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Aphyosemion (Fundulopanchax) nigerianum Clausen 1963

(this article was prepared before the agreement mentioned on the pages before)

In 1955, H.S. Clausen discovered a population of an unidentified *Aphyosemion* at Akure, western Nigeria. In 1957, zoologist J. Birket-Smith brought live specimens of this population to Denmark and I received the killifish from him. In 1958 - 60 eggs of this species were distributed by air mail to many aquarists abroad and several aquarium stocks were established, even as far away as New Zealand and Uruguay. I used the name *Aphyosemion calliurum* for this species at that time. As far as I am informed all aquarium stock at present originated in my tanks and belongs to the Akure population. In 1961, young Ulf Hannerz from Sweden caught two small males, apparently belonging to the same species, at the Wokocha River near Port Harcourt in the eastern Niger Delta area. In 1962, H.S. Clausen caught live specimens of a third population of Owo some miles east of Akure. The material from Ulf and H.S. Clausen was placed in my tanks.

Soon after the importation in 1957, H.S. Clausen and I were aware that the species from Akure could not be identical with Boulenger's *Haplochilus calliurus* which was said to originate from Liberia. As mentioned in the article about *Epiplatys dageti* (see later) something is wrong when one compares the written material from Boulenger and J.P. Arnold (who delivered the preserved material on which Boulenger based his description of *H. calliurus*). According to Arnold, the material was said to come from freshwater pools in Sierra Leone, whereas the Liberian material originated from Monrovia, Liberia and contained only *E. dageti* (called "chaperi") and *A. liberiense*. Clausen has inspected the type material at the British Museum and he is quite sure that this material belongs to the *Aphyosemion* found east of the Dahomey Gap. Also Arnold expressed doubt that the locality given to him by the sailor who brought the material was not the true one. Shortly after the first importation of *H. calliurus* Boulenger new importations of this fish came in from the Niger Delta area. The only differences that Arnold found between these two stocks was that the second importation did not develop very long fin rays in males. Descriptions of the live fish, drawings and photos etc. in the German aquarium magazines of that time clearly indicate that *H. calliurus* and, in particular, the second importation are extremely close to an *Aphyosemion* which H.S. Clausen brought home in 1962 from SW Nigeria.

A. nigerianum is found all over southern Nigeria, except in the westernmost parts of the western region.

Unlike most other *Aphyosemion*, this species is not confined to the rainforest and derived savanna, but occurs also in the Guinea savannas and extends over a large part of northern Nigeria. Here, as well as in western Nigeria, it is especially common in streams on old rock of the types grouped by geologists under the heading "basement complex", however although it is often replaced by *A. bivittatum* in the sedimentary areas (both in savanna and rainforest), it may be caught in any geological zone. It is particularly abundant in western Nigeria within the quadrangle between Awtun, Ife, Ondo and Akure, and in northern Nigeria on the highest parts of the Jos Plateau (Vom and neighborhood). The type locality is a swamp at Arum north of Wamba, on the southern foothills of the Jos Plateau. Although *A. nigerianum* is widespread both in southern and northern Guinea savanna, it has never been found in the still more arid Sudan Savanna belt. The eastern limit of its distribution is not known with certainty, and it is not unlikely to exist farther east than indicated on the map. The typical forms of *A. nigerianum* have not been found outside Nigeria, but closely related forms that may possibly be races of the same species, were collected from several places in Cameroon. Unfortunately, no live specimens of these survived the hardships of transportation. In the Oban Hills and adjoining districts in the Nigeria/Cameroon borderlands east of the Lower Cross River, *A. nigerianum* seems at least partially replaced by a related, but different (still undescribed), species, referred to later in this article as "Aphyosemion from Ndian River".

A. nigerianum inhabits natural waters of widely different ion concentrations with conductivities from below 20 to over 200 reciprocal megohms/cm. This perhaps explains why it has proved to be a much more robust aquarium fish than any other *Aphyosemion* imported (the section about distribution etc. is written by H.S. Clausen).

Within the Akure population, two male color varieties occur. According to aquarist tradition the terms "yellow variety" and "blue variety" will be used for these two varieties of the Akure population. From the Owo and Port Harcourt populations we only have had "yellow varieties" and it is likely that the "blue variety" does not exist inside these populations at present. The "new" varieties that came from the crossing of the Port Harcourt and the Akure populations will be mentioned later in this article.

When dealing with such highly complicated problems as the colors and color patterns of *Aphyosemion*, I think that one should not use the orthodox color descriptions as you, for example, will find inside "Aquarienfische in Wort und Bild" by Holly, Meinken & Rachov. In this article I will try to split up the problem into its "natural" components.

The colors and color patterns of the mature *Aphyosemion* males probably are a complicated system of "signals" given by the male to his surroundings. The brilliance and the contrasting color pattern of the ripe male probably makes it easier for the females to find a male when they are ready to spawn. Also the combination of patterns tells other fishes to what sex and to what species the male in question belongs.

The colors and patterns might be divided into 3 or 4 groups: the black, the red, and the yellow pigmentations and the bluish brilliance. The brilliance of the male mostly comes from the guanin crystals distributed over the body and sometimes also the fins of the male. Unlike the more constant colors of the pigmentations, the brilliance varies rather much depending on the composition and angle of the light in which the fish is seen. Normally *A. nigerianum* is considered as bluish green. This is the color in

incidental light coming from above. If one directs the light on the fish horizontally, the fish looks much more blue. If the light comes from below, the fish may look violet blue. As W. Foersch first pointed out for some South American Rivulins, the brilliance of rivulin males also depends on the light conditions in the tank where the brood is raised. Males from light tanks become much more brilliant than males from dark tanks. This is probably caused by an increased development of dark pigments in the latter. One result of the carbon dioxide blowing was finding that increasing the oxygen concentration of the aquarium water produced an increasing brilliance on killies. Indeed, if one keeps males of several species of *Aphyosemion* together in one tank, one will notice clear differences in the color reflected from the brilliant sides. Compared with other *Aphyosemion*, *A. nigerianum* has a greenish bluish brilliance, whereas *A. cinnamomeum* is violet blue.

Black pigments, so important when studying *Epiplatys*, play a minor role in *Aphyosemion*. Black pigment cells do not form conspicuous patterns but are rather evenly distributed on the sides. The red dots on body sides may show blackish edges or even an even blackish red color of the spots that make these more conspicuous. A few *Aphyosemion* however have important black pigments. Red pigments seem to be the most important pattern forming elements. These pigments form the conspicuous red spots on the body sides. There are about three times as many red dots on the body sides of males from the Port Harcourt population as on males of the Akure population. The Owo males are just like the Akure males. The "hybrids" produced with a Port Harcourt male and an Akure female had approximately twice as many red dots as had the Akure males. This means that the hybrids get just the average number of red dots as $1+3/2=2$.

Just behind the gill covers there is a certain concentration of red dots that are dark edged or even blackish red when the male is activated. Such "wounds" or "false eyes" are present also on males from other *Aphyosemion* and may be rather conspicuous on *A. (?) petersi*. A like pattern exists on males of *Pterolebias longipinnis*. A somewhat different, perhaps more ancient, pattern is formed on fighting and breeding males of *A. bivittatum* by a strong reduction of the upper black longitudinal band. I use the term "false eye" because it may be so that these blackish dots imitate an eye and thus save the real eye from some of the attacks that rivals direct against it during fight. As on many other *Aphyosemion* males the rows of red scale dots tend to form longitudinal red lines on the anterior part of the sides and vertical rows on the posterior part of the body. Such systems are more conspicuously developed on *A. coeruleum*. On the head the red pigments form more lines than dots. On the gill covers there are the usual "worm like" patterns. The throat pattern of this species is rather glaring, but also rather complicated. As usual among African Rivulines some basic pattern is visible. These patterns are generally associated with the system of lateral pores but not always to these.

Principally, the pattern of *A. nigerianum* is that of *A. bivittatum* if we change black pigments into red pigments. The red line just behind the lower lip is well developed. From below the eyes runs a more or less complete curved red line parallel to the first red line. There are also many red pigments below the gill covers and here and there (without a clear pattern) on the throat. As usual on the sides of *Aphyosemion*, the brilliance and the red dots of the sides run into the inner parts of the fins - not very much in the pectorals that principally show the same pattern as other fins. Midway, more or less, in the fins, except the caudal fin, there is a more or less complete broad red line. On Akure males of the "yellow variety" there is always an unbroken red line in the anal fin, whereas on blue males there is never an

unbroken red line in the anal fin.

First, one may consider this system as the reason for the presence or absence of yellow color on the outmost parts of these fins. For a long time I thought it to be so, but at present I find this problem much more complicated. Below this red line of the anal fin there is a very narrow but visible line of greenish blue. Then follow the conspicuous yellow edges. The red line in the dorsal fin of yellow males is more narrow and less complete than the Port Harcourt males and, also according to Clausen, than the Jos Plateau populations. The pattern of the caudal fin is equal to the patterns of the dorsal and anal fins in its principles.

The blue males of the Akure population have these typical unbroken red lines of the anal and dorsal fins. But the caudal fin pattern is just like that of the yellow males. This is the first "proof" that the yellow color of the fin edges is not caused (only) by the red lines seen in dorsal and anal of yellow males. Since 1957 I have not been interested in the production of a pure blue population, so my personal knowledge of the blue males is based on such that have come from my breeding of yellow males. As one is not able to see if a certain female is "blue" or "yellow" it is very difficult to get rid of the blue males. From my breeding results it is clear to me that the differences between the blue and the yellow Akure males is based on a single gene (or coupled group of genes) only and that the yellow male is the recessive and the blue male the dominant form. That means that if a certain male possesses one single gene for "blue" it will not be able to mature as a "yellow" male in spite of the fact that such a male also has a gene for "yellow". Yellow males have no genes for "blue". Blue males may have one or two genes for this color.

These simple genetics are not valid for all populations of this species. As mentioned above, the crossing of Port Harcourt and Akure populations produced a male with more red dots on body sides and fins than seen on males of the Akure population. My next thought then was to produce a male of the blue variety that should have such a concentration of red dots that the row of red dots inside the anal fin would merge into an unbroken red band in order to see if the "blue" male would exist after such transformation of the blue male. I did not reach this point of transformation (see below) but in crossings between *A. nigerianum* and *A. "species from the Ndian River"* I have produced such males which still are just as "blue" as ordinary blue males. Also in the broods from the Port Harcourt and Akure cross, there was one male that was about to close the red line in the anal fin and also one male which was about to close the red line in the anal fin and also this male was as "blue" as males of this cross may be.

On the back of male *A. nigerianum* the red dots tend to form red scale edges just as we find it on many species of *Aphyosemion* and *Epiplatys*. This tendency is weakly developed inside *Aphyosemion* and strongly developed inside *Nothobranchius*. *Epiplatys* are intermediate as both sorts of red pigmentations occur.

Yellow pigments are present in all males. On yellow males they form the conspicuous yellow fin edges. As I am not working on pure "blue" stocks I do not know with certainty how yellow pigments develop on such males during maturing. My blue males all had a single gene for yellow as only yellow males are used for spawning. When young, such blue males take on a glaring lemon color at fin edges. Old mature males of the Akure population loose this color normally. The blue males of the Port Harcourt/Akure cross may keep this lemon color for their whole life. But this is not the only departure from the simple

laws of heredity within *A. nigerianum*. The next generation of this cross produced a male that was "yellow" on all fins but the anal which was perfectly "blue": no trace of yellow in that fin and the normal warm yellow (not lemon) in other fins. Also hybrids from the Ndiab River species cross may show tendency to yellow color in the dorsal fin and not in the anal fin. These tests show that the problem of "yellow" and "blue" is not a simple one when more populations are considered.

From my many crossings inside *Aphyosemion*, I have learned that it is most likely that the gene which produces yellow is not different in different species. As you may know there are also a "blue" and a "yellow" varieties in *Aphyosemion cognatum*. However in this species it is very difficult to distinguish between the two varieties as there is no red "separation line" and because of the very many red dots which cover the fins. When seen against the light, it is easy to distinguish. Crossing both blue and yellow *A. nigerianum* males to the very same *A. cognatum* female gave the following results. From the blue male only (many) blue hybrids were harvested. From the yellow male I had only two males. One hybrid was typically yellow and the other one was typically blue... the number of red dots was somewhat higher than on *A. nigerianum*, but by far less than on *A. cognatum*. No "separation red line" was formed on any male, not even traces of a certain concentration in the middle of the anal fin. From the cross of *A. filamentosum* to *A. arnoldi* just the opposite occurred. Here the separation was "dominant".

The mature yellow *A. nigerianum* male is a very conspicuous fish indeed. In particular, when he stretches its fins. This situation will occur if he spots a female or a male. During the first phases of a fight or a spawning the male will not only stretch its fins, but it will also fold them close to its body. Just after the folding which is linked to heavy movements of the body it suddenly unfolds its fins and these and the gill covers (which have much red pigments also at the inner surfaces) are spread as much as possible. Then he repeats this folding of the fins and so on. These "scissor movements" are very typical for *A. nigerianum* and many more *Aphyosemion*. In my opinion, these movements are likely to be linked with the presence of yellow fin edges as such pattern produce the highest glaring contrast of colors when the male folds and unfolds its fins.

One may ask with it is like this that inside certain populations of *A. nigerianum* there are two rather differently looking varieties of the male type. Maybe this question could be answered like this:

Yellow males are conspicuous indeed. Their glaring appearance makes them rather easy to spot if females want them for spawning. However, they are also easily seen by predators looking around for some good food. There are reasons to believe that the males possess some advances in the reproduction of the population and also that these advances are counteracted by a higher degree of vulnerability towards predators. If inside a certain population the stress given by birds and fishes increases, it might be that the percentage of yellow males is reduced and that blue males become more numerous. It might even be that the yellow males, at a certain time, are eliminated in the population. However, as the yellow variety is not the dominant one (genetically), it will be very difficult to eliminate the yellow males from the population as many females and also some of the blue males possess their hidden genes for yellow. The presence of the dominant blue males thus acts as a "buffer" when predatory systems increase their stress on the population. If this idea is correct, the presence of the two varieties of *A. nigerianum* inside certain populations of this species may cast some light on the evolution of the male type inside *Aphyosemion*.

Inside *A. nigerianum* the reduction of the yellow color on fin edges is a complete one. Yellow fin edges or no yellow fin edges. Inside *A. cinnamomeum* only the yellow color of the dorsal fin is reduced. Inside Roloff's 1962 populations of *A. roloffii* from Sierra Leone and also inside wellknown *A. calabaricum*, there is no yellow color in the dorsal and the anal fin. The caudal fin may show yellow color on the upper and the lower edge, or only on the lower edge or no yellow color at all (*A. geryi* Lambert). Inside *A. cognatum* the reduction is produced by the increased number of red dots on all fins. Some reduction of the contrast is also pronounced when there is no "separation" (red) line in fins.

The development of body and fins is seen in photos. Inside *A. nigerianum* the upper and lower rays of the caudal fin do not form long filaments and only short lobes are seen on males from the known populations. The rays of the dorsal and anal fins are somewhat produced beyond the fin membrane. These short "hooks" probably are used to get a firm hold of the female during spawning as both fins clasp the female (or better say try to...) as usual within *Aphyosemion* and *Nothobranchius* etc. However, inside *Aphyosemion* these fins usually are too short to get a firm hold. Also in *A. nigerianum* there is no conspicuous prolongation of some of the pectoral fin rays that are used by males (*A. coeruleum*, *A. filamentosum*, etc.) also to hold the female when the male is "riding on her back".

Females of *A. nigerianum* are rather uniformly colored as most females of this genus. The belly has an orange tinge as females of *A. labarrei* and *Aphyosemion* from the Ndian River. The unpaired fins have some brown spots.

The results of the crossings of *A. nigerianum* to *A. cinnamomeum* have been reported in the draft for the latter. In the crossings *A. nigerianum* acts somewhat differently than other species of this genus. Best crossings give viable hybrids. This is not the case inside crossings of other species of this genus, as viable hybrids normally are only present in crosses with apparently closely related species.

Next five lines cannot be read completely!!!!

... and here (most) eggs developed normally and gave very viable fry) 20 eggs spawned only 6 were fertile. During the first 14 days I was unable to trace any development of a corda in any of these 6 eggs. After blastulation and gastrulation, development stopped completely. After a few more days all eggs were closely inspected. There were black pigment cells on the yolk of most of the eggs. Some eggs had a rather undifferentiated short body that might be the corda. The eye is visible and also the very blunt end of the "tail". The central part of the "body" was not visible. No movements, no blood, preserved.

Akure male and *A. gulare* female (called "beauforti") from SW Nigeria gave only a few eggs. One of them gave a very viable hybrid. It reached 2 1/2 inches and spawned eggs of equal size. However, not a single egg from many back crossings with *A. nigerianum* did develop.

A. australe male (aquarium stock) and Akure female (1958) gave eggs and embryos also developed normally. The fry however was difficult to raise. Again in 1965 this cross was prepared (Port Harcourt/Akure female) and the same thing happened. Some fry could not be raised to maturity, but 2 matured and after maturing they were not feeble. Both were males. See photos. They were shaped and

colored mostly like *A. australe* males. When young, both had lemon fin edges, but this color faded away with age. Compared with *A. nigerianum*, both were blue males. The red dots formed longitudinal lines on the foremost part of the body and tended to form transverse red bars on the caudal peduncle.

The Akure male and female were crossed to male and female of *A. cognatum* (Aquarium Hamburg 1954 stock, very close and perhaps identical to the material on which Meinken based his description). Most hybrids of this cross had deformed lower jaw and were not able to shut their mouths. The jaw was very big and spoon-like. Only one individual with deformed jaw reached maturity and learned to eat (even life Daphnia). As far as I was able to see it used its gills to hold the food before it swallowed it. All hybrids were males (more than 50 were raised to *A. cognatum* since). All were sterile in back crosses. Hybrids of these crosses are very feeble and difficult to raise.

A. christyi (aquarium stock 1958), the genotype of Aphyosemion, gave 15 hybrids with Akure female. These hybrids apparently were more viable than the hybrids produced with *A. cognatum*. However, only 2 individuals reached maturity. They were very close to the *A. cognatum* hybrids, but oddly enough they had more red dots on the male's body sides and also they were more brilliantly colored. On male's sides the red dots formed long red bands and it grew nearly to *A. nigerianum* size. The other individual was female like when young, but later on it developed a male's characters. It never spawned a single egg.

A. labarrei male (aquarium stock) and Akure female did not develop viable fry as all embryos died inside their eggs apparently from thrombus. Ed Seligmann of USA informed me that he was able to produce viable fry from this cross and his color slides show a male that comes close to my *A. cognatum* hybrids. As there are very big differences in egg size between these species (lab = 1.8 mm, nig = 1.0 mm, Akure stock), this may be the reason for the differences of our results.

The Akure male with *A. coeruleum* female (aquarium stock) gave more than 50 very viable hybrids. Both sexes were present in this cross. Males developed very brilliant colors and grew up to *A. coeruleum* size. They were very active and defeated even adult *A. coeruleum* males. Males were sterile in back crossings and with their sisters. Females spawned, but their eggs differed markedly in size - from less than 1.0 mm to more than 1.8 mm (eggs of *A. coeruleum* measure approximately 1.4 mm). In back crossings with males of *A. coeruleum* and *A. nigerianum* I got more than a hundred fertile eggs. Only big eggs were fertile. Embryos however died from apparently several reasons at different phases of development. Only a few fry were hatched. They were very feeble and only one fry survived its first weeks. It came out of a 1.7 mm egg. Its father was a yellow *A. nigerianum* male. Just after the hatching it measured 5.4 mm and it grew very slowly. It was badly deformed even from the hatching and its vertebral column was deformed by the way that it was like an upright "Z". 4 months old it measured only 30 mm and it was then colored like a blue Akure male. Despite its deformation, it was very active and it attacked and defeated Aphyosemion males of much larger size.

The unidentified Ndian River male and the Port Harcourt/Akure female produced eggs and embryos which developed normally. However, a few eggs developed an embryo which was not viable (see below). 8 normal fry were hatched and just now I am raising these to maturity. The biggest male (all are males) is very much like a normal *A. nigerianum* male of the yellow variety. However, it has a complete dark edge of the anal fin. This means that the yellow color on this fin is edged above and below by a red

band.

The results of crossings so far indicate that *A. nigerianum* is somewhat closer to the so-called Fundulopanchax than to typical Aphyosemion. However, the differences of crossings to these two groups are not big.

In connection with the results of these crossings I have to return to the cross of Ulf's Port Harcourt males to Akure females. The first generation contained both males and females. The deviations seen in the development of color patterns were natural. However, the results of the "uncontrolled" reproduction were highly unsatisfactory as only a few fry were harvested when the bottom of peat was dried and watered after 4-6 weeks. In order to control the reproduction, two males and two females were separated and spawned on nylon. The development of the eggs was studied. Eggs measured 1.2-1.5 mm (Akure females spawn eggs of 1.0 mm size). Such differences of egg size are abnormal within Rivulins where the egg size normally is a very constant character inside different populations of one species. The development of the embryos differed markedly in eggs of the same age. Most embryos died inside their eggs from thrombus or unknown reasons. From controlled and uncontrolled spawnings, a total of 8 viable fry have been raised. To make things even worse, these fry are rather feeble and difficult to raise. Only one female fell from these efforts.

If I had not had like results from crosses of different populations of *A. bivittatum*, it would be difficult to understand that individuals of two populations geographically close one to the other and which apparently belong to one single species, are not able to reproduce when brought together. It seems as if these two populations of *A. nigerianum* are about to develop into two different zoological species. Also one does not know if this differentiation is a result of the Niger River itself or if it is caused by some climatological events a long time ago.

A. nigerianum has been so extensively kept as an aquarium fish since 1958 that we are not able to add much information about the breeding and keeping of this fish. The Akure population is a very robust stock. Compared with most Aphyosemion species I found this species to be very aggressive and old males often develop into real murderers. The eggs are spawned at all levels of the tank. The membrane pattern belongs to the "reticulated type" but the pattern very often is very weakly developed. The fry measure 4.5-5.0 mm just after hatching. The maturing starts at an age of 6-8 weeks. Normally eggs do not develop in an "annual" way when kept in water with a free exchange of oxygen from the air. "Resting fry" occur now and then apparently depending on the type of water used for the eggs.