
The Scheel Letters, No. 16

The Genus Aphyosemion

In Denmark, the introduction of the "rain forest aquarium" (rainwater plus peat bottom etc.) has made it possible for skilled aquarists to keep and also to some extend breed the more feeble species of killies. Because of that, the various fishes called Aphyosemion have gradually found their way to our tanks. 1953-54: *A. australe* and *A. bivittatum*. 1954: *A. cognatum*. 1955: *A. filamentosum*, "*A.*" *petersi*, *A. sjoestedti*. 1956: *A. calabaricus*, *A. coeruleum*, *A. labarrei*. 1957: *A. "calliurum" ahli*, *A. calliurum calliurum*. 1958: *A. schoutedeni*. All species have been established, however only among very few aquarists.

The fishes called Aphyosemion form a confused mass of names, and are not very easy to survey, not even for the zoologist. Many so-called species have been described only upon a single preserved specimen, often even without any distinct locality in nature given. As I could not find any survey on these fishes, I dived into the literature in order to collect some facts about the "genus" Aphyosemion. I certainly know that this is not the field of aquarists, but simply I needed this information. Here they are (translated from three articles I wrote to the Danish pet magazine: Stuekultur, Feb., Apr., and May 1959). Please consider the material only as an attempt to find out what Aphyosemion really are.

"In the course of time zoologists have described very many "species" which more or less could be or have been referred to what we commonly call Aphyosemion or Epiplatys, as the later in some way seems to merge into the Aphyosemion. "petersi" and "duboisi" for example. About 75 different "species names" could be collected, but at least 20 of these have been omitted as synonymous. No doubt many more species names will be placed as synonyms in the years to come.

The genus Aphyosemion no doubt is a young group of fishes at the peak of evolution. And this evolution no doubt is greatly favored by their particular habits of living in pools and other small often isolated and even temporary freshwaters. This forces the species to fall into small local populations that are more or less isolated from each other and thus the development of certain specific characters is favored. Local races may develop. In order to throw light on this very interesting question I made up my mind in 1957 to try to cross breed the various aquarium kept species called by name of Aphyosemion in order to find out primarily: the affinity between these species, also if possible the various color patterns (if any) common to two or more of these species (as in guppy) and secondarily to try building up some new "aquarium races" which could be cultivated. Dr. Hoedemann kindly promised to carry out the zoological part of this work.

These crossing experiments that were not so difficult to make raised some problems. An example: crossing a "labarrei" male to a "schoutedeni" (or "cognatum") female gives a fine development of embryos in apparently all eggs. But if you cross the "schoutedeni" male to the "labarrei" female you will realize that the embryos in the eggs have not a chance to live within a week after spawning. Certainly the great difference in eggs size here may play a role, but other factors also may play a role such as the composition of the yolk and so on. As the crossings of 1959 mostly are very young fry or resting eggs, I possibly have to wait a few months more until a summary of the crossings could be drawn.

Zoologists (Myers a.o.) divide the genus Aphyosemion in three subgenera: Aphyosemion - Fundulopanchax - Callopanchax. The subgenus Aphyosemion includes the species in which the dorsal fin is inserted far back on body as is the anal fin. Also the dorsal fins mostly have a narrow base and less fin rays compared with the anal fin. These species previously (before 1924-35) were called "Haplochilus" or "Panchax", but these names are not in use now. Most species are slender, very handsome formed and elegant small fishes. The best known species, the "australe", may stand as a typical member of this subgenus as far as the shape of body and fins is concerned. These species all grow up to about the same size - a little more than two inches. The spawning act normally takes place among fine plants or roots of swimming vegetation and only rarely they spawn at the surface or into the bottom peat. Eggs measure from 1.0 to 1.5 mm and are provided with many long filaments, mostly concentrated in one or two poles and these filaments adhere the eggs to fine plants or algae. A few hours after spawning eggs will stand a rather hard pressure and they may be collected using your fingers (better cut them out). If eggs are deposited with plants, resting eggs (as far as I know) are never found, whereas this state of development may occur if the eggs bury into mud. The development of the embryo normally takes from one to 3 weeks and normally (in rainwater) the matured eggs will hatch willingly. Resting fry occur in some of the species, at least under certain circumstances, first of all in "schoutedeni", but also sometimes in "cognatum", "calabaricus" and possibly in others. Fry is 4.0-5.5 mm long and often to be found near the surface at least during the first week. They are not very shy and normally do not hide themselves.

This subgenus extends over the whole area of distribution of the genus whereas the two other subgenera form "islands" within this area. The main area of distribution runs from Sierra Leone in the Northwest along the coast of Guinea and south to the mouth of the river Congo. Only in the lowlands surrounding the Niger, the Ogooue and the Congo the members of the genus seem to penetrate deep into the continent. Sierra Leone has only one species: *A. roloffi* (imported in 1936) that may be a close relative of *A. calabaricus* in Nigeria-Cameroon. Liberia has *A. calliurum* (possibly not identical with the species "swimming" under this name in our tanks) that extends into Nigeria. This species was imported (G) in 1908 and later on. The Ivory Coast has *A. maeseni* and possibly also *A. guinensis* that are not kept as aquarium fishes. Nigeria has at least 4 species: *A. oeseri* (imported in 1928), *A. calabaricus* (imported in 1935), *A. calliurum* and *A. calliurum* ahli (imported in 1932). Cameroon has *A. escherichi*, *A. jaundensis* and *A. loloensis* in the northern part together with the *A. calliurum*. More southwards lives A. australe (imported in 1913), *A. cameronensis* (1913) which extends to the south and is known to be a rather variated species. Also *A. exiguum* (?) and *A. loboanus* (?) may be found here. Gabon has *A. australe*, *A. cameronensis* and the type species of the subgenus: *A. schoutedeni* (1949 under the name of "singa"). Deep into the Gabon 2 subspecies of *A. laufae* are found ("louessensis" and "ogoensis"). The land south of Gabon and north of Angola may be called Lower Congo. Here *A. schoutedeni*, *A. cameronensis* and *A.*

cognatum are found. "cognatum" was imported to Germany in 1950. Central Congo has *A. elegans*, *A. schoutedeni* extending to the northeastern corner of the basin where *A. margaretae* (only female known) and *A. christyi* may live. In the central and southeastern part of the basin no Aphyosemions are found, *A. ferranti* and *A. lujae* live near the rivers of Kasai and Sankuru. I cannot place *A. meinkeni* and *A. vexillifer*.

From the point of view of the aquarist, these species (as far as they have been kept in aquaria) form a well defined group of possibly closely related fishes. This is not the case with the next subgenus: the Fundulopanchax. These species are kept together mostly by the fact that the dorsal fin is inserted just above the anal fin. Also the dorsal fin mostly has a broader base as in Aphyosemion and normally nearly the same length of the base as has the anal fin. Before 1924-35 these species (if known) were called by the name of Fundulus (this name is now only used in connection with the New World Killies). In the subgenus Fundulopanchax the aquarists certainly will see two (three) distinct groups of apparently related fishes.

One group includes the "longitudinal banded Aphyosemion", the "bivittatum group" with Aphyosemion bivittatum bivittatum (imported in 1908). These species have a narrow area of distribution: Nigeria-Cameroon. Members of this group are easily recognized by the females which have (one? or more) distinct dark longitudinal bands running from the nose to the caudal peduncle. Most species are now (?) recognized as subspecies of *A. bivittatum*. These are: *A. bitaeniatum* that possibly also lives west of Nigeria, *A. bivittatum* and *A. multicolour* (imported in 1912) in the lowland of lower Nigeria. In Nigeria *A. bivittatum* hollyi and (?) *A. rubrostictum* (imported in 1932). Cameroon has *A. loennbergii* (imported in 1905), *A. splendopleure* (imported in 1929) and (?) *A. pappenheimi*, *A. riggenbachi* and *A. unistrigatus*. Some of the species (or races) have been crossed by Turkish Zoologists. In keeping and breeding these "bivittatum relatives" are like Aphyosemion.

The real Fundulopanchax may be assembled in a "gulare group". These species are more "clumsy" than most other Aphyosemion. These species often spawn in the surface layer of the bottom, but not rarely they spawn on fine plants. Also they are easily spawned on perlon (nylon wool). In perlon on low water I did not see any resting eggs until now. Eggs spawned deep (or placed deep) into mud normally will not develop within weeks or months. Eggs that are dried up into peat normally will develop, but resting eggs may be found even after up to 1/2 year after the drying up has started (*A. filamentosum*). Resting fry normally occur in eggs that are matured in water. However, now and then some fry hatched out from these eggs in particular if water is changed or gets little dirty. Hatching of one egg apparently often induces hatching of other eggs with resting fry. Some species have an egg type very like the members of the subgenus Aphyosemion, but at least in A. filamentosum (name possibly not correct) there are no filaments and egg membrane has another pattern (like sjoestedti). Within the real Fundulopanchax we find the biggest and the smallest of the aquarium kept Aphyosemion.

The *A. gulare* (imported in 1907) is little known to aquarists of modern times. Its close relative is *A. coeruleum* (imported in 1905) that may be a race. Nigeria-Cameroon.

Liberia has *A. liberiensis* (imported in 1908) but perhaps this species is not a real Fundulopanchax. The Ivory Coast has A. gardneri (imported in 1908) which extends eastwards deep into Nigeria and may consist of many races, now known as "species".

Ghana has *A. fallax* that possibly is close to *A. coeruleum*. 60 mm long - this species was imported to Germany in 1930. Togo-Dahomey has *A. filamentosum* that possibly is a race of "gardneri". Imported in 1932. Nigeria has (apart from *A. gardneri*) *A. arnoldi* (imported in 1908), *A. coeruleum* (1905), *A. gulare*, *A. nigri* and *A. zimmeri*.

Cameroon has A. gulare and A. coeruleum together with A. gustavi, A. schreineri, and *A. splendidum*. *Fundulus walkeri* in the southern part of Cameroon may be a Fundulopanchax (if not an error). I do not know where *A. spurelli* lives.

Apart from these two main groups of Fundulopanchax, some species are recognized as Fundulopanchax by zoologists. Aphyosemion batesi in NW Congo, *A. labarrei* in Lower Congo, *A. beauforti* in S. Cameroon cannot be placed in the two main groups. "labarrei" seems to stand closer to the subgenus Aphyosemion, but also this handsome species shows traits which are not seen in any other aquarium species of Aphyosemion. The easy crossing (of male) to "cognatum" and "schoutedeni" and the vitality of the hybrids (which no doubt all are sterile) point towards the subgenus Aphyosemion. The two "calliurum races" which I distributed in 1958-59 "by eggs" and which were caught near Akure by Birket Smith in 1957 are true Fundulopanchax in behavior and breeding and seem to stand close to "arnoldi" and also to "coeruleum". The subgenus Callopanchax includes only one species - *A. sjoestedti* (imported in 1909). In nature this species is said to live all the way from Sierra Leone to southern Cameroon. Only this species comes close to the Cynolebias-Pterolebias as "annual fish".

In literature we find some "species names" which I have not mentioned in this superficial revue of the Aphyosemion: "petersi", "duboisi", "maroni", "elberti" and "senegalensis" possibly are Epiplatys. "bualanus", "preussi", "obscurus", "carnapi", "microstomus", "bellicauda", "pascheni", "normani" are varities (or races) of *A. cameronensis*. "castaneum" and "*A. singa*" are *A. schoutedeni*. The real "singa" is a Congo species of Epiplatys. "polychromus" is *A. australe* and "pictus" is *A. meinkeni*.

Climatic Conditions

<u>The western coast of Africa</u> is touched by cold ocean currents. From the North comes a cold current running southwards and cooling even the coastal waters to 12 degrees Northern Latitude in the spring (Feb.) and until 17 degrees Northern Latitude in the autumn (Aug.). The water temperature does not exceed 21 C. In the South another even colder current comes up from the Antarctic carrying water of 13-14 C. In between these cold currents the warm Guinea current runs eastwards touching the whole coast between Gambia and Cape Lopez in the summer and the coast between Sierra Leone and sometimes as far south as the Mouth of the Congo in the winter. Aphyosemion are found within the range of the Guinea current.

<u>Sierra Leone and Liberia</u> have rather distinct rainy and dry seasons. Most rain falls in Aug. (above 800 mm) but also heavy rain comes in May-Oct. Jan.-Feb. in particular are rather dry (about 5 cm each month). The total rainfall may be 4400 mm a year (Freetown has 3780). The mean temperature does not change very much. 27 ½ C in the hottest (Mar.-May) and 25 ½ C in the cooler months (Aug.). The mean

temperature of the year is about 27 C.

Along the coast eastward of Liberia bring us into areas with much smaller rainfall. Abidjan (Ghana) has only 685 mm. Jan. and Aug. have 15 mm each. Most rain comes in June (175 mm). Abidjan-Accra has almost the same mean temperature 26 1/2 - 27 C for the year. 24 1/2 - 25 ½ C in the coldest months (Aug.) and 27 1/2 - 28 C in the hottest (Mar.-Apr.). The dry area along the coast extends into Togo.

Western Nigeria has much more rain and the rain is rather evenly distributed through the whole year despite the fact that we now are close to the equator. The annual rainfall is 1790 mm near Lagos which has 100 mm in each of the months Apr., June, Sep. and Oct. June has 470 mm but Dec. and Jan. have only 20-27 mm each. The mean annual temperature is 27 C, 25 ½ C in July-Aug. and 28 C in Feb.-Apr. The Niger Delta has more than 2500 mm but only close to the coast. A few hundreds of kilometers from the coast only half that amount of rain comes down or even less.

Eastern Nigeria (Old Calabar) gets even more rain. The annual rainfall is 300 mm or even more. Most rain falls in the months of May-Oct. (each above 300 mm). Dec.-Jan. has "only" 50 mm each. The mean temperature is only 26 C. 25 C in Aug.-Sep. and 27 C in Feb.-Mar.

Just at the point where the coastal line bends off and runs directly southwards we find one of the world's most rainy areas. Also we find many interesting killies and other aquarium fishes. The western slope of the huge Mt. Cameroon has more than 10 000 mm of rain a year. This mountain is about 4000 m high. Dejundja in Cameroon has 9400 mm (maximum 14 500 mm in 1919). Jun.-Oct. have more than 100 mm each. Jan. has only 187 mm. 2/3 of the rain falls during the night. Douala has only 3960 mm. Mar.-Oct. have more than 200 mm each and Jan. has 26 ½ C. Extremes are 35 C and 18 ½ C.

Gabon also has rather heavy rainfall. Libreville has 2400 mm. Jun.-Aug. are rather dry with 18-20 mm. Other months have more than 100 mm each. Mar. and Nov. have 350 mm each. Annual mean temperature is 26 C. July has 24 ½ C and Mar.-Apr. it is 27 C.

South of Gabon there is less rain and the annual rainfall near the mouth of the River Congo is about 100 mm at the coast. South of the River Congo the climate is too dry for Aphyosemion. The annual rainfall here changes rather much from one year to another caused by variations in the hot Guinea current. Boma and Matadi near the mouth of the Congo (Lower Congo) have 1130 and 1000 mm. Jan.-July are completely dry (0 mm), but also Aug.-Sep. are very dry (a few mm each). Nov.-Apr. have more than 100 mm each. A. labarrei lives near Matadi. Annual mean temperature is 25 ½ C and the difference between coldest and hottest months (mean) is 4 C.

Central Congo has more rain: about 2500 mm in the center and about 2000 mm at the edges of the basin. As in the huge basin of Rio Amazonas we find no distinct rainy or dry seasons. The great evaporation from the rain forests makes a local evaporation-rain-system. During the daytime the water evaporates in the warm air moving upwards. Towards evening or night, big clouds are formed by the decrease of temperature, caused by the moving upwards of the air and the time of day, and water falls down again as rain. Mean temperature is 25-25 ½ C and differences between coldest and hottest months are only about 2 C.

The Water Conditions

Strangely enough, compared to the Amazon Basin and South America, as a whole, only a few water analyses from this area seem to be published. In DATZ Nr. 4/1953 an incomplete analysis is given of waters near Abidjan (Ivory Coast):

- "soap hardness" (total hardness) 8.4 German Degrees,
- temporary hardness 7.0 G.D. (rather high at the end of the "short rains"),
- Chloride: 167 ppm (mg/l) as Cl^-.
- The city supply at Abidjan had a total hardness 7.0,
- temporary hardness 5.0 and Cl^- 149 ppm.

Stenholt Clausen, Ibadan, has told me that fresh water all over the rain forest area of lower Nigeria has 20-30 reciprocal megaohms. This is equal to the "best rainwater" in Copenhagen. 20-30 reciprocal megaohms corresponds to distilled water with 12-18 ppm of common salt resolved. At Ibadan (annual rainfall about 1270 mm) natural water had 100-200 rec. megaohms (equal to 55-110 ppm of common salt in distilled water). From Conway's water analysis one may estimate "typical rain forest water" as 15-70 rec. megaohms (10-40 ppm NaCl). I made an incomplete analysis of some natural water from Ijebu Ode (in the lowland east of Lagos) which had about 40 fishes in about 2 liters for about 2-3 days. Water had less than 1 German degree of soap hardness and about 80 rec. megaohms. Stenholt Clausen measured also natural water in Cameroon and found 8-10 rec. megaohms and water to be compared with purest distilled water.

For the River Niger only one incomplete analysis has been found. French Sudan: temperature at the surface 31 C in May and 18-19 C in Jan. pH may increase up to 7.6 when sun is burning at the surface water (vegetation?) but normally the water is "acidic". The water of the river measured "1 degree Hydrometrique" (that is 10 ppm of $Ca(HCO_3)_2$ or 0.5 German Degrees of hardness.

Until recently I had no success in finding information on the water of the Congo system. I only knew that at Stanley Pool the water had pH 6.4-6.7 and that the hardness was close to 2 German Degrees. Then Dr. Poll sent me his new book: "Recherches sur la faune ichthyologique de la region du Stanley Pool" III (Estrait des Annales du Mus_e Royale du Congo Belge, ser. 8 S. Zoologie, Vol. 71, 1959) and in this book a complete analysis of the water of Stanley Pool was found:

Stanley Pool: Sep. 1957. Area about 500 km, depth up to 10 meters. The water level oscillates by about 3 meters through the year, being the lowest in Mar. and Sep. and highest in Dec. The water is rather turbid and the Secci-disk cannot be seen below 50 cm. The bottom is sandy.

- Water temperature at the surface: 27.3C.
- Temperature at depth 3 m: 27.4 C. pH is 6.53.
- Temperature of air: 26.8 C.
- alcality phenolphtaleine
- methylorange

- acidity phenolphtaleine 0
- methyorange 0.296 meq/l 0.044 0
- Hardness: 3.6 French Degrees
- Ca^{2+} 14.4 ppm 14.4/20 0.72 meq/l
- Mg^{2+} 0.05 0.05/12 0.00 Known Cations: 0.72 meq/l
- Cl^- 13.0 13.0/35.5 0.37
- SO_4 8.6 8.6/48 0.18
- HCO_3 18.1 18.1/61 0.30 Known Anions: 0.85 meq/l

As the pH value does not play any part in the equilibrium between cations and anions in this case, there should be at least: 0.85 - 0.72 = 0.13 meq/l more cations in the water. These cations possibly are sodium (Na^+), see later.

Hardness

- 1 French Degree corresponds to 0.56030 German Degrees of hardness
- Total hardness: 3.6 x 0.5603 = 2.20 German Degrees
- Temporary hardness: (from meq/l HCO_3) 0.30 x 0.356 = 0.84 German Degrees
- Lasting hardness: 2.20 - 0.84 = 1.18 German Degrees

Salinity The following data are given:

residue /total residue solids /residue soluble

- dried at 105_C 114 ppm 49 ppm 65 ppm
- dried at 600_C 83 ppm 45 ppm 38 ppm vsuspended in solution
- Balancing (dried at 600_C) $Ca(HCO_3)_2$ changes to CaO: 0.30 meq/l = 0.30 (20+8) = 8.4 mg/l
- $CaSO_4$ 0.18 meq/l = 0.18 (20+48) = 12.2 mg/l
- $CaCl_2$ (0.42 - 0.18) 0.24 meq/l = 0.24 (20+35.5) = 13.2 mg/l
- NaCl (0.37 - 0.24) 0.13 meq/l = 0.13 (23+35.5) = 7.6 mg/l
- Total salts (dried at 600_C) calculated 41.4 mg/l that is 3.4 mg/l above the results of the analysis given.

Other Data

- CO_2 free = 1.94 ppm Fe = 1.22 ppm
- O_2 free = 5.54 ppm NH_4 = less than 0.01 ppm
- NO_3 = 0 CO_3 = 0 (as pH is below 8.2)
- NO_2 = less than 0.01 ppm OH^- = 0 (as pH is below 8.2)

This water is very close to the type normally used in "rain forest tanks".

Two small rivers run into the Stanley Pool: the N. Djili and the N. Sele. Poll gives the analysis of the water of N. Sele and this analysis is very interesting and possibly shows us the maximum of pH in a low buffered freshwater.

- Temperature in the water 26 C, pH 8.51 (no free CO_2 present!!!!)
- Alkality-f: 0.054 meq/l
- Acidity-f: 0
- Acidity-f: 0
- Hardness: 2.8 French Degrees totally = 1.53 German Degrees
- Ca^{2+} 11.2 ppm 11.3/20 0.57 meq/l
- Mg^{2+} 0.05 8.0/48 Cations known 0.57 meq/l
- Cl^- 8.0 8.0/35 1/2 0.23 meq/l
- SO_4 9.6 9.6/48 0.20 meq/l
- HCO_3 12.3 12.3/61 0.20 meq/l
- CO_3 3.24 3.24/30 0.11 meq/l
- Unknown Cations: at least 0.74-0.57 = 17 meq/l
- Temporary Hardness: (0.20 - 0.11) 0.356 = 0.87 German Degrees
- Lasting Hardness: 1.53 - 0.87 = 0.66 German Degrees
- residue total /residue solid /residue soluble
- dried at 105_C 95 ppm 24 ppm 71 ppm
- dried at 600_C 78 ppm 21 ppm 57 ppm
- Balancing (600_C) $Ca(HCO_3)_2$ and $CaCO_3$ to CaO: 0.31 meq/l : 0.3128 = 8.7 ppm
- $CaSO_4$: 0.20 meq/l : 0.2068 = 13.6 ppm
- $CaCl_2$ (57-51): 0.06 meq/l : 0.0655 = 3.3 ppm
- NaCl (0.23-0.06): 0.17 meq/l : 0.1758 = 10.0 ppm 35.6 ppm about 22 ppm of soluble mineralic components are unknown

Other data:

- free O_2: 7.34 ppm
- Fe: 0.18 ppm
- NO_3: 0
- OH^-: 0
- NH_4: 0.01 ppm
- NO_2: 0

These two Congo waters indeed are very much alike. In particular the temporary hardness differs very little, showing that both waters are buffered to the same extend. This might be of importance because it makes probable that the soil in the landscape around the rivulette N. Sele contains marine deposits of chalk and gypsum.

In the meantime I received from Dr. Rolf Geisler his analysis of the water from Yemoji, near Ijebu Ode, Ijebu Province, Western Region, Nigeria (see Stenholt Clausen: "Biological and taxonomical notes on Nigerian Freshwater Syngnathus..." in "Videnskabs. Medd. fra Dansk naturh. Foren. Vol. 118/1956). In his paper, Clausen informs of the following freshwater fishes living in this water: *Pantodon buchholzi*, *Nannocharax ansorgei*, *Phractura ansorgei*, *Aphyosemion bivittatum*, *Epiplatys sexfasciatus*, *Micropanchax macrophthalmus*, Procatopus sp. (possibly the species which I keep), *Eleotris nanus* and *Polycentropsis abbreviata* (I only mention the fishes which I have kept myself). This water sample of about 2 1/2-3 liters came in with 11 *Barbus callipterus*, 10 *B. ablabes*, 10* *Phractura ansorgei*, 10* *Nannocharax ansorgei* and 1* *Eleotris nanus*. Specimens were 3-5 cm (specimens with "*" were caught in the Yemoji water). Fishes possibly lived in this water sample for about 50 hours.

- pH (electrom.) 4.5*
- alkality (methylorange) 0 meq/l
- Cl^- 10 ppm
- NO_2 0.003 ppm
- NO_3 25 ppm*
- NH_4 5.2 ppm*
- Fe^{2+}/Fe^{3+} 0 ppm
- total hardness 0.5 German Degrees
- calcium hardness 0.5 German Degrees
- magnesium hardness 0 German Degrees
- temporary hardness 0 German Degrees
- permanent hardness 0.5 German Degrees
- $KMNO_4$ value 8.8 ppm
- CO_2 free 8.8 ppm
- Conductivity 143 recip. megohms/cm*

The (*) high content of in particular Nitrate (NO_3) and also Nitrite, Ammonia no doubt comes from waste products by the fishes during their stay in this small sample of water. The sample was kept in a plastic container (to avoid any contact with glass) for about 2 months before it was mailed for analysis. During this long time the waste products had time to oxydize and decompose to NO_3 (NO_2 and NH_4 and possibly the high content of CO_2 also comes from the decomposition of waste products). In this unbuffered water (no methylorange alkality) the 8.8 ppm of CO_2 decreased the pH to the 4.5 value. The $KMNO_4$ value shows us that the decomposition possibly did not run to an end. The conductivity is very high indeed. Clausen writes that he normally found values of about 20-40 recip. megohms in this water. My (not very well sized) instrument showed about 80 recip. megohms in this water when the sample came in and at that time the pH was little above 6.0 (slightly greenish to bromthymole blue), possibly 6.2-6.4.

Another sample also from the Yemoji water came in about two weeks later containing 21 specimens (2-4 cm) of *Epiplatys bifasciatus* (which had been moved into this water type because the sample of their natural water (Share) was polluted). The sample also contained about 2 1/2 liters and fishes had been in the water also for about 50 hours. Dr. Rolf Geisler found:

- pH (electrom.) 6.75
- alkality (methylorange) 0.39 meq/l
- Cl^- 25 ppm

- NO_2 0.0014 ppm
- NO_3 4.9 ppm*
- NH_4 2.8 ppm*
- Fe^{2+}/Fe^{3+} 0 ppm
- total hardness 1.1 German Degrees
- calcium hardness 0.7 German Degrees
- magnesium hardness 0.4 German Degrees
- temporary hardness 1.1 German Degrees
- permanent hardness 0 German Degrees
- $KMNO_4$ value 12.6 ppm
- CO_2 free 11.3 ppm

Nitrate (Nitrite, ammonia) value shows us that the sample was cleaner than the first one, but also that ($KMNO_4$) the decomposition did not run so far towards the endpoint as in sample 1. Possibly the formation of nitrate (sample1) replaced the temporary hardness into permanent hardness. We badly need an unpolluted small sample of this water in order to be sure of the influence of the waste products from the fishes upon the analysis.

Calculated Conductivity of Stanley Pool Water

Aquarists who use a conductivity meter might need a (calculated, as we have not any real measurement) value giving the conductivity of the common freshwater composition in the Congo River (please use the "page 19 diagram" in "The electrical conductivity of aqueous solutions"):

- Ca^{2+} 0.72 meq/l 33 recip. megohms/cm
- Na^+ 0.13 meq/l 5 1/2 recip. megohms/cm
- Cl^- 0.37 meq/l 23 recip. megohms/cm
- SO_4 0.18 meq/l 11 recip. megohms/cm
- HCO_3 0.30 meq/l 11 1/2 recip. megohms/cm
- Conductivity (minimum value) 84 recip. megohms/cm

That is equal to distilled water added about 46 mg/l (ppm) of common salt (NaCl).

Calculations on the Yemoji water (1 sample)

The 25 ppm of Nitrate (NO_3) is equal to 25/61 = 0.41 meq/l of NO_3. This amount of nitrate conducts about 25 recip. megohms/cm. pH of this sample was low enough to be taken into consideration when dealing with the conductivity: pH 4.5 conducts (the hydrogen ion) about 10 recip. megohms/cm. Thus the (abnormal) contents of NO_3 together with the very low value of pH are responsible for a conductivity of about 25 + 10 = 35 reciprocal megohms.

Back to Aphyosemion

Well, I digressed from the genus Aphyosemion amongst all the chemistry. Some scattered information on the location of the species (Ecological):

Aphyosemion multicolour was found near Apapa near Lagos in western Nigeria in a small pool at the edge of the woods. Only a few specimens were caught in each pool. The pools contained lots of vegetation in the water and only little free water.

Aphyosemion loennbergii was found in brooks and small, slow running streams in Cameroon.

Aphyosemion bivittatum was caught in swamps and streams where the fish lived in small shoals. Stenholt Clausen found this species all over the tertiary lowland south of Ibadan in the rainforest area - only in waters of very low conductivity and never in waters on the "old rock".

A. bitaeniatum was found at Ikang (by Ladiges: see "Fisch in der Landschaft" 1951). In his book Ladiges deals with the village of Ikang in connection with "Olflussgebiet Nigeriens" which is the delta of the river Niger. Also there exists a village named Ikang at the coast very near Calabar. Fidl gives the following location: Ikang (Deutsch Togo) in a small pool used by the natives and settlers for water supply. A small brook fed this pool (about 5 square meters) which had a sandy bottom. The water of the pool was very turbid. Here we caught Epiplatys grahami. Along the brook several small pools, 10-20cm deep, were situated and the water here was clear. Bottom covered by decaying leaves. Here he found the *A. bitaeniatum* in abundance.

A. coeruleum and *A. gulare* was taken in quiet, slow running waters or in stagnant water, also in blind branches of rivers filled up with subaquatic vegetation. Also in brackish lagoons.

A. arnoldi was found in small, heavily overgrown swamps containing almost "black" water.

A. gardneri lived in pools and slow brooks and the more quiet parts of the bigger rivers, but also in footprints on swampy ground. Ladiges found this species in small pools at the road from Abidjan to Agboville (Ivory Coast) but also in a spring fed swamp with transparent, colorless and cool water.

"*A. calliurum*" (I mean the two aquarium kept species or races which were distributed in 1958) was found near Akure east of Ibadan but also (as far as I remember from an interview with Mr. Stenholt Clausen in 1957) very close to Ibadan and in freshwaters on the "old rock". These waters might conduct up to 100 recip. megohms or even up to 200 recip. megohms at some places. Stenholt Clausen told me about a certain ditch in the open country where he found these fishes. Water was completely filled up with filamentous green algae and it was possible in a simple way to catch the fishes by lifting out of the water the mats of algae. At several localities the two different races lived together in the same waters. These fishes were considered to be a great help against mosquitoes.

Ladiges found *A. oeseri* in the backland of Old Calabar in dense virgin forest in deep swamps which had only little space of free water.

A. cognatum was taken in small pools, ditches and slow running brooks near the river Congo at Leopoldville. Also it was found in floating vegetation in the river (Stanley Pool?) at places with up to 4-5 meters of water.

A. roloffi lives in small freshwaters near the river Sierra Leone. Roloff found the species in a swampy area. A small brook runs through some small pools and he walked along the brook to its sources (a spring fed pool which had very cool water). Here he estimated the temperature to be about 20 C or even below that value. In the pools downstream he estimated the temperature to be about 30 C and in these pools he only found adult specimens. The fry was found in another pool which was constantly fed by the brook: depth 20-35cm, no subaquatic vegetation, but grasses hang from the edges down into the water and the fry were hidden within the grasses. The bottom was covered by mud (or slit?).

Dr. Poll in his survey on Aphyosemion and other killies of the Congo basin area writes that the species of Aphyosemion (11 different species) live in the big forest or in the gallery forest or in areas where that type of forest recently was found.

From the scattered information on the ecological factors we might believe that Aphyosemion mostly are found in small or very small freshwaters mostly in or in connection with the tropical forest. These waters might be stagnant or slowly running. But some species are also found in the more stagnant parts of the bigger rivers. The composition of the water generally is not known, but we might estimate that most waters are very soft and very pure (low conductivities), acidic or slightly acidic, more or less colored by humic components. The localities mostly have a muddy or sandy bottom and subaquatic vegetation is found in some of the localities.

Keeping the Species in Tanks

During the first 40 years of this century about 25 different species (or races) were imported to Germany. In spite of the evident great interest in these fishes, also among common aquarists, most species rather rapidly disappeared from the market. All over Europe the most skilled breeders experimented in the breeding and keeping of these lovely fishes, but as people mostly tried to "force" these fishes in the common way of keeping aquarium fishes, not trying to create a new way of keeping, the stocks slowly languished. Only two species: the "australe" and the "bivittatum" were kept and bred constantly through the years, possibly because these two species mostly were bred in parts of Germany where the water conditions locally were suited for the original stocks. Slowly these two species developed some stocks (from the "width" of the genetics in the original stocks which were able to live under "normal" conditions in aquaria and even to be bred under these conditions. No doubt both species in nature live under real "rainforest conditions". But still -by far- these two "culture stocks" are easily kept and bred. Possibly the "calabaricus" and the "coeruleum" also might be considered as "culture stocks".

All aquarium kept species might be kept under the same conditions in tanks. I did not find any important differences in the needs of the 12 different stocks that I keep now. Indeed some species are more feeble than others, but also in this respect the differences in "rainforest tanks" are negligible. Give your Aphyosemion species a "peat tank", filled with good rainwater and keep a fair temperature of about 20 C and you will not find severe problems in the keeping of these fishes. All aquarium kept species will take any good dry food, but in order to supply the fish with "vitamins" etc. you will offer them a good supply of live food at least once a week.

Some breeders add common salt to the rainwater. Up to 1500 ppm of NaCl is used, but such large amounts mostly are used in alkaline waters and in particular when there is no peat in contact with the water. Up to recently I have used about 300 ppm of common salt added to the rainwater type, but also because my Procatopus species did not like low conductivity water, but also because I then might avoid the accustoming of "new" fishes to low conductivity waters (as most aquarium fishes are kept in 400-500 recip. megohm water). If you move fish from 500 recip. megohm water to p.i. 50 recip. megohm water you possibly will burst the gills of the fish by the sudden change in osmotic pressure. 300 ppm of common salt in a slightly acidic water however did attack the "stainless steel" in my tanks, in particular, if the tank was heated from the bottom. Therefore I am now trying to replace the "chlorine" salt to a sulphate or a phosphate.

Aeration rarely is needed in the Aphyosemion tank. These fishes seem to be insensitive to low concentration of oxygen. Most species will stand low temperatures much better than most other aquarium fishes. Temperatures may drop far below 18 C without any hurt to the fishes (if they are not diseased at that time).

The various species are rather feeble when the water contains waste products and in particular if the water turns turbid by mass development of bacteria. The fish then will lock their fins and loose their natural vitality. Therefore it might be clever to use quickly growing plants as Ceratopteris (water sprite) and provide much light and maybe you also will blow the water with pure carbon dioxide in order to secure a healthy plant growth. If the fish are used to strong light (in rain forest tanks) they will not hide themselves in the plants.

All species (except "filamentosum") are very good jumpers and a leap vertically 15 cm above the water surface will not be difficult to 4-5 cm "cognatum" or "labarrei". When the fishes have been moved to a new tank they likely will try to escape using every small hole they may find. Possibly more specimens die from "drying out on the floor" than from any disease. But after some time they accustom themselves to the new surroundings and from then on they rarely will find themselves trying to jump out. Most leaping takes place during the night.

"cognatum" and "calabaricus" but also to some extent other species often dive deep into the soft bottom peat and hide themselves there for hours or even days. Also they often place themselves in the upper layers of the peat and you only are able to see some parts of the head. Possibly this behavior has something to do with their life in nature (low water?).

Breeding the Aphyosemion

All aquarium kept species except the "sjoestedti" will spawn freely on perlon, filamentous algae or in Myriophyllum. I have not been able to trace a distinct line between the so-called bottom spawners and the plant spawners. However the members of the "gulare group" prefer to spawn near the bottom or at the upper layer of the bottom whatever this consists of fine mud, coarse peat, carbon or sand. Also "cognatum", "calabaricus", "schoutedeni" and even "australe" spawn at the upper layers of the bottom if they have no plants to place the eggs into. "sjoestedti" might be trained to spawn on perlon if they are kept in bare tanks, but then they often place the eggs at the lower part of the perlon.

Females that have been isolated from males for one week very often will spawn more than 50 eggs within a few hours when placed together with a male in a small tank for breeding. Here are some data from my log-book: "calabaricus" 75 eggs, "coeruleum" 93 (84 within 4 hours), "cognatum" 60, "labarrei" 24. I found it interesting that the small female of "calabaricus" did spawn 75 eggs within 24 hours and also that this large amount of eggs repeatedly was spawned twice with intervals of only 7 days. The production of eggs depends on the feeding. Plenty of food is needed to reach the high values. Some species do eat their eggs, but rarely during the spawning. I wonder how the female is able to "shoot" the eggs deep into a tuft of perlon.

Eggs of all species (also very often from "calabaricus") are very hard and tough and might be removed using your fingers gently. But this should not be done at once after spawning. (It is said) The eggs do not attain their full strength in less than some hours. If you spawn on perlon, possibly it will be clever to move the perlon containing eggs into pure water of the type used for spawning and, only after 24 hours, you can cut the eggs from the perlon. Then also you easily find the infertile eggs (grey or white eggs). No doubt, for optimal breeding, I found the spawning of isolated females once a week to be superior to any other method of breeding. By the perlon method you always know how many eggs you get and can remove all bad eggs. Also for mailing this way of breeding might be the best one for all species that will breed under such conditions. Eggs are stored in flat cups containing the normal, soft and slightly acidic water, with or without adding of the mixture of methylene blue plus trypaflavine (concentration 1 gramm to each 50-100 liters of each medicine). It is not easy to find out if adding of this dye always will be necessary, but in some cases it helps, not against fungus but against bacteria. Potassium permanganate (KMNO4) penetrates the eggs more easily then the M-T medicine.

In most species eggs will show a visible embryo within one week after spawning but this does not always happens in eggs of "coeruleum" and rarely, if ever, in eggs of "sjoestedti". Eggs then will turn into a dark color and after 2-3 weeks the shining eyes of the embryo show us that the fry is ready in egg. Resting fry commonly occur in Aphyosemion. It seems to be the normal phase in all known species in the "gulare group" and also in "schoutedeni", "cognatum" and "calabaricus" this phase very often occurs at least in some eggs. We do not know what hinders the eggs from hatching in a normal way at normal times, but the salinity and the alkalinity of the water might play a role. Eggs showing resting fry might be treated with dry food and fry then will come out some hours after the adding of dry food to the water. Please do not leave eggs in this water when it gets turbid and begins to stink. You might prepare the dry food water and then add the mixture to the eggs. Also you might put the eggs containing resting fry into little moist peat and keep them there for a week or so and then try to hatch in rainwater. Eggs with resting fry also often do hatch if only you change the water in the cup. Also the hatching of one egg induces the hatching of all eggs, in some cases.

The species that normally might give us the phase of resting eggs should not be bred in the way (often recommended in aquarium books) of placing one or more breeding pairs in a well planted tank and have them spawning there for one or two weeks. After the removing of the breeding pair people expect that fry will come within two weeks from the first day of spawning but normally this does not happen. The fry hatch now and then (some eggs possibly do not hatch at all) and the differences in size will be much too big and big fry will eat away the smaller ones soon after their hatching. However this method sometimes is rather prolific and might give you hundreds of fry. I used it on "cognatum" late in 1954 and had 3 subsequent broods of about 100 fry each from spawning one male and two females for two weeks - spawning on coarse peat, no plants, very soft, brown and slightly acidic water. If you have the breeding pair spawning on very fine mud (in particular the species in the "gulare group") eggs will be hidden more or less deep into the mud. As far as I know no egg will start the development of an embryo as long as the eggs stay in the fine mud. At least this is the rule in "filamentorum". If you then after weeks or even months wash (sift) out the eggs from the mud and place them in a cup with free entrance of air they will develop in the way newly spawned eggs will do. That will say that resting eggs occur as long as eggs stay in the fine mud.

When I bred the "filamentosum" by large quantities in 1955/56, I used to dry the bottom peat and keep it "dry" for about 4-6 weeks and then put the peat into rainwater for hatching. Re-drying of the peat normally gave some hatchings at least, but never (by far) as many as in the first watering. As I did not control the peat by washing out the unhatched eggs after each watering, I am not sure that resting eggs occurred in the peat after each first watering. In order to be quite sure of the possible existence of the phase "resting egg" in Aphyosemion (except "sjoestedti" where this phase is a normal one) I watered a certain sample of peat from "filamentosum".

Data:
Several pairs of "filamentosum" spawned for many weeks on peat moss in a 15 liter glass tank. Peat bottom was taken out on 25 Nov. 58. Eggs (plenty) were concentrated by washing away all fine particles. Eggs in peat (now only coarse peat) were dried up at once (less than one day as the air in the fishroom is very dry at that time of the year -about 20-30% of moisture). Peat was then stored in a 200 ccm glass with airtight lid on.

- 04 May 59 (after 160 days of uninterrupted drying) 1/2 the amount of peat received the first watering.
- 05 May 59: only one fry did hatch, this is a "belly slider" very thin indeed, possibly not liveable. Peat washed and 8 eggs were found. 3 eggs had embryos very close to the "hatching point", 4 eggs had smaller embryo, with circulation of blood elements and only pigments on eye. 1 egg had small, transparent embryo, no blood, no pigments.
- 05 May 59: the other half of the peat was watered. Washed at once. 6 eggs found. 3 of these eggs had large embryo, all had heavy pigmentation and circulation of blood elements, but they were not at the same phase of development. The other 3 eggs had small, transparent embryo with no pigments and no blood systems developed.
- 23 May 59: some of the eggs did hatch in the meantime and some of the eggs with small, transparent embryo did develop in the normal way. Some eggs did catch fungus.

This sole sample clearly shows that resting eggs do occur also in the "gulare group" of Aphyosemion during the drying out of peat. Possibly by far most of the eggs which were in the peat in Nov. 58 did develop to the impressed phase of resting fry and after some months died and decomposed. I did not find any dead eggs containing dead embryos, like in the Nothobranchius when storing developed eggs of this (these) species for too long time.

The eggs in this "filamentosum" sample were compared with normal eggs from this species microscopically and they were real "filamentosum". This egg is easily distinguished from all other eggs of killies in my stock. Now I have one female half grown from these eggs. All the rest did not live or were eaten by other fry.

It is not known how long a resting egg might be hidden in fine mud under water without being destroyed. Once I found lots of transparent eggs from "filamentosum" in the mud of a tank that had no "filamentosum" for at least 5 months. Eggs looked just like lately spawned eggs. After a normal drying of about 4-6 weeks no fry came out from this peat and peat was not searched for eggs. A few months in this phase possibly will not hurt eggs. Also it is not yet known how long a resting fry of Aphyosemion will be able to live inside an egg without being killed or being so weak that after hatching it will not be able to live. But after all we often hatched sound fry from resting eggs that had been in this phase for several weeks. The feeding of the fry normally is not at all a problem. Newly hatched fry normally measure more than 4.0 mm and will take any live food sized as newly hatched brine shrimp (Artemia salina). My log-book gives the following data on the length of newly hatched fry (within one day after the hatching).

- egg in mm fry in mm (caudal fin incld.)
- *A. australe* about 1.2 3.4-3.8 (possibly not normal)
- *A. calabaricus* 1.15
- *A. "calliurum"* 1.0 4.4-4.9
- *A. coeruleum* 1.35-1.45 4.8-4.9
- *A. cognatum* 1.4-1.5 5.0
- *A. filamentosum* 1.25-1.33
- *A. labarrei* 1.6-1.8 5.8-6.0
- *A. petersi* 1.25
- *A. sjoestedti* 1.40-1.45 6.5
- *A. schoutedeni* 1.20

The pattern of the egg membrane shows little differences. Eggs of "calabaricus", "filamentosum" and "sjoestedti" have a more or less regular "net pattern" all over the surface. The other species have a dotted membrane often with small streaks. The filamentous slimy threads on the surface of the membrane are very difficult to find in "filamentosum" and this egg does not adhere any particle of peat (like eggs of Nothobranchius and Cynopoecilus). On the eggs of other species threads might be concentrated in one (two?) poles and might be very long and elastic (often much longer than egg diameter).

The yolk ball in eggs of Aphyosemion is very large compared with the diameter of the whole egg. But the size of the yolk seems to vary much more than the size of the egg as a whole.

Eggs of "schoutedeni" have yolk of 0.90 mm, eggs have 1.21 mm (3 eggs).
Eggs of "coeruleum" have yolk of 1.05 mm, eggs have 1.35 mm. Eggs of "calabaricus" have yolk of 0.88 mm, eggs have 1.13 mm.
Eggs of "petersi" have yolk of 1.05 mm, eggs have 1.26 mm.

Normally (microscopical examination of eggs) a clear line between yolk and "white" in eggs means a sound egg.

It is not usually a good idea to raise fry of different species in the same tank. Their rate of growth is not the same for the various species. But all those many stories of "cannibalism" in aquarium magazines do not prove to occur in that many cases, and you will find occasions of big and small fry living closely together in peace. Fry mature after 5-6 weeks or more depending on the species, the feeding, the temperature, etc. Exact rules cannot be given. Compared with most other aquarium fishes, the fry of Aphyosemion are rather quick growing.