. However, as I said before, this character is not independent of two other characters (D/A and D).

The corresponding character for the anterior-most anal fin ray normally is not given in descriptions. I measured this character on my close-up photos and found a group variation for the species at hand to be from 54 to 67% of the standard length (SL). The specific variation was 7 or 8 units and for this reason not very many separations could be had from this particular character. Also most forms group within the range from 58 to 60% SL.

Length and shape of the caudal fin Most descriptions publish data concerning the length of the caudal fin. However, normally these data are not very exact (and probably normally they can not be exact, as these fin rays easily break) as it is said that this fin is (much) longer or shorter than the head, or equal to the head. As the length of the head is rather variable, these data cannot be used for comparison without calculations that will make the results even more inexact.

As my photos show large adults with unbroken fins, I have been able to make more exact measurements of the length of this fin. These measurements show that in Epiplatys (and Aplocheilus) individuals normally develop (much) longer caudal fin rays (central rays) than in Aphyosemion and Nothobranchius. For these measurements females are suited as in some species the male develops very long rays in this

fin. On males and females I had these measurements in "% of SL" (maximum values for this character).

Central rays:

- 44%: BIV (males)
- 43%: BIF, SEX
- 42%: unidentified Epiplatys of the GRA-MAC group
- 40%: LON
- 39%: SHE
- 38%: CHE, COE
- 37%: SEN
- 36%: DAG, GRA
- 34%: FAS
- 33%: OLB
- 32%: DUB, MAC +
- 31%: FIL
- 30%: GUL
- 29%: AUS, COG
- 28%: CAL, LAM
- 27%: ARN, NIG
- 26%: NDI, ROL, SJO
- 25%: CAB, CHR
- 24%: CIN, STR
- 23%: LAB

BIV and COE develop very long central rays in males (in BIV only in some strains). If the data published in descriptions are used we have this distribution (figures probably are not very exact). Also in this character DUB comes in between Epiplatys and Aphyosemion.

- 42%: BAU
- 36%: DEF
- 33%: ANS, BOU, BRU, CHI, FAS, GRA, LON, MAT, ZEN
- 32%: LAM
- 30%: BIF, DUB, EXI, MAR, MUF, NII, NIC, OLB
- 29%: BIV, CHE, CHR, DAG, DEC, JAC, LOB, LOL, LUJ, MAC, NOR, PET, ROL, SEN, SHE
- 28%: BEA
- 27%: BEL, CAS, DOR, FER, NYO, OBS, UNC
- 26%: CON, MAE, NIM, ORN, SAN, THI
- 25%: CAM, CAR, CHA, ESC, JAU, LIB, MIC, PAS, PRE, SUP
- 24%: BUA, CAB, GUL
- 18%: MEI

The values for BRU, ROL and CHR probably are too large. The value for CHA is too small.

Also the shape of the caudal fin (in males) is published in most descriptions. Within West African Rivulins the shape of this fin in females divides the whole lot of nominal species in two or three groups.

In Epiplatys (and Aplocheilus), in both sexes, the central rays produce a short lobe that is very distinct in all species which I have seen alive, except for DUB in which the produced central rays do not develop the distinct lobe. Also this character develops less in a pronounced way in the group Fundulopanchax (relatives of COE), but not in Callopanchax, Nothobranchius and Aphyosemion Aphyosemion. This particular "lobe", formed by the produced central rays in some species, very rarely is mentioned in descriptions.

In the male of some nominal Aphyosemion and Epiplatys some of the rays in the lower part of the caudal fin produce, forming a "sword" or "streamer". This development is rare in Epiplatys and in species I have seen, only DAG, CHA, SHE, SEX and CHE developed this character. In Aphyosemion also the upper rays produce normally or (STR) only these rays produce in males. "Streamers" apparently do not occur in the Callopanchax group of Aphyosemion (SJO, GUI, ROL, LIB, CAB, MAE, MEL, PET etc.), whereas this character is very common in the Fundulopanchax group of this genus, however in forms which grade between Fundulopanchax and Aphyosemion Aphyosemion (NIG, GAR, NDI, CIN etc.) the streamers are shorter or almost absent. In the subgenus Aphyosemion this character is highly variable, as the caudal fin is rounded in some males, truncate in other species and provided with long streamers in still other males.

Central rays of caudal fin produce (forming a distinct lobe?): ACU, ANN, BIF, CHE, DAG, DEC, FAS, GRA, LON, MAC, MIC, MUF, NIC, NIM, ORN, PAS, SEN, SEX, SHE, TES, according to descriptions.

The caudal fin is "pointed" in these species: ANS, BAU, CAL, CHI, DEF, FLV, LOE, MAR, MAT, MEL, NDE, NIM, NOR, NYO, OLB, RIG, SUP, UNC, according to descriptions.

The caudal fin is "subacuminate" in these species: DAB, DUB, FER, SAN, according to descriptions.

The caudal fin is "rounded-pointed" in these species: BEA, BEL, CAL, CAM, DOR, ESC, JAU, OBS, PAS, SHE, according to descriptions.

The development of "streamers" in males may differ considerably when males of different demes are compared. In Stenholt Clausen's.... and bred in my tanks, very long streamers developed in all males of the Ijebu Ode strain, whereas all males of the Meko strain developed very short prolongations of these rays or (most males) no prolongations at all. Also in CAL and FIL this character is very variable in males. For this reason this character probably is not very useful in systematics.

According to the descriptions the following different shapes "related to streamers" occur in the nominal species:

- Trilobate: AUS, COE, NII, POL, ZIM
- Lyre: ARN, BAT, BIV, CAS, ELE, FAL, FIL, GAR, LOE, LUJ, MUC, OGO, RUF, SIN, SPP, SPL
- Truncate: GUL, LAB, NIG, SCH, THI
- Rounded truncate: BEA, CAB, CIN, GUI, ROL, SPU
- Rounded with one streamer (at top of the fin): STR

Indeed these groupings of species according to the shape of the caudal fin is not very useful in

systematics. More details are given in the section dealing with the crossings.

Position of ventral fins Most descriptions publish data concerning the position of the ventrals or pelvics. These data however are not very exact. For 52 species it is said that the ventrals are situated midway between the root of the caudal fin and the end of the snout. This information probably is not to be considered as absolute, as my information indicates that the specific variation of this character ranges about "8 %" of the SL and that these fins normally are not situated midway between the root of the caudal fin and the end of the snout, but closer to the latter than to the former. I found this distribution of species:

- 52% SL: OLB
- 51% SL: COE, FAS, OLB, SEN, SEX
- 50% SL: CIN, COE, FAS, LAM, LON, NIG, OLB, SEN, SEX
- 49% SL: CIN, COE, FAS, FIL, GUL, LAM, LON, NIG, OLB, SEN, SEX, SHE, SJO
- 48% SL: ARN, BIF, BIV, CAL, CIN, COE, DAG, FAS, FIL, GUL, LAB, LAM, LON, NDI, NIG, OLB, ROL, SEN, SEX, SHE, SJO, STR
- 47% SL: ARN, BIF, BIV, CAL, CHE, CIN, COE, DAG, FAS, FIL, GRA, GUL, LAB, LAM, LON, NDI, NIG, ROL, SEN, SEX, SHE, SJO, STR
- 46% SL: ARN, AUS, BIF, BIV, CAL, COE, COG, DAG, FAS, FIL, GRA, LAB, LAM, MAC, NDI, NIG, ROL, SEN, SEX, SHE, SJO, STR
- 45% SL: ARN, BIF, BIV, CAL, CHR, COE, COG, FAS, FIL, GRA, LAB, NDI, NIG, ROL, SEX
- 44% SL: ARN, BIF, BIV, CAB, CAL, CHR, DUB, FAS, GRA, NIG, SHE
- 43% SL: BIF, BIV, CAB, CHE
- 42% SL: BIF, BIV, CAB
- 41% SL: CAB
- 40% SL: CAB

For this rather limited material I found these specific variations:

- FAS: 8
- BIF: 7
- BIV: 7
- NIG: 7
- SEX: 7
- SHE: 7
- SEN: 6
- ARN: 5
- CAB: 5
- CAL: 5
- FIL: 5
- LAM: 5
- OLB: 5

As the group variation is 13 units only it is likely that not very many separations can be obtained from this character. I found no coherence between this character and the length of the head, whereas some coherence probably exists between the position of the ventrals and the position of the anterior-most anal

fin ray.

Descriptions published this information:
Distance from end of snout to base of ventrals in percents of SL:

- <<50%: LOL, SAN
- < 50%: BAU, BEL, CAR, CON, JAC, MIC, NYO, ORN, PAS, RIG, SUP, TES, UNS
- <=50%: BIV, BOU, CAM, ELE, ESC, MEL, NOR, SIN, TAE
- =50%: ANS, ARN, AUS, BAT, BIF, BIT, BRU, BUA, CAB, CAL, CHI, CHR, DEF, DOR, ELB, EXI, FAL, FAS, FER, FLV, GAR, GRA, GUL, GUS, JAU, LIB, LOB, LOE, LON, LUJ, MAC, MAE, MAR, MUC, MUF, NII, NIC, NIM, OBS, OLB, PAP, PET, POL, PRE, ROL, RUS, SCH, SJO, SPP, SPU, STR, THI, UNC, VEX, ZEN, ZIM
- >50%: BEA, COG

If this character should be taken into consideration in the systematics of West African Rivulins the data for this character should be more exact, as the data mentioned above do not support any differentiation between nominal species.

Length of rays in pectorals, ventrals, dorsal and anal fin
Most descriptions publish information concerning the length of the pectorals and the ventrals and the longest ray in the dorsal and anal fin. The length of the pectorals often is given as the relative length compared with the length of the head and also it is said that this fin reaches (or does not reach) the root of the ventrals. The length of the ventrals is given in relation to the anterior-most anal fin ray (reaches this ray or does not reach this ray). I do not think that the length of the pectoral fin has much importance in the systematics of these fish. Indeed some rays of this fin produce considerably in some species, but the individual variation is large. In Fundulopanchax the males often use this fin to guide the female in pre-mating display and for this reason the lower rays often produce. Produced pectoral rays as occur in Epilatys. In ANN (Monrovia and Kasewi strains) the male may develop very long pectoral rays. In a still unidentified relative of BIF the male may develop extremely long pectoral rays that may reach beyond the last ray of the anal fin. Such development however is rare and this character probably only has importance as a supplemental character.

The length of the ventrals in males probably is more important. This fin does not produce in Aphyosemion and Nothobranchius (except for SPL). Also in Epiplatys this development is rare. In SEX from Nigerian localities west of the Cross River drainage males normally develop long ventrals. Apparently males of SEX from Cameroon and Gabon never develop long ventrals. Produced ventrals also occur in LON and LAM and in some derivates of FAS. In African Rivulins produced ventral fin rays occur in males only, whereas in Aplocheilus (LIN and DAY) this character occurs in both sexes. Dorsal and anal fin rays may produce in males of Aphyosemion and Epiplatys. As I have already mentioned for the streamers of the caudal fin, produced dorsal and anal fin rays often are an individual character of the deme. BIF from the Niger drainage normally does not develop streamers at the anterior corner of the anal fin, whereas this character is common in BIF from the Volta drainage and in Sierra Leone demes. In the common aquarium strain of DAG (the E. dageti monroviae subspecies) males do not develop a much-pointed anal fin. Stenholt Clausen's strain 1965 of this form, caught at the locality from where the old (1908) aquarium strain probably originated, indeed develops such streamers in some males. As I already

pointed out for Stenholt Clausen's 1962 strain of BIV from S. Nigeria, large variation in the development of produced rays of the caudal fin is evident. This is also true for the posterior rays of the anal and the dorsal fin in this species. On my own material I measured maximum lengths of produced dorsal and anal fin rays in males (given in percent of standard length of the body):

Dorsal	**Anal**
88%: BIV	63%: BIV
32%: FIL	42%: BIF
31%: CAL	38%: CHR
30%: CHR	35%: LON
23%: AUS, LON	30%: SHE
22%: ARN, COE, GUL, NIG, SEX, SHE, STR	29%: DAG, SEX
21%: BIF, COG, FAS	28%: OLB
20%: NDI, OLB, ROL	26%: GUL
19%: CAB, DUB, SJO	25%: CHE, FIL
18%: DAG, LAB	23%: ARN, COE, SJO, STR
17%: SEN	22%: CAL
16%: CHE, CIN, GRA, LAM	21%: AUS, DUB, FAS, NIG
15%: MAC	20%: COG
	19%: LAM, ROL, SEN
	18%: NDI
	17%: CIN, LAB
	16%: CAB, GRA
	15%: MAC

Further characters of "Boulenger's standard description"

For most species it is said that "the head is flat above", "the mouth is directed upwards", "the lower jaw is projecting". This information probably has no systematical importance at all. It is also said that "the preorbital is very narrow", but so it is in all nominal species (character of this subfamily). Most descriptions also say that "the lateral line is represented by an interrupted series of pits". Also this character probably is of no importance in this group of Rivulins. No descriptions publish any information on the very well developed lateral line system of the head. It is a pity that rather many descriptions do not publish information concerning the exact locality from which the types originated, as this "character" probably has more importance than any other information given in descriptions. About 20% of the nominal species have been based on aquarium kept individuals of unknown origin and "West Africa" or "Tropical Africa" is the only information given on the type locality. "Colors and color patterns" are considered later.

Conclusion

This formal study of information given in descriptions of West African Rivulins has made quite clear to me that the principles on which most nominal species have been based are not sufficient to support the maintenance of rather many of the nominal species. I have based this study on "typological thinking" in the sense of E. Mayr (Evolution and Animal Species, 1963) and I have taken it for granted that "species are characterized by their differences from other species".

These findings may be used in one of two ways. One may make a lot of nominal species synonyms of previously described (also ill defined) species or one may try to disclose further reliable characters to support the maintenance of at least some of the nominal species which can not be maintained on the criteria so far used. From the point of view of an engineer, E. Mayr's definition of the word "species" is just what we want. Mayr says: "groups of actually or potentially interbreeding natural populations which are reproductively isolated from other such groups". Not a single word is said about "differences" in morphology in this definition of the "unit": the species. As crossings may give away certain information about "reproductive isolation from other forms" I should like to inform you on the results of the crossings which I studied since 1957.