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Crossings Part 1: Rivulinae Myers in Cyprinodontidae

This report deals with crossings between individuals belonging to different taxonomic species of Rivulins (subfamily: Rivulinae Myers in the family Cyprinodontidae or "egg laying tooth carps" or "killies"). For the crossings, African and Asian species have been used. Most crossings deal with West African species as the crossings are used in the research on this group of Rivulins that Stenholt Clausen and I are cooperating in. My crossings of species in Nothobranchius and Cynolebias-Rivulus are not taken into consideration in this report. The Asian species - all belonging to the genus Aplocheilus McClelland - are taken into consideration because these species are probably close relatives of the African Epiplatys.

Since 1962 various crossings of individuals belonging to different demes or populations of one species have been studied and the results of these particular crossings probably are of great importance as a supplement to the results from the inter-specific and inter-generic crossings. The purpose of these crossings has changed much through the almost ten years within which the crossings were produced and studied. At the beginning I was interested in the production of new and colorful strains of aquarium-kept species. As such hybrid strains have been produced with much success in the Gambusinos (the family Poecilidae), I thought that it might be possible to combine various genes for handsome color patterns also in Cyprinodontidae. I soon learned that fertile hybrids could not normally be produced in Rivulinae. Indeed many hybrids were not even viable. Dr. J.J. Hoedeman of the Amsterdam Zoological Museum however became interested in these crossings and animated me to continue to produce new types of hybrids within this group of fish. For this reason many of the hybrids produced during the first few years are now in the Amsterdam Museum and I am not able to publish morphological data concerning these individuals. After his return from Nigeria in 1959, Stenholt Clausen took over Hoedeman's place and from now on the crossings were concentrated on West African Rivulins. My strains of Nothobranchius and South American Rivulins were delivered to other aquarists, whereas the Asian species were maintained.

Most preserved material of hybrids and the parent species are, for the present, in my own collections. They will be placed in the Copenhagen Zoological Museum when our research on Rivulins has been finished. Many eggs containing abnormal hybrids which died in eggs were sent to Dr. W. Wickler (Max Planck Institut fur Verhaltenspsychologie, Seewiesen) to be used in his research on eggs from Cyprinodontidae: AUS/CHR, AUS/COG, AUS/PET, CHR/PET, COE/NIG, DAG/CO, DAG/LIN,

NIG/LAB, NIG/NIG.COE, PET/COG, PET/DAG. All other eggs containing abnormal embryos are in my own collection in Bouin's fluid.

The keeping and breeding of the parent species

Some West African Rivulins are easily kept and bred, whereas other forms request a constant challence to the skill of the aquarist. When the parent species comes in from Africa they are at once placed in aquaria containing the usual hard and alkaline Copenhagen tapwater (salinity 300-500 ppm, temporary hardness about 15 German degrees, pH>7.6). All tanks have a one-inch deep layer of fine peat or mud. Such water is very "unnatural" for these fish, but I found this type of water etc. to be the best to use during the first few days or weeks. If these fish are placed in water that, in most measurable details, corresponds to the natural waters of West Africa they often will be killed by various diseases. Probably the "unnatural" water will harm the disease- producing organisms more than the fish themselves.

Many species will not be able to reproduce in the hard and alkaline water. Most eggs are not fertilized and fertile eggs will be ruined sooner or later. I found that if the calcium and magnesium ions were exchanged by sodium ions some improvement was obtained, but still many eggs containing live embryos were ruined as the egg membrane decomposed. If the pH of the water was changed by adding of a sufficient amount of hydrochloric acid to eliminate all hydrocarbonic and carbonic ions, the eggs developed and hatched normally. This means that two water types or aquarium types had to be used. One water type: hard and alkaline, was used to "store" the parent species and to raise the fry, whereas the other water type: soft and acidic, was used for spawning, crossings, and storing of eggs.

In order to control the egg membrane for "leaks", 1-2 ppm of methyleneblue (tetra-methyl-thionine chloride) is added about 12 hours after the spawning and harvesting of the eggs. After this length of time the egg membrane should not permit any penetrating of the dye through the membrane. If eggs take up the dye the egg membrane probably is not in good order and difficulties will develop which in most cases will kill the embryo. The methylene-blue dye also in some way protects the eggs against bacteria and fungus. The peat used for these tanks has been in such use for many years. When the peat becomes "dirty" it is regenerated, first in a strong solution of soda for one week or more, and then in a strong solution of hydrochloric acid in water. After a short washing the peat is again ready for use as all or most adsorbed compounds are removed by the strong alkaline or acidic solutions.

Individuals belonging to the parent species are kept in small (15-20 liters) glass tanks, each containing one or two pairs. All fish are fed live food which I raise myself: daphnia, fruitflies, rainworms, various mosquito larvae. The fry are raised on brine shrimp and/or rotifers.

Preparing the individual fish for crossings

For practical purposes it is desirable to have a large number of eggs from one single crossing act. This makes the control, the comparisons and the bookkeeping easy. A large number of eggs often can be obtained from crossings in Aphyosemion and, in particular, Fundulopanchax, whereas in Epiplatys and Aplocheilus one normally cannot get sufficient egg numbers from a single spawning because the individuals will not spawn. One week or so before the crossing the females that should be used in the crossings are isolated single in separate tanks under heavy feeding on the best live food (if possible black mosquito larvae are used - Culex). Often adult females need much food in order to produce sufficient egg

numbers. When the female is ripe her belly is swollen and reddish and she may develop the "spawning-color-pattern" of that species.

Males to be used in crossings are kept together with other males or with females of the species to which they are intended to be crossed. If these males are kept single they often will develop aggressive characters to such extend that they will fight and kill any female, even in case she invites for spawning. Males from Fundulopanchax often will not discriminate and such males might be taken directly from tanks containing females their own species. They will at once spawn with any female from related but different species. Males from Epiplatys and Aplocheilus and some groups in Aphyosemion often are not at all willing to spawn females from different species. These males often need a long time of training before they accept such females as partners in spawning. For this reason the partners are placed together in well-planted separate tanks until it is evident that they are spawning.

In Rivulins the female approaches the male when she wants to spawn and it is the female normally who discriminates. In Epiplatys and Aplocheilus both sexes however may discriminate. They may fight each other for weeks or pay no attention at all to the other individual. Some combinations of species in this group probably will not produce natural crossings. The two sexes might be kept together for months under heavy feeding without a single spawning act. Sometimes it appears as if females do not produce eggs under such conditions. For these reasons, females that have been trained in crossings are most valuable as they can be trained to accept any sort of male. Most of the crossings, in which a COG female was used, were produced by a single female that after months of use in crossings even spawned a big SJO male without any hesitation.

All crossings have been "natural" spawnings. First because much information can be harvested from the behaviour of the individuals in these crossings, second because such crossings are "good sport" for the aquarist.

The crossing act

Small tanks are useful when species in Aphyosemion are crossed. If possible the "pair" should be watched over during the crossing and at least until spawning has started. There will always be a great risk that the female will not accept the male at once and in such a case the male may kill the female in short time. Changes of color patterns should be noticed (Epiplatys, Aplocheilus and some species in Callopanchax) as these "signals" or exchange of stimuli may differ from those produced during infraspecific spawnings.

Rivulins (except for Trigonectes) do not develop any social character and even the fry does not shoal. Individuals of all ages will fight each other if they are not trained to crowded conditions. For this reason ripe females of these species often develop certain color patterns or certain behavior when they approach matured males. These color patterns developed by females (most species in Epiplatys and some in Aplocheilus and a few Callopanchax in Aphyosemion) correspond to color patterns developed during fear. The normal "spawning color patterns" in this group of Cyprinodonts is a broad lateral band of black color. This band develops on the body sides from the gill covers (eye, snout) to the root of the caudal fin (into that fin in Aplocheilus lineatus = LIN). In some species also males that lose a fight develop this

marking. This "prespawning pattern" however is not compulsory in some species (SEX, CHA) and is not (?) used in other species (LIN, DAG) except for crossings. In a few species (BIF, BIV) this dark pattern is visible also when the individuals are not spawning, fighting etc. Males of BIF and BIV however lose this marking during spawning and fight and also fighting females lose this particular marking.

Females in Callopanchax (SJO, GUI, ROL, LIB etc.) develop a certain dark spot anteriorly on the throat in premating display. In SJO this marking comes and goes in connection with the development of the dark lateral band that does not develop in (some strains of) LIB and ROL. These particular stimuli probably correspond to the lateral band in Epiplatys and Aplocheilus.

Males from many species: most Epiplatys, all Callopanchax, CIN in Fundulopanchax and AUS in Aphyosemion Aphyosemion develop a very dark color all over the lower part of the head in prespawning display. This particular pattern often also develops during fight. Generally males from all species in Old World Rivulins develop more melanophores on the lower part of the head than females do. However, in many species these melanophores apparently are not used to produce the total blacking of the lower part of the head during display.

These stimuli of Epiplatys and Aplocheilus probably are one reason for the difficulties found in the preparations of crossings within these genera. Dim light or light from below often proved to be useful to decrease the discrimination of individuals.

Tanks for crossings contain water and some nylon only. This makes the harvesting of eggs easy and eggs do not adhere particles to their surface that makes inspection easy. For combinations that are thought to render easy spawning so called "nylon wool" is used. If the crossing is supposed to take more time the so called "Scheidnass mop" comes into use. Jack Scheidnass from Philadelphia (who first taught me Rivulin keeping) made these "mops" from coarse nylon "woolen yarn" forming a big tuft. In this mop the eggs are hidden and the fish will not be able to eat their eggs. For some of the bottom spawning species (Callopanchax and Fundulopanchax) very fine mud often is used. Such mud should be boiled in advance because it may contain hibernating eggs from annual Rivulins. After the spawning all or some of the eggs are strained out from the mud and placed in water for control.

For crossings of Epiplatys or Aplocheilus larger planted tanks are often used. As these species normally will place their eggs near the surface of the water, plants should reach the upper water layers and a floating nylon mop is used. The female now is able to hide in the plants near the bottom until the individuals become used of each other.

Care of eggs

Eggs normally will not stand any handling just after the spawning. A certain time is needed before the egg membrane becomes sufficiently hardened. For this reason the eggs are left in the tank used for crossing for six to twelve hours. After this time they will stand handling and can be harvested from the nylon using your fingers gently. Eggs are now stored in 200 milliliter glasses, airtight closed, but containing sufficient air to supply oxygen to the eggs. I had many eggs spoiled from vapors from isopropanole or ethanole which entered into such glasses not closed by airtight lids when photographing preserved fish.

Methyleneblue is added to the water (1-2 ppm) to control the egg membrane for "leaks" and for protection. Eggs are inspected twice a day during their first week in order to remove any nonmaturing of the eggs if several nonfertile eggs develop. Nonfertile or dead eggs will take up the dye and if the glass is held over a white surface such eggs are easily seen. About twelve hours after the spawning the eggs are controlled for blastula. For this control a strong magnifying glass is sufficient. The eggs are taken into a small burette that is held against some strong light. When the burette is "rolled" between fingers eggs can be inspected from all sides. Later on, the microscope is used for controlling the development of the embryo and in particular for control of the development of the blood system. 100-150 x is sufficient.

It is important not only to mark the glasses according to the code for the crossing but also for the date of the spawning. Otherwise one probably will forget to force the eggs to hatch if they do not hatch in a natural way when they are ready to hatch. As embryos from crossings often develop very slowly it may take up to four weeks before they are ready to hatch. Normally two or three weeks are used to mature the eggs.

The daily control of the eggs will expose these to sudden changes of temperature and light. These stimuli will act on mature embryos in the way that they will start their circulation of blood that in many species will be completely stopped at that phase of development. These stimuli will exhaust the embryo sooner or later and it will not be viable when hatched.

Ripe eggs normally will hatch if the concentration of oxygen around the eggs decreases below certain (unknown) values. I have used water containing decomposing organic matter ("dry food") to force eggs to hatch. Indeed this method often will be very dangerous to the embryo and several times many embryos are killed. Eggs from some species (Fundulopanchax, but also ANN) are very difficult to hatch, independent from the method used for forcing the hatching. One may add a small amount of dirty mud to the glass and after the precipitation of the mud particles the eggs may hatch or be killed. Eggs from annual Rivulins may need several months to become ripe. During this length of time, the egg membrane might be ruined by bacteria or fungus if eggs are kept in water (for control). In such a case I prefer to keep most eggs in moist peat ("as smoking tobacco") and to keep some eggs for control in glasses in water. Eggs are stored at 22-24 C all the year round. A fine study on egg development in Rivulins is found in N. Peter's "Embryonale Anpassungen oviparer Zahnkarpfen..." in Int. Rev. Ges. Hydrobiologie, vol. 48, 1963, pages 257-313.

Abnormalities during the early development of the hybrid zygote

During the development of the hybrid zygote in the egg several abnormalities may occur. These abnormalities often will kill the zygote sooner or later. As I have not had time to study common embryology and as I have not had the equipment to be used for such a study of abnormalities I will only be able to describe these abnormalities in my own words.

Abnormalities that occur just after the spawning are difficult to trace. First, because eggs should not be handled too early, and, second, because such research probably cannot be made with the primitive tools of the amateur. It is important to be able to distinguish between "live eggs" and "dead eggs". In the group of "live eggs" one should be able to distinguish between "nonfertile live eggs" and "fertilized live eggs". I

consider the eggs as "alive" when I am able to trace a space between the yolk and the egg membrane. This means that the yolk membranes are unbroken. Between the yolk and the membrane the "white" is seen. When the "white" is not seen, the eggs are considered "dead" if the species concerned does not spawn eggs that have very little "white". Some hybrid females do spawn such eggs. I consider the egg as "alive and fertilized" when I am able to see a real blastula. In some crossings "pseudo blastula" occur. This is a "blister" which develops at the animale pole. In the microscope the blastula is clearly divided into several cells. Not so in the "pseudo blastula". Normally an egg that has not been fertilized (sterile hybrid males used) will become a "dead" egg within 24 to 48 hours. Not so in some annual Rivulins. Eggs of these forms may stay alive and "unfertilized" for up to one week or even more. This fact makes things difficult indeed.

It appears as if in some crossings the egg will not "close" after the spawning. The egg takes up dye and develops a real blastula, but very soon the egg is ruined by bacteria etc. In some crossings (AUS/DAG, CAL/MAC and some of the BIV/BIV backcrossings) I failed to discover any blastula. In my opinion, however, these eggs were fertilized and they did not decompose after "normal" length of time. See BIV/BIV (cross no. 15, UM/LA males backcross). Probably some of the crossings that are not considered in this report because apparently there was no fertilization belong to this type.

Some blastula (SEX/LIN is an example) appear to be built up from very large (abnormally large) cells. After the blastulation the developing zygote spreads over the surface of the yolk. After the development of the multidish it might be difficult to see the zygote until it reaches the equator of the yolk. At this phase of the development a deep groove often occurs on the yolk and deforms the egg. After this phase the groove disappears completely and it is extremely difficult to watch the embryo. The eggs look as if they were "just spawned". In this phase eggs of some of the annual species hibernate. See NIA/SPU and GUL/SPU. Eggs from crossings in Nothobranchius (several combinations) and in Cynolebias (all combinations!) that are not reported in this paper did not develop beyond this phase. The eggs remained transparent ("alive") up to one year and then decomposed.

About three days after the spawning the "corda" normally will be visible in eggs. When the corda appears it measures about 90 degress on the equator of the yolk. In some crossings the development does not continue beyond this phase or this phase does occur in a few eggs only. The eggs rest in this phase for days or weeks before they decompose: CAL/ROL, CHE/SEX, LIB/NIG, MIL/NIG, ROL/NIG, SJO/COG and THI/ARN are examples.

The viable hybrid embryo however normally will reach 180 degrees on the yolk within one more day. At that point of development further abnormalities may occur. Eggs from some African annual Rivulins (Nothobranchius and a few Fundulopanchax) hibernate in this phase for weeks or months. See ARN/SPU.

Having reached 180 degrees on yolk the tail of the embryo normally will continue its growth along the "equator" of the yolk. Many hybrid embryos are not able to do this and the tail turns to the side, often at a right angle and the embryo "curls up". In this situation (which may occur in the parent species -less marked) the body of the embryo forms a "spiral" at one end of the egg. Normally the development of the blood system on the yolk will be insufficient and the development of the embryo will take more time if it

proves to be viable. The reason for this "curling up" of the tail of the embryo probably is found in the development of a groove for the tail on the yolk. These embryos often are not situated in any groove, but "sits" on the yolk. Curling up of the embryo often is an indication of severe abnormalities to come in the following days. Some of these embryos may hatch indeed, but often their backbone is deformed to such an extent that they are not able to move or swim.

In several crossings (see CAL/SEN, FAS/DAG, PAN/LIN and SEX/LIN) a strange abnormality occurs at this phase of development or a little earlier. In these eggs (not always in all eggs) the outer membrane of the yolk rises and forms a blister. Apparently the space between this membrane and the inner membrane of the yolk becomes filled up with some liquid, thus forcing the outer membrane to rise. Sometimes this blister reaches the size of the yolk ball itself and the egg membrane may burst from this deformation of the interior parts of the egg. Sometimes the blister is much smaller or does not occur at all in some eggs. If an embryo is formed it will be situated with the anterior part of the body on the blister and the tail on the yolk. From the throat of the embryo a thin vein crosses the interior of the blister and reaches the center of the plane formed by the inner membrane that separates the blister from the yolk ball. Sometimes this vein pulsates and moves the inner membrane gently up and down. Normally the vein contains no blood elements, but in some eggs a few elements may move through this vein. In these cases the embryo soon stops growing, but it remains alive for many days or a few weeks. During this time more and more dark pigments develop on the yolk and the blister.

Abnormalities in development of the blood system in hybrids

These abnormalities occur so frequently among hybrid embryos that they probably represent the main reason why embryos die in eggs. The development of a good blood system may fail if the egg is too big. See NIG/LAB. Eggs of NIG measure about 1.0 mm (Akure strain), whereas that of LAB may reach 1.8 mm. This means that the LAB egg contains up to six times the volume of the NIG egg. Bad development of the blood system in connection with the "curling up"... (cannot read last line).

An interesting -not lethal- abnormality in the development of the blood system occurred in the BIF/BIF population cross. When the males of this cross were backcrossed to females of one population the development of the embryo was normal up to the eighth day. Now the "heart broke down" and the blood was not able to circulate during the next few days. After this time the heart again recovered and the circulation in most eggs was normal again.

A different -normally fatal- abnormality occurs in many crossings and backcrossings. I have called this abnormality the "thrombus. A thrombus may develop in this way: at some point of the yolk or in the body of the embryo a few blood elements are heaping up and do not move. Apparently the serum still circulates through the "thrombus" and more and more blood elements are stopped at that point that soon looks like a big red mass. The concentration of blood elements decreases in veins and the circulation becomes slow in spite of the strong beats of the heart and the increased pulse. After some days all elements are stored in one or more big red masses on the yolk and/or in the body of the embryo. After more days the pulse decreases and the beats of the heart become weak. After more days the heart stops completely and the embryo now may live for several days before it decomposes (or is preserved). Such a thrombus often occurs at the extreme end of the tail. Sometimes the whole blood system is not blocked up by such thrombus and there is normal circulation in some parts of the body.

A different -and for many species normal- complete stoppage of the blood circulation occurs when the embryo is almost ripe for hatching. This is a normal situation and the blood circulation will start again if the embryo is exposed to light or heat. The start then will come after some minutes (annual Rivulins) or seconds (nonannual Rivulins). This complete stop also occurs in Epiplatys, but probably not in all species. In case of such a stoppage of circulation, the blood elements will be evenly distributed in the veins. After a certain time in light the heart will start moving. First the elements will not circulate but move till and fro.

Other abnormalities in the late development of the hybrid
Deformations of the embryo are difficult to trace when the embryo is still in the egg. In the AUS/CAB and SEN/PAN crosses, the head and the tail of the embryo were distinct, whereas the central parts of the embryo could not be seen, diffuse tissues. In some crossings (BIV/BIV and NIG/LAB) the body of the hybrid embryo became swollen and water-filled and more or less transparent. Deformation of the jaws occurs in DAG/COG and NIG/COG.

Care of hybrids after hatching
When the development of the hybrid takes place in the egg the observation of the development and the abnormalities are not very difficult and the conditions could be made rather uniform and constant. When the fry hatches out this control is lost for some time. The fry stay in the glass until they are able to swim. In the BIF/SEN cross the fry hatched normally, but they were not able to move. All die after some days. The swimming fry is placed in tanks containing hard and alkaline water. If possible the brood is divided into two or more groups that are placed in different tanks of their own. These tanks should offer the best possible conditions to the young fish that often are very feeble during the first days. If plants and bottom peat are used one should be very careful not to bring hibernating eggs into the tank. The hybrids first are fed brine shrimp (Artemia) and/or rotifers. Every day the fry are inspected in order to discover attacks by "velvet" (Oodinium), the pest of young Rivulins. Some broods of hybrids die during this first critical period of their life.

When the fry have reached about 10 mm total length the first crisis is over and the young fish do not hide so much between plants or in corners. Attacks of Oodinium are more easily seen and cured. When the young fish starts maturing the next severe crisis may occur. This crisis also occurs in the parent species, at least in some. Heavy losses may occur during this period of development, but normally at least some hybrids will recover. After maturing the hybrids normally will develop to hard fishes that are easier to keep.

Further codes used in crossings

- DAY = Aplocheilus dayi (Steindachner) 1892
- BLO = Aplocheilus blocki (Arnold) 1911
- LIN = Aplocheilus lineatus (Cuvier & Valenciennes) 1846
- PAN = Aplocheilus panchax (Hamilton-Buchanan) 1822
- SL4 = Aphyosemion "species no 4" in Roloff's collections from Sierra Leone, 1962, Kenema area
- MIL = Rivulus milesi Fowler, 1941, aquarium strain (Golden Tail Rivulus)

- NDI = Aphyosemion species from Ndian River, Cameroon. Stenholt Clausen 1959
- NIA = Aphyosemion species from Niari River, former French Congo. Brichard & Roberts 1964

Codes for localities are composed by two capital letters and are added to the code for the species in this way: BIV-LA = Aphyosemion bivittatum from Lagos. The AQ stands for "aquarium strain" of unknown origin.

Codes for hybrids

The cross and the hybrid are coded in this way: MIL/NIG is the cross between a male of MIL and a female of NIG. This code might be changed to MIL.NIG if backcrossings are made. NIG.COE/NIG indicates the backcross of a NIG.COE or NIG/COE male hybrid to a female of NIG. If an F2 generation is produced this is coded NIG.COE/NIG or NIG.COE-NIG. BIV-BE/PO is a population cross in A. bivittatum. A male from Benin City (delta area) has been crossed to a female from Porto Novo in Dahomey.

(1) ARN/FIL 1961

These two species are very closely related and form a certain small group in Fundulopanchax. This group is characterized by a negative D/A value (see pages before) reaching "-5A" and a rather low value of scales in a lateral series (pages before). By the unit "Fundulopanchax" I mean "close relatives of COE" and this original d efinition excludes such forms as BIV and LAB which have been placed (described) as belonging to this subgenus in Aphyosemion. Fundulopanchax are characterized not only by their D/A value (-5 to +6A) but also by ctenoid scales in males. ARN is known from the Niger Delta area only. The type came from Warri in the western part of the area. My livestock originated from Wokocha River near Port Harcourt in the eastern part of the distribution area. Stenholt Clausen has preserved individuals from Sapele near Warri. These individuals correspond well to the aquarium strain, collected by Ulf Hannerz in 1961.

FIL is known from SW Nigeria only. The type (aquarium fish) was said to originate from "Togo" (Lome), but the species has not been reported from that area by zoologists. My strain for crossings was a mixture of different strains in the aquarium trade and a strain that Stenholt Clausen caught near Ijebu Ode in 1959. No abnormalities were discovered among the "hybrids" produced from these different strains. See Aquarium Journal 1963 (Scheel: A. arnoldi) page 162 ff. Stenholt Clausen has many preserved individuals from this area. The range of this species at least goes to Abwokuta in the west. Aquarium-kept individuals of this species very often are called ARN.

ARN and FIL do not differ in measurements and counts. Constant differences are found in color patterns and more marked in egg patterns. Generally FIL is a more robust fish that develops a deeper body. The ctenoid in scales is very marked in males and extends all over the central and lower part of the body, thus producing a marked development of sensory papillae in the anal fin, the upper rays of the pectoral fins and sometimes also in the ventrals. The crossing took place on fine mud and after some weeks seventeen fertile eggs were harvested. These eggs developed without visible abnormalities and very viable hybrids hatched. The young hybrids were raised without difficulties and males matured at an age of three weeks (after hatching). Females spawned at an age of four weeks. This rate of development is normal for small species in Fundulopanchax and Nothobranchius. During maturing the young hybrid males developed an intense orange red color all over the lower parts of the body and in the lower fins. This brilliant color

corresponds to ARN males of that age, whereas in FIL only a very weak orange color may develop in young males. The handsome orange red color however soon was lost and instead a brilliant blue color developed on the body sides, as in FIL.

Males of ARN differ from males of FIL by the red pattern of the anal fin. In FIL (all strains which I had since 1953) a broad red band develops near the center of the anal fin. This band does not develop in ARN males. Most hybrid males developed this band completely, but in some males this band was broken. Males of ARN develop a rather narrow red band near the upper edge of the caudal fin. In FIL, this band is replaced by a line of red dots. Hybrid males developed the ARN pattern, but in some hybrids the band was not complete. When the hybrid males were full size, this band was the sole marking which distinguished them from adult males of FIL. Also in the shape of the body the hybrid males were just like FIL males.

Females of ARN and FIL are easily distinguished by the trained aquarist. The hybrid females were just like females of FIL. No differences were detected.

At an age of about six months the hybrids were very difficult to keep (tuberculosis?) and I lost most females. I was able to keep alive one male up to an age of eleven months.

In my opinion a very marked difference exists between ARN and FIL if the eggs are studied. The eggs of both species differ from all other species of Aphyosemion and Epiplatys as they do not adhere particles to the egg membrane or to the egg filaments. This is a character found in all species of Nothobranchius that I studied so far. Eggs of ARN and FIL differ from eggs of all species in Nothobranchius by the pattern of the egg membrane. In ARN and FIL the membrane develops a very marked reticulated pattern. This is a character of Callopanchax (all, except for PET), Fundulopanchax (rather variable) and very weakly developed in some species of the subgenus Aphyosemion and of Epiplatys. Eggs from Nothobranchius never develop even traces of this particular pattern.

Eggs of ARN differ from those of FIL by the size (1.0 in ARN, 1.3 mm in FIL) and by the development of "filaments" on the egg membrane. Eggs of FIL may develop a few long filaments near the pole or such filaments may be absent. Eggs of ARN develop short rather stiff "hairs" on the membrane. The hairs are evenly distributed. I have studied eggs of all the many species of West African Rivulins that I kept. No species develops the hairs seen in ARN. All species of Nothobranchius develop such hairs. Indeed I am not indicating that ARN is the "missing link" between Aphyosemion and Nothobranchius. See also cross 82, THI/ARN.

The hybrid females spawned, but their eggs could not be fertilized by their brothers, nor by males of the parent species. The eggs measured about 1.0 mm (as in ARN) and no variation in size was noticed (eggs from hybrid females often vary considerably in size). The pattern of the egg membrane did not correspond to that of the parent species, as the reticulation was "broken up" as in COE (sometimes) and SPU. The "hairs" found on the eggs of ARN were present, but they were much longer and corresponded more to the filaments near the pole found on some eggs of FIL.

Individuals of the two parent species, and their hybrids, were tested by Dr. Sick for hemoglobine

patterns. All developed the normal pattern for Aphyosemion: a four-line pattern. The development of ctenoid scales in males was very weak and no sensory papillae developed on anal fin rays. Sensory papillae were situated at the upper ray of the pectorals as in ARN and FIL.

ARN and FIL differ from their larger relatives: GUL and COE, not only by their reduced number of scales-long, but also in their development of scales on the forehead (see J.J. Hoedeman in Bull. Aqua. Biol. vol. 1, 1958, pages 23-28 and Aquarien und Terrarien, vol. 4, 1957, pages 294-296). In ARN and FIL the anterior-most frontal scale (the G scale) corresponds to most species in Aphyosemion and Epiplatys. In GUL and COE the development of this large scale is not complete and the anterior part of the G scale "breaks up" into smaller scales (H scales) that in these species are situated below the anterior edge of the G scale. More than fifty individuals (nature caught) of FIL were carefully studied in order to discover any H scale. No such scales were found. In ARN I found one individual that had one such scale. I have six hybrids left. None of these has any H scale.

Here are some counts on FIL (Ijebu Ode individuals), ARN (Wokocha River individuals) and on the 6 preserved hybrids (figures correspond to number of individuals. Scales long however double these figures as I count both sides of the body):

D= 14	15	16	17	18	A= 14	15	16	17	18
ARN 0	2	4	6	0	0	1	6	3	1
ARN/FIL0	0	0	4	2	0	0	0	4	1
FIL 2	22	25	7	0	1	9	36	10	0

Sq-long	24	25	26	27	28	29
ARN	1	6	6	6	0	1
ARN/FIL	0	0	2	3	2	1
FIL	2	7	17	43	7	0

	Dm	Am	Sqm
ARN	16.3	16.4	26.0
ARN/FIL	17.4	17.2	27.2
FIL	15.7	16.0	26.5

Hybrids produced by crossings in Epiplatys and Aphyosemion, Aphyosemion normally develop the medium values of data for the parent species. This rule is not true for several crossings in Fundulopanchax. Here the hybrids often develop more dorsal and/or anal fin rays than do the parent species. The ARN/FIL hybrids developed more fin rays and slightly more scale numbers than did the parent species.

(2) ARN/SPU 1964-65

Also APU belongs to the Fundulopanchax group in Aphyosemion. This species however is found outside the range of other species in this subgenus. SPU lives in the humid parts of the rainforest of SW Ghana and SE Ivory Coast. In my opinion SPU represents a form that has several "ancient characters" and an alike ancient form might have given rise to the development of most forms in Fundulopanchax. Young individuals of SPU resemble individuals of NIG in a remarkable way and SPU probably is very closely

related to NIG. Older individuals of SPU resemble such forms as ARN and GUL. The types of SPU originated from the Tano River drainage of SW Ghana. My strain of SPU was caught by the French zoologist, J. Arnoult, N of Abidjan in Ivory Coast. In this area is where Dr. Sheljuzhko caught individuals of SPU in 1952. Sheljuzhko's individuals were distributed as aquarium fish in Germany in 1952-53 as individuals of GAR (which indeed is a very close relative also). In Sheljuzhko's strain the males did not develop any yellow or orange or red color in fins. In Arnoult's strain all males (probably) develop a very conspicuous orange red color in all fins. Normally the orange red color covers the outer median part of the fin and they correspond to the types for SPU in this. ARN and FIL are small-sized Fundulopanchax. SPU and NIG are medium-sized Fundulopanchax, whereas GUL and COE grow even larger. The SPU/ARN cross also was tried, but the male SPU killed my last full-grown ARN female.

The ARN/SPU combination worked better. The crossing was prepared on fine mud and after two weeks of spawning I had 36 eggs all of which were fertile. Because of my holidays I stored these eggs in "tobacco moist peat" for five weeks. After this time I washed out the eggs for control. I found 31 eggs. All eggs contained a "180 degree embryo" (pages before) apparently hibernation. This is the phase of "resting embryo" or stadium IIb of Peters. Now the eggs were stored in clean water without peat for control. After one more month 14 eggs contained a ripe embryo. The eggs did not hatch (normal for Fundulopanchax) and for this reason I forced them to hatch. I killed eight embryos in eggs, hatched four viable fry and had two ripe eggs unruined. At that time I had nine eggs containing a "180 degree embryo", as ten eggs were ruined during photographing. After one more month I had four ripe eggs and three eggs containing a "resting embryo". The four eggs were forced to hatch. After two more weeks I had two ripe eggs and one "resting embryo". The last egg was ripe after another two weeks. The last egg was hatched five months after the spawning. Ten hybrids were raised. Nine are preserved now and the last one has to live for a long time in order to measure the maximum size. All hybrids developed as males according to colors and behavior. They were spawning females of SPU and NIG, but no egg developed. Apparently the males were able to fertilize eggs as I saw a real blastula in some eggs, but the "multidish" was not normal and after this formation the eggs did not develop any corda. The hybrids were very viable and active fish. They belong to the most handsome individuals in West African Rivulins. In all their characters... (can not read last line)

Here are some counts for 12 individuals of ARN (Wokocha strain) for the 9 hybrids so far preserved and for 10 individuals of SPU (Arnoult's strain).
D= 14 15 16 17 18 Dm
ARN 0 2 4 6 0 16.3
ARN/SPU 0 0 0 5 4 17.5
SPU 1 6 3 0 0 15.2

A= 15 16 17 18 Am
ARN 1 6 3 1 16.4
ARN/SPU 0 1 5 3 17.2
SPU 0 2 8 0 16.8

Sq-long 24 25 26 27 28 29 30 31 32 Sqm
ARN 1 6 6 6 0 1 0 0 0 26.0

ARN/SPU 0 0 0 2 2 3 6 4 1 29.6
SPU 0 0 0 0 0 2 8 8 2 30.5

In their dorsal and anal fin counts the hybrids are not intermediate to the counts for the parent species. As usual in Fundulopanchax crossings, the hybrids exceed the counts of the parents. ARN and SPU are sufficiently separated (the two demes under consideration) by their counts for scales in a longitudinal series. They also differ markedly in egg types. The egg of SPU adheres mud, measures 1.4-1.5 mm and normally has a broken reticulated pattern on the membrane.

The hybrid males matured at an age of three weeks. They all developed a very brilliant orange red color all over the body and the fins. This handsome color gradually weakened and gave place for a brilliant blue cast. The orange color however was not lost as in the ARN/FIL hybrids. The development of the color pattern of the caudal fin is remarkable. In SPU there are no inner red line that separates the yellow orange color from the green blue color of the inner part of the fins as in NIG and most species of Aphyosemion that develop yellow or orange edges on the fins. In SPU however the orange area normally is well separated from the green blue area of the fin. In ARN the "lyre" pattern of the caudal fin is not quite regular as the upper red line is very close to the fin edge. In the hybrids (all hybrids) a very regular and conspicuous lyre pattern developed, like the pattern found in males of NIG and other Aphyosemion of this sort. For the development of the red "separation bands" in see also NIG/SPU and SPU/NIG. At an age of four to five months the hybrids measured up to 31 mm standard length. This is the size of full-grown ARN males. In ARN the adult male develops rather long or even very long streamers at the upper and lower edge of the caudal fin. In SPU males normally do not develop such streamers. The produced rays of that fin correspond to those of NIG: short "swords". About two-thirds of the hybrids developed long streamers, equal to those of ARN, whereas one third developed streamers as in SPU.

Ctenoid scales in ARN develop over larger areas than in SPU. In the latter the ctenoid scales are normally concentrated in midrows of scales and often they do not develop in front of the ventrals. Sensory papillae rarely develop on anal fin rays, but normally a few may be found on these rays. Sensory papillae on the upper ray of the pectoral fin may or may not develop, depending on the distribution of ctenoid scales. In some individuals however ctenoid scales are present on the gill cover in SPU. Most hybrids developed ctenoidy as in SPU, however in a few hybrids the ctenoid scales are also found on the lower rows of scales and many sensory papillae are found on anal fin rays. Many hybrids had several ctenoid spines on scales on the gill cover.

I have already attached some to the development of the frontal scale pattern in Fundulopanchax (see ARN/FIL). Development of H scales is rare in Old World Rivulins indeed. In ARN and SPU development of H scales probably is rare. I have seen one individual of each that developed these (this) scale. One hybrid developed two large H scales that also were resting on the anterior part of the G scale. Another hybrid had one H scale, also situated on the G scale. Another hybrid had one H scale, also situated on the G scale. The breaking down of regular scale pattern on the forehead is not unusual in hybrids in this group of fish. See also NIG/NIG, NIG/SPU and SPU/NIG for development of H scales in pure species and in hybrids.

(3) AUS/CAB 1957

Both species are nominal Aphyosemion. AUS formally belongs to the subgenus Aphyosemion. Many aquarists however have considered this form as a "Fundulus" (= Fundulopanchax form) and they have based this idea on the behavior of this species. I quite agree with these old time aquarists as AUS in several ways corresponds more to my idea of a "Fundulopanchax" than to the idea of an "Aphyosemion". The crossings of AUS indeed support this idea. AUS has been described on aquarium kept individuals (the description of POL as AUS was never described in the usual way) and there are no published records on this species from nature. It is likely that AUS is found in the coastal parts of the Ogooue River drainage. More details on AUS is given in connection with the AUS/NIG cross.

CAB is a synonym for LIB. Stenholt Clausen's collection of CAB in the biotope near Monrovia from where the types for LIB originated, indeed supports this idea. As synonymizations are not my job, I will use the CAB name in this report. Also Stenholt Clausen's findings are only a few months old. Indeed CAB did not originate from "Old Calabar". Ahl had this "locality" from F. Mayer from Hamburg who again had his information from a dealer of aquarium fish who had his information from a professional collector of aquarium fish (these people normally will not give correct information on the locality from where they had their fish -if they really caught the fish themselves- and they are in their good right not to publish such data. Their job is trade, not science). Stenholt Clausen has discovered a morphological system that divides all West African Rivulins distinctly into two groups. This system is based on the pattern of lateral line pores on the forehead and the system is most useful in identification of these Rivulins. AUS after this system falls clearly among the "eastern Aphyosemion" (all Fundulopanchax plus all species living east of the Togo-Dahomey Gap) whereas CAB clearly falls within the Callopanchax group (SJO, GUI, ROL, LIB etc. and PET). Crossings between individuals belonging to different "groups" (in Aphyosemion) have not given viable offspring so far (and probably will not be giving such hybrids).

I had seven eggs from a single spawning. Four days after the spawning the embryos were visible in all eggs. After three weeks all embryos apparently were visible in all eggs. After three weeks all embryos apparently were dead or dying. The embryos were small and their bodies were diffuse and indistinct. The tail however was distinct. One embryo was still alive. The pulse was low and most yolk was still present in the egg. After 26 days only three eggs were still alive. Embryos had unpigmented eyes. The body was indistinct, a shapeless mass of cells. Embryos apparently were about to die. A second cross was now prepared to control the first cross (I was not aware of the distinct separation of Callopanchax from other Aphyosemion at that time). Four fertile eggs developed. After ... (cannot read last line) See also AUS/PET, CAL/ROL, CHR/PET, SL4/NIG, PET/COG, ROL/NIG and SJO/COG. All these crossings represent crossings between species belonging to "western" and "eastern" Aphyosemion.

(4) AUS/CAL 1963

CAL is a south Nigerian Rivulin. In his description of CAL, Boulenger said that his material (aquarium kept individuals from J.P. Arnold in Germany) originated from Liberia. Arnold however said that the individuals were said to come from "freshwater pools" in Sierra Leone and he expressed much doubt on the reliability of this information. Apparently Boulenger by denying exchanged the labels for two shipments of preserved fish from Arnold (DAG and CAL) as also his locality for "CHA" = DAG does not correspond to the locality published by Arnold. Stenholt Clausen has very many preserved individuals of CAL from the Ijebu Ode area of SW Nigeria and here in 1962 he caught the strain used for

this cross.

AUS and CAL resemble each other very much and after the first importation of AUS back in 1913 this species was considered as a variant of CAL (the southern variant = australis). This resemblance however might be a matter of convergence and also these two forms differ in behavior. Both forms belong to the "eastern" forms in Aphyosemion, but in CAL the female develops a certain dark rounded marking on the anterior part of the throat which otherwise is not found outside Callopanchax (= western Aphyosemion).

On preserved material at my disposal I made these counts:
D= 08 09 10 11 Dm
CAL 4 17 18 0 9.4
AUS 0 4 2 7 10.0

A= 12 13 14 15 16 Am
CAL 1 13 23 2 0 13.4
AUS 0 0 2 3 8 15.5

Sql-long 27 28 29 30 31 32 SQM
CAL 1 8 31 29 3 0 29.2
AUS 0 0 1 7 14 2 30.8

Notice the low anal fin count for CAL. The mean value for this character is rather low for an Aphyosemion.

As usual in Aphyosemion this cross was not difficult to arrange. The spawning started a few minutes after the bringing together of the two individuals. Two spawnings were used. Several eggs developed an embryo, but only three eggs gave a ripe embryo that was able to hatch. Other embryos died in their eggs from unknown causes. One week after the spawning all eggs contained a very slender embryo measuring a bit more than 180 degrees on the yolk. Only a few black pigments were visible. After totally three weeks I had three eggs containing a ripe embryo and one large embryo dead in egg. The ripe eggs would not hatch and they were forced to hatch. The hybrids were able to swim. After two more weeks the hybrids were still swimming and had grown larger. However, they still were very slim bodied. After three more weeks the three hybrids "lost the air of the swim bladder" and sank to the bottom and could not swim. They were very slender and "eel like". One hybrid had a deformed backbone. The hybrids lived for some more weeks and when two had died and disappeared I preserved the third individual. Under the microscope this individual does not demonstrate any visible abnormalities. 8 mm SL, D=8 or 9, A=15 or 16. It should be noticed that fry from West African Rivulins do not develop into "belly sliders" as these hybrids did. See also AUS/COG and AUS/LAB which gave similar results. COG and LAB... (cannot read last line)

(5) AUS/CHR 1059
CHR for the present is the type for the subgenus Aphyosemion Myers in Aphyosemion Myers. The original type was CAS, but this species later on was found to be synonym with SCH that again falls into synonymy with CHR. Probably also CHR will be found to be a synonym for DEC and so on. CHR is a

common species in the huge Congo drainage above the falls at Leopoldville and below the falls at Stanleyville. AUS for the present is also placed in the subgenus Aphyosemion, but as I said before this species probably is much closer to COE (the type for the subgenus Fundulopanchax in Aphyosemion) than to CHR and probably AUS has to be placed in Fundulopanchax after a certain revision of the criteria for this subgenus.

36 eggs were spawned in one spawning. Four days later a small embryo was visible in 19 eggs. During the early development of the zygote the development was rather promising and the blood system worked well. A little later the circulation of blood elements decreased and the embryos differed more and more in size and development. Some embryos "curled up" in their eggs. The heart of the embryos apparently was situated too far from the throat. 17 days after the spawning most embryos were still alive, but in a few only the blood was circulating (slowly). After 31 days no blood circulation was present in any egg. Embryos died (probably from thrombus). Preserved.

(6) AUS/COE 1958

Both forms belong to the group of "eastern Aphyosemion". Formally they belong to different subgenera in Aphyosemion, but as I said in connection with the AUS/CAB cross AUS might fall out as a form more closely related to the Fundulopanchax than to the species in the subgenus Aphyosemion (relatives of DEC or CHR etc.). COE is the type for the subgenus Fundulopanchax in Aphyosemion Myers. COE is also identical with Aphyosemion (Fundulopanchax) sjoestedti (Loennberg) 1895 from the Ndian River in Cameroon. Stenholt Clausen recently has placed a paper to the Committee for Zoological Nomenclature concerning this strange question and he has recommended that the aquarium fish known as SJO keep this name (because of the long use) whereas Loennberg's species is placed in COE as "synonym". This claims however that SJO (Arnold's species) is considered as the type for Callopanchax Myers. Boulenger's misidentification of Arnold's aquarium fish, back in 1910, caused this confusion of names.

I had twenty eggs from one spawning. These eggs did not "close" after the hardening in water, rich in oxygen. Methylene blue entered the eggs, but this dye did not harm the embryos. Only four eggs, however, survived the first few days. One week after the spawning the eggs contained a rather large embryo that had already developed a fine blood system. Ten days after the spawning the first black pigments had developed in the eye of the embryo. 23 days after the spawning the first sound and swimming fry hatched out. All four eggs have viable hybrids. Less than four weeks after the hatching (the age of the individual should be calculated from the day of hatching, not from the day of spawning, as ripe fry may remain in eggs (resting fry) for days or weeks (or months in annual Rivulins)), the males started maturing. Two males and two females developed. Two months old, the largest individual measured about 60 mm total length. These hybrid males did not develop brilliant colors as hybrids normally do in Aphyosemion, females apparently contained eggs. On 6 June 1958 I mailed these four hybrids alive to Dr. J.J. Hoedeman who was very interested in these particular hybrids. I do not know what happened to these hybrids later on. The AUS/NIG cross represents a similar cross.

(7) AUS/COG 1957 and 1959

COG belongs to the subgenus Aphyosemion. This form is a close relative of the type (CAS or CHR or DEC). AUS probably is not a close relative of the species of that subgenus. COG was described from Leopoldville in Congo and Poll reports several individuals from this area in the Congo Museum.

Four spawnings were arranged: two spawnings during 1957 and two during 1959. I had 12+32+35+22 = 101 eggs from these spawnings. Most eggs developed an embryo. The growth of the embryo is very slow in this cross. Three weeks after the spawning I took a "large" embryo out of an egg. It measured 1.2-1.3 mm only. The cause of the slow development probably is found in the poor development of the blood system on the yolk. Some eggs died from a "thrombus". Other embryos died from unknown reasons. No ripe embryo could be produced as all died in their eggs long time before they reached this phase. See also the similar results of the AUS/CHR cross.

(8) AUS/DAG 1959

DAG belongs to the genus Epiplatys. In crossings DAG however reacts differently from other species in Epiplatys as this species does not "discriminate" between individuals of Epiplatys, Aphyosemion or Aplocheilus. The results of these crossings are rather similar. DAG may represent an "ancient" form as far as genetics are concerned. The types for DAG originated from SE Ivory Coast, but for this cross I used a female of the common aquarium strain (E. dageti monroviae Daget & Arnoult 1964).

The DAG female did not accept the AUS male as a good partner for spawning and training was needed. However, after some time she did not discriminate and a fine spawning was observed. In this spawning the movements of the two individuals were well coordinated. I had eleven eggs. Three days after the spawning the eggs were still transparent. Four days after the spawning only two eggs were still alive. These two eggs lived for one week. They never developed a corda and instead a mass of undifferentiated cells was seen near the animale pole. See also BIF/DAG, CHR/DAG, DAG/COG, DAG/GRA, DAG/MAC, DAG/LIN, DAG/SEX, FAS/DAG, PET/DAG, SEX/DAG. The results of the AUS/DAG is not normal for DAG in crossings.

(9) AUS/LAB 1958

LAB belongs to the subgenus Aphyosemion (it was described as a member of Fundulopanchax). It comes close to COG. The types originated from the Lower Congo drainage (around Thysville). LAB belongs to the difficult group of "flame tailed" Aphyosemion which are found all the way from Old Calabar to the Congo River drainage, NKI, LUJ and NIA are other members of this group. In my opinion LAB is the member of that group which comes closest to the CHR-COG group, whereas NDI is the form that comes closest to the NIG-GAR group in the north.

I had eight eggs. Five eggs developed an embryo. The early phases of the embryo development were promising and the blood system was fine. Eggs from LAB however are very large and in crossings in which LAB females are used, this may produce difficulties. One embryo however did not develop any blood system at all and this embryo was very slowly growing, far behind the other four. One month after spawning the eggs still were unhatched and an inspection under the microscope gave this result: four embryos are still alive. In one embryo, however, a large thrombus is visible at several points of the yolk. The heart of this embryo is still working, but not a single blood element is moving in the veins. Two embryos are circulating their blood. The fourth embryo is building up thromboses. Five weeks after the spawning three embryos are still alive. Fifty (!!) days after the spawning one fry hatches out of the egg. The two remaining eggs now were forced to hatch. One hybrid had deformations of the body. All three fry died after a few days. Probably they were not viable.

(10) AUS/NIG 1959 and 1963

NIG belongs to the group of Fundulopanchax in Aphyosemion. NIG however grades into the subgenus Aphyosemion in some characters. As males normally develop ctenoid scales, the form should be considered as a Fundulopanchax. Much information on NIG is found in Aquarium Journal, 1964, pages 510 ff (Scheel: A. nigerianum). NIG lives in Nigeria in the dries parts of the forest (on the parent rock) and also in the savanna. In the Cross River drainage NIG is replaced by GAR ... (cannot read last line)

1958: I used a female of the Akure strain (AK). Seven eggs were spawned, but only four eggs developed an embryo. After six days the development of the embryos is very promising. Eyes already have pigments and the development of the blood system is fine. 26 days after the spawning the hybrids were forced to hatch. They measured 4.7 mm. Only one hybrid survived the first critical days. It matured as a male, but dies at an age of two months only.

1963: I used a PH/AK female (population hybrid, see NIG/NIG). These PH/AK females when spawned with their brothers (F1 also) did not produce many viable offspring. Strange enough their eggs developed much better in crossings. I produced four viable hybrids. One month old these hybrids were slowly maturing as males. They differed much in viability and I was unable to raise two of the hybrids to adult size. On preserved individuals of NIG-PH/AK (they differ somewhat from other strains in NIG), on AUS of the aquarium strain and on one hybrid I made these counts:

D= 09 10 11 12 13 14 15 Dm
AUS 4 2 7 0 0 0 0 10.0
AUS/NIG 0 0 0 1 0 0 0 12.0
NIG 0 0 0 0 0 7 1 14.1

A= 14 15 16 17 Am
AUS 2 3 8 0 15.5
AUS/NIG 0 1 0 0 15.0
NIG 0 0 2 6 16.8

Sq-long 29 30 31 32 Sqm
AUS 1 7 14 2 30.8
AUS/NIG 0 0 2 0 31.0
NIG 1 2 6 4 31.0

In AUS the anterior-most dorsal fin ray stands over the eighth to tenth ray of the anal fin, whereas this ray in the hybrid stands above the sixth anal fin ray and in NIG-PH/AK the fourth to the sixth anal fin ray is reached. I have searched for ctenoid scales on preserved males from AUS, but I did not find a single spine. However in this species the male develops sensory papilla on the upper ray of the pectorals. In the hybrid AUS/NIG some scales in midrows developed ctenoid spines. Compared with the ctenoidy in NIG-PH/AK (very strong for NIG) the ctenoidy of the hybrid was weak.

Young AUS/NIG hybrids (only males produced from this cross) develop much yellow color near the edge of the fins. This color is completely lost with age. The hybrids were not tested for fertility, but

probably they were just as sterile as other hybrid males in Aphyosemion.

(11) AUS/PET 1958

Like CAB also PET is a member of the Callopanchax group as this species develops similar patterns of lateral line organs on the forehead. Also in the development of other characters and in the principles of the color pattern PET clearly belongs in this group in nominal Aphyosemion. PET however differs markedly from all other Callopanchax known to me by the egg type. All species in Callopanchax develop a marked reticulated pattern on the egg membrane. Not so in PET. The surface has no particular pattern. For this reason PET is perhaps an important species in the evolution of West African Rivulins. PET was described from SE Ivory Coast. It has been taken also in the western and central parts of the Ghanese rainforest. No other species of Callopanchax is found so far to the east and ranging into the area occupied by Fundulopanchax.

I had thirteen eggs in one spawning. Seven eggs developed an embryo. After five days embryos had a working blood system. After eight days the development of the embryos differed markedly. After twelve days all eggs were carefully inspected under the microscope. Two very small embryos, rather shapeless, were dying and were preserved together with an egg containing a much larger embryo, suffering from severe thrombus. The remaining eggs contained live embryos, but only in one egg the circulation of blood was considered as promising. 25 days after the spawning all embryos were dead or dying from severe thrombus. This result (see also CHR/PET, PET/COG and PET/DAG) indicates that in crossings PET gives better results than other Callopanchax do.

(12) BIF/BIF 1963-64 population cross

BIF is an Epiplatys but it differs from all other Epiplatrys that we kept in the hemoglobine pattern. BIF develops a complicated pattern, not similar to other patterns developed by Epiplatys and Aplocheilus. BIF is a savannah form that has a very large range of dispersal. It is found all over the savannah of West Africa except for the Savannah of the Congo drainage and the coastal savanna north of the Congo mouth. Also in the Nile drainage, BIF is found and the types originated from this river system.

After having found severe isolating post-mating mechanisms to be acting in crossings between individuals belonging to different populations of NIG (see NIG/NIG) and BIV (see BIV/BIV) and also between ARN and FIL, SL4 and ROL I made up my mind to produce further crossings between individuals belonging to different demes or populations of one species. I had two different strains of BIF:
BIF-NI from Share on the Niger, near Jebba. Stenholt Clausen 1958
BIF-VO from SW Ghana (15 miles NW of Keta on the coast). Also caught by Stenholt Clausen, 1962.

I was able to prepare a population cross. I found no visible morphological differences between these two strains which also developed similar hemoglobine patterns. In the BIF-VO strain males may develop long streamers at the posterior edge of the anal fin. I raised more than ten "hybrids" from this cross. Only one individual, however, developed into a female. Abnormal sex ratio is common in some species of Rivulins and should not be considered as an "abnormality" in this case.

As this female was too small for spawning with her brothers I backcrossed one of these with the BIF-VO female:

BIF-NI.VO/VO backcross

I had twenty eggs. All eggs developed. In this case I should like to give a full report on the results in order to show where abnormalities arise.

- 1st day: blastulation and multidish develop normally
- 2nd day: gastrulation produces a deep groove on the yolk when it reaches the equator of the yolk. The groove is deeper than usual in Rivulins. No corda visible
- 3rd day: no change
- 4th day: corda measures about 90 degrees on the yolk
- 5th day: corda measures 180 degrees. Once more a deep groove appears on the yolk
- 6th day: a working blood system has developed. Pulse 114-124-128
- 7th day: in spite of the egg groove in the yolk the tail of the embryos turns off at 180 degrees. Marked but not maximum (90 degrees). Blood system improving
- 8th day: in a few eggs the circulation of blood elements has come to a complete stop. Elements are all heaping at the entrance to the heart which beats strongly. Elements enter the heart, but are forced back again. No elements come through. Pulse 134, 140, 144. Pulse decreased in some eggs. One egg dies. Nineteen live eggs left
- 9th day: circulation of blood has stopped in most eggs. The pulse (these eggs) is high. 180, but still there are no blood elements coming through the heart. Almost all elements are stored at the entrance to the heart, forming a big red mass. Apparently the valves of the heart do not work
- 10th day: in eight eggs the circulation of blood still does not work. In other eggs some circulation has developed and blood elements move through the veins
- 11th day: only four eggs still have no circulation of blood. In most eggs the circulation now appears to be normal
- 12th day: only two eggs have no circulation of blood. All other eggs are normal

The two eggs mentioned above did not recover from this abnormality and died a few days after. Also one more embryo died from unknown reason. I hatched sixteen sound fry that were raised without further difficulties.

BIF-AQ/NI.VO "backcross"

Much later the single female BIF-NI/VO matured. At that time I had already preserved all the males NI/VO and I had only a male from an aquarium strain (unknown origin) at my disposal. From this "backcross" I had 26 fertile eggs. These eggs developed without visible abnormalities and gave sound and viable fry.

As the breakdown of the blood system in NI.VO/VO backcross was fatal to only a few individuals this abnormality is not considered as an "isolating mechanism" in BIF. This means that in crossings between individuals from different populations (different major river systems) BIF reacts as SEN (see SEN/SEN). The phenotype of BIF shows a remarkable constancy in color pattern and in morphology all over the huge range of distribution. Here are some counts on my own material (NI.VO/VO are still alive) and on individuals from various museums thatI have seen:

Nile : Lake No (British Museum)

Sierra Leone : Makeni and Kamakwie (Copenhagen Museum)
Liberia : Robertsport (Philadelphia Museum)
Ghana : Volta localities (Copenhagen Museum)
Nigeria, west : Ilorin, Share, Pategi, Ndeje (Copenhagen Museum)
Nigeria, central : Kabba, Lokoja, New Lapai, Lafia, Abugi (Copenhagen Museum)

D= 07 08 09 10 Dm
Nile 0 4 2 0 8.3
Sierra Leone 0 1 7 0 8.9
Liberia 0 7 4 0 8.4
Ghana 0 6 7 1 8.7
Nigeria, west 1 19 26 5 8.5
Nigeria, central 0 10 21 2 8.8
NI/VO 0 12 2 0 8.1

A= 14 15 16 17 18 19 Dm
Nile 0 0 3 3 0 0 16.5
Sierra Leone 0 1 7 0 0 0 15.9
Liberia 0 1 3 7 0 0 16.6
Ghana 0 0 7 4 2 1 16.8
Nigeria, west 1 0 22 23 5 0 16.4
Nigeria, central 0 1 18 13 1 0 16.4
NI/VO 0 0 7 6 1 0 16.6

Sq-long= 25 26 27 28 29 Sqm
Nile 0 4 2 0 0 26.2
Sierra Leone 0 1 10 2 0 27.1
Liberia 0 1 6 6 2 27.6
Ghana 1 7 10 1 0 26.6
Nigeria, west 2 31 60 7 2 27.0
Nigeria, central 1 9 52 3 0 26.8
NI/VO 1 10 4 0 0 26.2

The reduction of the average value for the number of dorsal fin rays and scales in a lateral series found in the NI/VO strain probably is not a result of aquarium maintenance as 38 individuals of the Nigeria west series were raised in my tanks under similar conditions. Probably this reduction is caused by some genetic combination in the "hybrids". The figures indicate that BIF should not be divided into two subspecies: *E. bifasciatus bifasciatus* in the Nile drainage and *E. bifasciatus taeniatus* in West Africa. BIF has been reported from the Chad drainage and NDE in my opinion are juveniles of BIF. At least they correspond exactly to such juveniles.

(13) BIF/DAG 1959
BIF is a very shy fish and for this reason this species is difficult to cross. When individuals of BIF are removed from their tank and placed in other tanks it may take months before they recover from their

shyness and panics. In this BIF resembles SEN, the second savannah Epiplatys. A BIF-NI male was used. I had fifty eggs from one spawning. This is much from a DAG female. 49 eggs were spawned within four hours. The female DAG was from the common aquarium strain (*Epiplatys dageti monroviae*). Only very few eggs were fertile. These eggs developed an embryo that soon died from unknown reasons. No viable hybrids were produced.

(14) BIF/SEN 1961

A BIF-NI male was used. The SEN female was from the Chad strain. SEN apparently is found in all localities of the savannah where BIF occurs. This species however also occurs in localities where BIF (probably) is absent. The most important of these localities is the Congo drainage near Leopoldville. In Sierra Leone where BIF appears in savannah localities, SEN is replaced by FAS. SEN = SPI (Stenholt Clausen probably will publish details on this problem after our inspection of the types for SPI which gave this result). In their measurements and counts SEN and BIF are so close that it is difficult or impossible -without the use of unorthodox morphological characters- to separate these two forms. The color patterns differ markedly however and SEN probably is not a close relative of BIF.

I had fourteen fertile eggs in this cross. I found no abnormalities to occur in the embryonal development. Just when the hybrids were ready to hatch the isolating mechanisms set in and the fry became absolutely motionless. Under the microscope only light movements of the heart and the pectoral fins were seen. In some fry also the heart had stopped. Some fry however did hatch out and were resting on the bottom of the glass, motionless. No deformations or thrombus was observed. The hybrids now died one by one. The last one died one month after the hatching, unchanged. I have not observed this "abnormality" in other crossings.

(15) BIV/BIV 1962-64 infraspecific crossings

BIV for the present is considered to belong to the subgenus Fundulopanchax because of formal criteria. Indeed BIV is not a close relative of COE (the genotype) and also this species -or group of species or subspecies- stands very isolated in Aphyosemion. About ten taxonomic names bave been created for species Aphyosemion that probably are members of the "BIV group": BIT, HOL, LOE, MUC, PAP, RIG, RUS, SPP, UNS and ZIM. Also other ill-defined species of Ahl may fall in this group.

The westernmost populations of BIV are found near Porto Novo in Dahomey. From here BIV extends eastwards on the sediments of Nigeria (forest and savannah) into the Cross River drainage, the Ndian River drainage (type locality) and further east and southwards into Cameroon. The southermost populations probably are those of Spanish Guinee. Minor differences in measurements and counts exist when various demes of BIV in this huge range of distribution are compared. In my opinion these differences are not at all sufficient indications of any differentiation into more than one species. Also the color pattern remains remarkably constant through the range of distribution and does not support any separation into several species.

During the thirties, C. Kosswig crossed different aquarium strains of BIV (nominal BIV, LOE, MUC and SPL) and found strong postmating isolation mechanisms to be at work within this group of forms. Some hybrids were completely sterile. These findings support a division into more than one good species.

During 1962, Stenholt Clausen collected live individuals of BIV from six different localities in the western range of distribution for BIV. These localities are:
PO : Porto Novo in Dahomey
ME : Meko near the border Dahomey-Nigeria
LA : Lagos
IJ : Ijebu Ode, SW Nigeria
BE : Benin City, western delta area
UM : Umudike near Umuahia on the watershed Niger-Cross

I raised six aquarium strains on this material corresponding to the six codes mentioned above. These six strains differed from each other in minor details in color patterns and in the development of fins in males. I was able to distinguish clearly between the six phenotypes in males when these were imported, but when the aquarium strains had been raised I was not able to distinguish clearly between the males of the LA and the IJ strains and also the PO males came very close to these two types of males. I was not able to distinguish clearly between females of these six strains. Only females of the UM strain differed somewhat from other females (broader dark bands).

From this live material I produced six hybrid strains. I had not sufficient tanks (nor time) to produce all fifteen possible combinations as I also had to be take care of other Rivulins that Stenholt Clausen had sent home alive from Ghana, Nigeria and Cameroon. These are the codes for the hybrid strains:

IJ/LA : only two males were raised
LA/ME : six males were raised
ME/BE : seven males were raised
BE/PO : 37 males were raised
UM/LA : three males and six females were raised
BE/IJ : few individuals, delivered to the Hamburg Museum

The sex ration in these hybrid strains is not normal as only one strain produced females. I found no distinct abnormalities in sex ratio in the six pure parent strains.

IJ/LA hybrids (males) and their backcrossings
These two males developed into the most handsome BIV individuals I ever saw. The streamers of dorsal, anal and caudal fin developed such length that they exceeded the very long streamers that often develop in males of the IJ strain. The color pattern corresponded exactly to that of aquarium raised males of the IJ and LA strains. One of these males was backcrossed to a UM female. Indeed, I know that a LA or a IJ female should be used for such backcrossings. However, at that time, most individuals of the parent strains were no longer kept in my aquarium room for lack of tanks and were at the Zoological Museum. Also I did not intend to produce any F2 individuals, the only purpose of the backcrossing was to see if the males were fertile or sterile. I had ten eggs. Nine eggs developed a normal blastula. The blastula in BIV eggs is easy to trace as it is very distinct, high and concentrated. After the blastulation three eggs died from unknown reason (probably not external reasons). In six eggs the corda developed, but the tail of the embryo turned off at 180 degrees. The embryos "curled up". All six embryos however developed a good blood system and were hatched as sound fry except for two that could not get their heads out of the

egg. Such things happen indeed and are not "abnormal". By accident these F2 individuals were mixed up with other fry of BIV and were no longer taken into consideration. Probably they were normal.

LA/ME hybrids (males) and their backcrossing

The LA/ME hybrids were rather feeble. I kept 14 of these in my own tanks and I was only able to raise six of these to adult size. I placed about sixteen individuals in the tanks of the Zoological Museum and here only three individuals reached adult size. Also for the backcross of these males I used the UM female as I had no adult LA or ME females in my fishroom. 13 eggs were spawned and twelve of these developed a normal embryo which hatched out as sound viable fry. Another large series of these eggs was destroyed by vapors from isopropanole. Also in this backcross there was no indication of isolating mechanisms.

ME/BE hybrids (males) and their backcross

Also for the control of fertility of these males I used the UM female. I had ten eggs and all of these developed normally and gave viable fry. Another series was ruined by vapors from isopropanole before I learned to keep lids on egg glasses.

BE/PO hybrids and their backcross

These males were also backcrossed to UM females. I had 49 eggs during one month of spawning. At least 15 (25) of these eggs developed a normal blastula. Only six eggs however produced a corda. No vapors of isopropanole are acting here!!! In one egg the embryo however died a few days after the development of the corda. Five eggs developed a larger embryo that however "curled up". All five eggs hatched after 16 to 19 days, but four fry died before or after the hatching. Only one individual out of 15 or 25 fertile eggs could be raised from this backcross. BE/PO males also were spawned with UM/LA females. See later.

UM/LA hybrids and their reproduction and backcrossings

UM/LA males and IJ females - as the LA and IJ demes probably belong to one population of BIV the IJ female used in this backcross probably could be considered as equal to a LA female. Two UM/LA males in turn were spawned to one IJ female. Before and after these spawnings this particular female has been controlled for fertility and her eggs proved to be normal. With the first male I had 41 eggs. I was not able to discover any trace of a blastula in any of these many eggs. Apparently the eggs were not unfertilized as they did not die within normal time for BIV eggs that are not fertilized. So I tried the second males also. I had 19 eggs that also did not develop even traces of a blastula and which also appeared to be fertilized. When the second male was spawning this IJ female the first male was spawning a UM female.

UM/LA males and UM females

I had four eggs. Three of these developed a normal blastula. Two eggs developed a corda that however was not situated in the usual groove on the yolk as normal for BIV. These two embryos were just "sitting" on the yolk. After seven days a working blood system was visible. After nine days I discovered that the heart was situated much too far from the throat of the embryo. After eleven days the development of the blood system was not promising. Only few veins were seen on the surface of the yolk and the circulation of the few blood elements was slow. After sixteen days the circulation of blood has stopped. The embryos are dying. Preserved. This was the development of the "best" egg. The second egg

never developed any blood system at all. After eleven days it was also preserved.

UM/LA males and UM/LA females

UM/LA females were able to spawn. However their production of eggs was very low. The y were fed black mosquito larvae, week after week, but not even this good food was able to improve their spawning results. When young these females produced abnormal eggs as the yolk of their eggs was extremely small. With age (after one year) their eggs became more normal and almost reached the yolk size normal for BIV. The egg size was normal at all ages. I used two females and had 44 eggs spawned through many months. In eight eggs (some had very small yolk balls) a normal blastula was noticed. In nine more eggs (one had an abnormal large yolk ball, no "white" was visible) there were indications that the eggs had been fertilized by the male. No blastula however was seen in these eggs. Five eggs developed an embryo (corda) but in one of these eggs the development of the embryo stopped at that phase and after a few days the embryo died from unknown reasons. Four eggs developed a "180 degree corda". In three of these eggs the embryo was not situated in a groove and embryos curled up. In one egg the groove was present and the embryo did not "curl up". The egg that had the best development was lost by accident during inspection. Nine to eleven days after spawning two of the three eggs that developed the 180 degree corda stopped their development before any blood system has been produced. From now on they remained unchanged and died thirteen and 21 days after spawning. The last egg developed a working blood system ten days after the spawning. First the development of the blood system was rather promising, but 14 days after spawning it was evident that the blood system was about to break down. Circulation was slow and the elements were few. A few days later the circulation of blood was stopped completely. One big thrombus was visible and after 22 days the embryo died.

UM/LA females and UM males

Two UM/LA females were used but only one egg was harvested. This egg had a normal yolk ball and developed. After seven days the body of the embryo became swollen and "water filled" and the size of the body was much too small for the age. After this the embryo did not develop further and after one month I preserved the egg.

Results: The results of the UM/LA cross indeed indicate severe postmating isolating mechanisms as individuals of these two populations apparently are not able to exchange genes, at least not directly.

UM/LA females and BE/PO males

This spawning indeed represents the "mixing of genes" from four different populations. Two "pairs" were spawned in separate tanks. The UM/LA females at that time were young and all eggs had that very small yolk ball previously mentioned. After many weeks I have had a few eggs only. In two eggs I noticed a normal blastula on the small yolk ball. In two more eggs I was not able to trace any blastula, however one of these eggs developed a corda and also the two eggs mentioned first developed a corda. Five days after the spawning the corda measured 90-180 degrees on yolk only. Eight days old the embryos had developed a working blood system and the circulation of blood was quick and promising. Twelve days old the eggs had a greatly decreased circulation of blood and in the veins only few elements were seen. Much yolk is still present in eggs. Embryos move and their pectoral fins wave. After fourteen days one of the embryos developed a distinct thrombus and all circulation of blood stopped. The circulation in the two remaining eggs was slow and the pulse was irregular. On the sixteenth and the eighteenth day dead embryos hatched out of the eggs (one of these and the one with big thrombus). Now

only one live egg remained. After twenty days also this embryo developed a thrombus and the circulation of blood stopped. The embryo was still moving in the egg. A close inspection of the fry that hatched alive the next day disclosed severe thrombus in the head and in the gill region. However, in the tail the blood elements were still circulating. Next day the fry died.

BE/IJ hybrids

The more or less pronounced breaking down of the F2 generation in some of these crossings indeed surprised me and claimed that the BE/IJ or IJ/BE cross had to be made in order to see if isolating mechanisms had also developed in these two populations because the geographical distance between these two localities is shorter than between the UM and the LA populations.

I produced 27 fertile eggs in this combination. Two embryos died in eggs and 25 viable fry hatched out normally. From neglecting good aquarium-keeping I lost most of these hybrids. All developed as males. Five were preserved and three or four were delivered to the Zoological Institute of the Hamburg University.

On July 1964, Pr. C. Kosswig took over all live material of the parent strains and the hybrids still alive. Probably Dr. W. Villwock will continue the study of isolating mechanisms in BIV.

I found these differences between the six parent strains of BIV:

Pectoral fin color: in the PO, ME, LA and IJ strains the males have colored pectoral fins. The color is orange or red at the free edge and may be yellow at the root of the fin. Most saturation of color is found near the lower edge. In BE and UM males no such color is seen in live individuals, however after preservation in alcohol one is often able to trace some orange or red color at the fin edge. IJ/LA males developed colored pectorals. UM/LA, ME/BE, BE/PO, BE/IJ and LA/ME hybrid males did not develop conspicuous color of pectorals in life.

Color of scales below dorsal fin: in all strains of BIV some of the scales situated below the root of the dorsal fin develop a metallic shine. In the "western demes" (PO, LA, ME and IJ) this shine is bronze, whereas in the "delta demes" the shine is grass green. All male hybrids developed the bronze shine except BE/IJ that were too young for an exact analysis. In the ME/BE males the bronze shine changed into a green shine backwards on the back.

Color of anal fin: males of BE and ME strains developed little orange red color in this fin. This color in these individuals was seen near the lower edge of that fin. A like pattern also was found on males of a "southern IJ strain" taken by Stenholt Clausen about 15 miles south of the locality from which he had the IJ strain. This pattern also developed in the LA/ME, ME/BE and BE/IJ strains. In the IJ males (except for the "southern deme") and males from UM, PO and LA strains the orange red color of the anal fin covered almost the whole fin. This pattern also developed in the IJ/LA and UM/LA hybrid males. The BE/PO hybrids were intermediate to these two patterns.

Produced fin rays in males: the longest streamers in dorsal, anal and caudal fin occur in the IJ males. In the UM male the dorsal streamer and the upper streamer of the caudal fin develop almost the length

found in good IJ males. In the UM males the anal fin and the lower part of the caudal fin develop much shorter streamers. Dorsal streamers and upper caudal streamers are medium in all other strains, but they are short or absent in the ME males. Also there is a coherence between the development of streamers in the anal fin and in the lower part of the caudal fin. IJ males develop the longest streamers in these fins; LA males come close. Medium-sized streamers develop in BE and PO males, whereas these "streamers" are very short or absent in UM and ME males. In ME many males, even old ones, have rounded fins.

Behavior: rather pronounced differences in aggressiveness characterize the different strains. The IJ males are by far the most aggressive ones.

Throat patterns of males: generally the different strains develop similar throat patterns. In UM males the whole lower part of the head is orange red, whereas this color in other males is restricted to the light area in front of the broad black traverse band on the throat. All these males develop a conspicuous lemon throat color just after preservation in alcohol or isopropanol. Males of the BE strain and in particular those of the ME strain develop a brilliant lemon color on the lower parts of the body. This conspicuous coloration develops even more markedly in ME/BE males and in these males the lemon color extends all over the body and more or less also in the fins.

Counts: Stenholt Clausen's collection of Nigerian and Cameroon Rivulins contains numerous individuals of BIV from very many localities. See Stenholt Clausen "Correlation of Ichthyofauna... in Nigeria" in Dansk naturh. Foren. vol. 126, 1964, pages 317-322, about distribution of BIV in Nigeria.

Most of these natural caught individuals are very small (compared to aquarium-raised individuals) and in most individuals the dorsal fin is folded in a way that makes counts difficult. As I only count fin rays of individuals of which I am sure that I am able to count exactly I have not prepared statistics on the whole material.

For comparisons I divide the counts into "river drainages" starting from the west.

- Yeoua : Meko, Iboro, Aiyetore and Badagry
- W. Ogoun : Abeokuta, Ifo and Iju-Otta
- Omi : Yemoji, Ishiwo, Ibefun, Ijebu Ode and Iperin
- E. Ogoun : Foriku (south of Ondo)
- N. Niger : Ndeji-Pategi, Bida, New Lapai, Agbaja, Auchi and Omo (savanna)
- S. Niger : Warri, Benin and Ughelli (rainforest)
- Sanaga : Malimbo
- Nyong : Elanga

D= 09 10 11 12 13 Dm

- Yeoua 0 1 24 20 2 11.5
- W. Ogoun 0 0 5 3 0 11.4
- Omi 2 21 57 23 0 11.0
- E. Ogoun 0 0 1 1 0 11.5
- N. Niger 1 12 7 3 0 10.5
- S. Niger 1 8 6 0 0 10.3

- Sanaga 0 0 3 0 0 11.0
- Nyong 0 0 3 8 2 11.9

A= 11 12 13 14 15 Am
- Yeoua 0 0 16 30 1 13.7
- W. Ogoun 0 1 1 5 1 13.7
- Omi 1 7 35 56 4 13.5
- E. Ogoun 0 0 0 2 0 14.0
- N. Niger 0 3 17 3 0 13.0
- S. Niger 0 4 7 4 0 13.0
- Sanaga 0 0 2 1 0 13.3
- Nyong 0 1 6 4 2 13.5

Sq-long= 24 25 26 27 Sqm
- Yeoua 0 8 80 9 26.0
- W. Ogoun 0 3 15 1 25.9
- Omi 2 24 58 3 25.4
- E. Ogoun 0 0 4 0 26.0
- N. Niger 1 15 24 0 25.6
- S. Niger 5 19 8 0 25.1
- Sanaga 0 1 5 0 25.8
- Nyong 0 0 6 10 26.6

There is a small decrease in counts for fin rays within the Niger River drainage, both in the savannah and rainforest populations of the moist forest in the delta area. More important perhaps is the fact that the Sanaga and Nyong River populations apparently do not differ in these important counts and at least these southern populations cannot be separated from the Nigerian BIV by these morphological characters. It is likely that these southern populations are genetically well separated from the Nigerian BIV. This idea is supported by the fact that SPP (called MUC by aquarists) is still kept by aquarists although the individuals from that these strains developed were imported back in the early thirties. These strains of SPP are rare compared with the strains of BIV (Lagos area) kept by aquarists all over the world. These strains probably represent the MUC phenotype of BIV.

In BIV some individuals develop equal numbers of rays in the dorsal and anal fin. However, some individuals develop more rays in the anal fin than in the dorsal fin. In order to show how this "character" varies I made the following counts on individuals from the "western area" (Yeoua, W. Ogoun and Omi River drainages):
D/A = X/X+5 X/X+4 X/X+3 X/X+2 X/X+1 X/X
2 11 40 55 12 2

This character indeed is rather variable in these demes of BIV. As we have seen the Nigerian BIV does not separate from the Cameroon BIV by the number of fin rays or number of scales-long.

Apparently a constant (?) difference is found in the D/A ratio: in Nigerian BIV the foremost dorsal fin

ray stands above the third to sixth anal fin ray, whereas this ray in Cameroon BIV stands almost exactly over the first anal fin ray in most individuals in Stenholt Clausen's collections.

[continued in Scheel Letter No. 53; Part 2]