

The distribution of *Chromaphyosemion* Radda, 1971 (Teleostei: Cyprinodontiformes) on the coastal plains of West and Central Africa

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Abstract: The species of the monophyletic genus *Chromaphyosemion* Radda, 1971 live in small streams and rivulets ('marigots') in the coastal plains from Togo to Gabon. In their distribution area, some glacial forest refuges are postulated, mainly in Cameroon, Equatorial Guinea and Gabon. It is assumed that evolution and biogeography of this genus is connected with the evolution of the Central African rainforest during the Quaternary. In this paper *Chromaphyosemion* is grouped into 16 forms, defined by their colour patterns. The distribution data show that the maximum diversity of this genus is found in the proposed glacial rainforest refuges of Cameroon, suggesting a structurally complex history of these old rainforest blocks.

Key Words: Aplocheilidae, *Chromaphyosemion* biogeography, rainforest refuges

Introduction

Responsible for the biodiversity of African tropical ecosystems, according to some authors, is the influence of climatic changes during the Quaternary and the resulting fragmentation of rainforest (Maley 1991, Mayr & O'Hara 1986). This probably induced major extinctions and, as an effect of the fragmentation, an isolation of populations, genetic bottlenecks and later a recolonization, which affected rainforest-bound species especially (Huber 1998b). Of special interest are position and number of rainforest refuges. Some authors provide a map of various currently assumed refuges in Western and Central Africa (Hamilton & Taylor 1991, Lévêque 1997, Maley 1991, Sayer et al, 1992). In this paper I want to test if the distribution of a mainly rainforest-bound group of small aplocheilid fish with limited dispersal abilities correlates to these assumed refuges in their distribution area.

The recent distribution and evolution of aplocheilid species and species groups seems to be closely connected with the historical changes of rainforest distribution and climates through the Quaternary (Huber 1998b). This means that a detailed study of the phylogeography of these fish should give further insight into the history of the tropical rainforest in coastal lowlands. Especially the different forms of *Chromaphyosemion* with their relatively small ranges, could contribute additional data to the studies of historical rainforest fragmentation.

The aplocheilid genus *Aphyosemion* Myers, 1924 is subdivided into several subgenera (Myers 1924, Huber 1977, Huber & Seegers 1977, Kottelat 1976, Radda 1971 b, 1977). One of them, *Chromaphyosemion* is clearly monophyletic (Amiet 1987, 1991, Seegers 1981) and here considered as a genus. *Chromaphyosemion* are

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small fish which reach about 5-7 cm total length and live in small rivers and streams in the coastal lowlands from Togo to northern Gabon (Eberl 1996, Radda 1971a,b, 1975, Radda & Huber 1976, Radda & Pürzl 1977, 1987). They are isomorphic with marked sexual dimorphism. The different forms are commonly distinguished by male coloration and sometimes by female colour pattern as well. Scheel (1966, 1968, 1974, 1990) did much comprehensive work on this group, based on crossbreeding experiments and karyotyping of different populations. His results reveal a high degree of reproductive isolation and variable chromosome numbers between populations. At the beginning of his studies he synonymized all described species with *Aphyosemion bivittatum* (Lönnberg, 1895) which then was considered as a 'morphospecies' because no morphological character could be found to distinguish subunits, and colour patterns are not visible in preserved material (Scheel 1966, 1968: 166 ff.). Scheel himself was aware of the fact, that the BIV-group - as he named them after *A. bivittatum* - consists of different 'bio-species' (sensu Mayr). In 1974 and 1990 Scheel revalidated some of the 'species', which in his opinion also consist of groups of different 'bio-species'. Amiet (1987), Daget et al. (1986). Scheel (1968, 1990) and Seegers (1986) tried to clarify the taxonomic confusion in this group. Fish hobbyists as well tried to redefine the known species by their coloration (see Eberl 1996 for a comprehensive review, e.g. of Poliak and Legros).

According to the actual state of knowledge it is most practicable to treat the forms which can be separated by their colour pattern as species; this does not anticipate any other decision in the future. The aim of this study is a review of the distribution data of the different *Chromaphyosemion* species and the comparison of the results with the data on rainforest refuges in that area.

Material and Methods

Preserved specimens from the studied live populations and slides of their live coloration are stored in the collection of the 'Zoologisches Forschungsinstitut und Museum Alexander Koenig' (ZFMK). Additional distribution data and pictures are taken from Amiet (1987, 1991), Eberl (1996), Huber (1996), Langton (1996), Radda (1971a,b, 1975), Radda & Huber (1976), Radda & Pürzl (1977, 1981, 1982, 1987), Scheel (1966, 1968, 1974, 1990), Seegers (1997) and Teugels et al. (1992). Populations are grouped according to shared characters in body coloration and fin

Plate 3: A selection of forms (probably species) of *Chromaphyosemion* Radda. Figures 1-6 show forms, which are all named *C. splendopleure* by most authors, 7 *C. loennbergii* and 8 the population marked on the map with ?; Amiet refers this also to *C. loennbergii*.

1 (upper row, left) *C. splendopleure*, Tiko; 2 (upper row, right) *C. cf. splendopleure*, Muyuka, Police Station; 3 (second row, left; a.s.o.) *C. sp. aff. splendopleure* 'Dizangue', Mangoule; 4 *C. sp. aff. splendopleure* 'Kopongo', Kopongo CSK 95/27; 5 *C. sp. 07*, near Nkolbonda; 6 *C. sp.* 'Likado', Likado River; 7 *C. loennbergii*, Song Bibai; 8 *C. sp.*, Chutes d'Ekom

Photographs by Eigelshofen (1,4,7. and 8) and Pohlmann (2,3,5, and 6)



colour patterns of adult males. The populations of one phenotype can be separated from other related phenotypes by one or more diagnostic characters or a combination of characters.

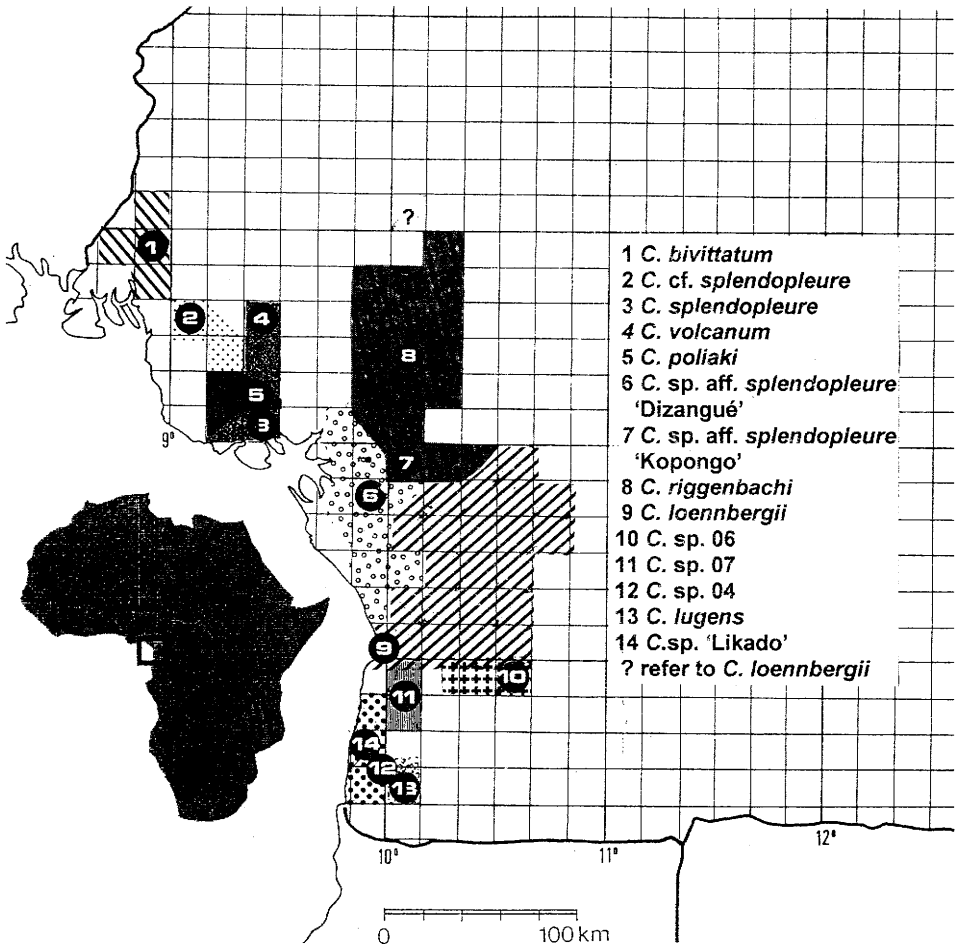


Fig.1: Map of the coastal plains of Cameroon with the schematic ranges of the *Chromaphyosemion* species in Cameroon (modified after Amiet 1987). The numbers on the map correspond to the following species. If known, the number is placed at or near the terra typica.

Within the species accounts species names are used according to Daget et al. (1986) and Huber (1996) with addition of the species, described after the publication of these checklists. Here only those synonyms are given which occur in the literature used; additional synonyms are given in Daget et al. (1986), Seegers (1986) and Wildekamp (1993). Only a short description of the coloration is given, especially in those cases where I differ from previous authors; otherwise the first description is cited where a useful colour description is given. A more detailed description of body coloration and fin colour pattern of different species is given by Amiet (1987,

1991), who supplies a very detailed description for *Aphyosemion* s.l. along with a determination key, and Eberl (1996). For all species, the known distribution area and a reference to published pictures and / or preserved material is given. Poliak, Legros and Eberl (reviewed in Eberl 1996) separated populations of '*Aphyosemion splendopleure*' into three 'phenotypes', which are here redefined and in some aspects changed.

The distribution data of the species from Cameroon are presented in a map (fig. 1). The pattern of species density and distribution is compared with published maps of postulated rainforest refuges in the area in question (Hamilton & Taylor 1991, Maley 1991, Sayer et al. 1992).

Results

Genus *Chromaphyosemion*

Chromaphyosemion Radda, 1971: 118 (type species: *Fundulopanchax multicolor* Meinken, 1930 by original designation). This name is considered to be a synonym of *Chromaphyosemion bitaeniatum* (Ahl, 1924) (see Seegers 1986). *Chromaphyosemion* was described by Radda (1971 b) as a subgenus of *Aphyosemion*.

Diagnosis: *Chromaphyosemion* is distinct from all other *Aphyosemion* s.l. by two dark lateral bands in both sexes (vs. one or none). The male coloration can change very fast, depending on mood and hierarchical status of specimens (vs. less conspicuous changes in *Aphyosemion*). No blue or green metallic base colours on the sides of the body (vs. present in most other *Aphyosemion*). In males, two or three dorsolateral rows of scales with a metallic sheen (*C. riggenbachi* with none to two rows) (vs. no metallic sheen on these scales or a metallic sheen on the whole body). The form of unpaired fins in *Chromaphyosemion* is unique and differs from all species of *Aphyosemion* (Amiet 1987, Radda 1971b). Caudal fin rounded with pronounced dorsal and ventral streamers in males, sometimes trilobated in large specimens. Dorsal fin large and triangular. Anal fin trapezoid. In males, white, yellow or orange streamers are developed at unpaired fins, mostly with a different hue to that of the fins.

Amiet (1987), Huber (1996) and Scheel (1974) give the following additional combination of characters to define *Chromaphyosemion*: dorsal fin inserts above or slightly behind anal fin origin. Number of dorsal rays 9- 14, number of anal rays 11- 16, D/A- position 1/1 -4 fin rays (vs. a higher number of anal and dorsal rays if the D/A-position is in the same range).

Amiet (1987), Murphy & Collier (1999) and Seegers (1981) showed that *Chromaphyosemion* is a monophyletic group with no apparent intermediate forms to *Aphyosemion* or related genera and therefore it is considered as a genus. The relationship to other species-groups remains unclear. A recent study on molecular systematics of *Aphyosemion* and *Fundulopanchax* fails to provide a well supported hypothesis – except the monophyly of most of the studied species groups (Murphy & Collier 1999).

Distribution: *Chromaphyosemion* species live in the coastal plains from Togo to northern Gabon. In the following species accounts the approximate distribution from West Africa to Central Africa is provided.

The species of Chromaphyosemion

Chromaphyosemion bitaeniatum (Ahl, 1924)

Terra typica: Niger, Nigeria

Synonyms : *Fundulus bitaeniatus* Ahl, 1924 - *Aphyosemion bitaeniatum* (Eberl 1996, Huber 1996, 1998a, Seegers 1984, 1997) - *Aphyosemion bivittatum* (Radda 1971b, Radda & Pürzl 1987, Scheel 1968, Schröder 1967) - *Aphyosemion multicolor* (Radda 1975, Radda & Pürzl 1981, Seegers 1981)

Examined material: ZFMK 21986 - 21987, Afanyangan (TMBB 90/13), Togo; ZFMK 21988 - 21989, Agbetiko (RT 97), Togo; ZFMK 21990 - 21991, Ibeju Creek, Nigeria; ZFMK 21992 - 21993, Yemoji River, Nigeria

Pictures : Eberl 1996 [p. 34, Lagos]; Radda & Pürzl 1987, [p.69, southern Benin]; Scheel 1968 [p. 116, Meko, Nigeria; p. 117, Umudike, Nigeria; p. 120 upper fig., Lagos, Nigeria]; Seegers 1997 [p. 59, fig, AO3240-4 - AO3244-4; p. 60, AO3747-4 - AO3749-4; p. 61, AO3752-4]

Distribution : This species is found in the coastal plains from Togo to the Niger delta in Nigeria, which is about half of the distribution area of the genus. Along the Niger this species occurs further inland. From the eastern border of the distribution area one population is known from Umudike, which is between the river systems of the Niger and the Cross.

Remarks : Unpaired fins mainly orange with a blue or blue-green groundcolour. The amount of blue-green and orange in the anal fin can vary between and within different populations. A very conspicuous dark wound-like marking behind the operculum (Scheel 1974).

Scheel (1974) and Schröder (1967) showed that between different populations various degrees of reproductive isolation are found. Despite these findings there are only relatively small variations between the coloration of different populations.

Chromaphyosemion bivittatum (Lönnberg, 1895)

Terra typica: rivulet..., near the waterfall of river N'dian [Cameroon]

Synonyms : *Aphyosemion bivittatum* (Amiet 1987, Eberl 1996, Huber 1996, 1998a,b, Radda 1971a,b, 1975, Radda & Pürzl 1981, 1987, Radda & Wildekamp 1977, Scheel 1966, 1968, 1974, 1990, Seegers 1981, 1986, 1997)

Examined material: ZFMK 21994 - 21995, Kwa Riverfalls Plantation, Nigeria; ZFMK 21996 - 21997, Funge, Cameroon

Pictures : Amiet 1987 [plate 34, fig. 5-6]; Eberl 1996 [p. 22, Mundemba; p. 23, Funge and Biafra]; Radda & Pürzl 1987, [p.71, Funge]; Seegers 1997 [p. 61, AO3245-4, AO3246-4 and AO3970-4]

Distribution: This species is known from the area between the Cross River (Nigeria) and Funge (Cameroon).

Remarks : *Chromaphyosemion bivittatum* is characterized by one, seldom two, dark spots on the base of the caudal fin in males (vs. absent in the closely related species *C. lugens* and *C. sp. 06* (Amiet 1987, 1991, Eberl 1996)).

Chromaphyosemion cf. splendopleure (Brüning, 1929)

Synonyms : *Aphyosemion bivittatum* (Radda 1975, Scheel 1966, 1968) - *A. bitaeniatum* (Eberl 1996, in part) - *A. aff. multicolor* (Radda & Pürzl 1982, in part)

- *A. splendopleure* (Amiet 1987, Huber 1996, 1998a,b, Radda 1971a,b, Radda & Pürzl 1987, Scheel 1974, 1990, Seegers 1981, 1986, 1997, in part) - *A. splendopleure* 'Meme'-group (Eberl 1996, in part) - *A. sp. aff. splendopleure* (Radda & Wildekamp 1977)

Examined material: ZFMK21998 - 21999, Lykoko, Cameroon; ZFMK22000 - 22001, Muyuka Police Station (C 89/15). Cameroon

Pictures: Amiet 1987 [plate 37, fig. 16 and 19]; Eberl 1996 [p. 45, Muyuka Police Station]; Radda & Pürzl 1982, [p. 19, Oron, Nigeria], Radda & Pürzl 1987 [p. 70, Ekondo Titi, Cameroon]; Seegers 1981 [p. 156, fig. 6], Seegers 1997 [p. 122, AO3530-4, AO3945-4, AO3947-4 only the right-hand picture; p. 123, AO3948-4]

Distribution: These populations are found in the lower Cross in Nigeria (Radda 1975). and south of Funge to the Mungo River (Cameroon). Strains are known from Oron, Ekondo Titi, Mbonge, Lykoko, Owe and Muyuka.

Remarks: The colour of the unpaired fins is blue-green with yellow, the metallic sheen in the dorsal scales is yellow to gold and body colour can range from blue to pink. the throat and part of the belly are yellow. This separates *C. cf. splendopleure* from the nominate *C. splendopleure*. Eberl (1996) listed both forms under his 'Meme'-phenotype.

It is not known if the populations of the Cross River area are in connection with those of the Meme area or if they are divided by the distribution area of *C. bivittatum*. *C. cf. splendopleure* is closely related to *C. splendopleure*. It is possible that a cline between both species may be found in the area around Kumba, but in the area around Muyuka and Tiko they are easy to distinguish.

Chromaphyosemion splendopleure (Brüning, 1929) and *C. volcanum* (Radda & Wildekamp, 1977)

Terra typica: Tiko in Kamerun [Tiko in Cameroon] (*C. splendopleure*) "... in einem kleinen Bächlein, welches durch den südwestlichen Stadtteil Kumbas fließt" [small rivulet, which flows through the southwestern part of Kumba = Kake River] (*C. volcanum*)

Synonyms : *A. splendopleure* (Amiet 1987, and Eberl 1996, in part) - *A. bivittatum* (Scheel 1968, in part) - *A. volcanum* (Amiet 1987, Eberl 1996, Huber 1996, Radda 1997, Radda & Pürzl 1987, Radda & Wildekamp 1977, Scheel 1990)

Examined material: ZFMK 22002 - 22003, Moliwe, Cameroon; ZFMK 22004 - 22005, Bamukong, Cameroon; ZFMK 22006 - 22007, Tiko, Cameroon; ZFMK 22008 - 22009, Bombe (CXC 23), Cameroon

Pictures : Amiet 1987 [plate 37, fig. 17- 18]; Eberl 1996 [p. 52, *A. volcanum*]; Seegers 1997 [p. 122, AO3946-4, AO3949-4 and AO3950-4]

Distribution : These species are known from Moliwe, Bamukong, Tiko, Yoke, Bombe and Kumba, which is an area from the foothills of Mount Cameroon to the region south of Lake Barombi Mbo. Most of the rivulets, in which this form is found, are tributaries of the River Mungo.

Remarks : These species have in general a red to orange body colour with a copper-red to reddish metallic sheen in the dorsal scales. Mainly orange-coloured unpaired fins with yellow to orange streamers. The throat is orange.

This group comprises two described species which are phenetically closer to each other than to the populations of *C. cf. splendopleure*. These species seem to be closely related compared with the following species, which are also included in *C. splendopleure* by various authors. *C. splendopleure* and *C. volcanum* are here grouped together due to their apparent similarity and are treated as one group of closely related populations. There is an ongoing discussion in the aquaristic literature about the validity of the taxon *C. volcanum* (e.g., Eberl 1996, Radda 1997) but neither reproductive isolation nor its reverse has been so far tested; herein both taxa are considered as valid until further data are provided.

Chromaphyosemion sp. aff. *splendopleure* (Brüning, 1929), 'Dizangué'

Synonyms : *Aphyosemion splendopleure* (Amiet 1987, Huber 1996, 1998a,b, Radda & Pürzl 1987, Scheel 1974, 1990, Seegers 1981, 1986, 1997, in part) - *A. splendopleure* 'Dizangué' (Eberl 1996) - *A. bivittatum* (Scheel 1968, in part)

Examined material: ZFMK22010 - 22011. Mangoule, Cameroon

Pictures: Amiet 1987 [plate 36, fig. 13-14]; Eberl 1996 [p. 1, Dizangué]; Seegers 1997 [p. 122, AO3943-4 and AO3944-4]

Distribution : This species is found along the coast between Douala and Kribi. The western limit is the Atlantic Ocean and in the east it reaches the distribution areas of the species living further inland, *C. riggenbachi* and *C. loennbergii*.

Remarks : *C. sp. aff. splendopleure* ('Dizangué') differs from the nominate *C. splendopleure* in body coloration and fin colour pattern. The lower lateral band is characteristically very conspicuous. The dorsal part of the body is brown, below beige to green-yellow. The caudal fin has a mainly flame pattern but not on a blue groundcolour (like *C. loennbergii*). Together with the following species these fish show a marginal blue to blue-green band in the anal fin (vs. absence in the other two forms which were formerly included in *C. splendopleure*). The anal fin is in most populations translucent yellow-green (Amiet 1987) (vs. orange, orange-red or yellow in all other populations previously included in *C. splendopleure*). A wound-like marking as in *C. bitaeniatum* is present (vs. absence in the previous forms).

Chromaphyosemion sp. aff. *splendopleure* (Brüning, 1929), 'Kopongo'

Synonyms : *A. splendopleure* (Amiet 1987, Huber 1996, 1998a,b, Radda & Pürzl 1987, Scheel 1974, 1990, Seegers 1981, 1986, 1997, in part) - *A. splendopleure* 'Kopongo' (Eberl 1996) - *A. bivittatum* (Scheel 1968, in part)

Examined material: none

Pictures : Amiet 1987 [plate 36, fig. 15]; Eberl 1996 [p. 49, lower picture shows the Kopongo fish]

Distribution : This species is only known from a small number of localities around Kopongo (Amiet 1987, Eberl 1996). This area is possibly enclosed by the distribution of the 'Dizangué' species, but they are not in sympatry, or at the border of the *C. riggenbachi* area (see also Eberl 1996).

Remarks : *C. sp. aff. splendopleure* (Kopongo) differs from the previous species especially by fin coloration, and is possibly closer related to *C. loennbergii*. Only some red dots in the orange-coloured anal fin (vs. many in *C. loennbergii*). Anal fin

with a submarginal red and a marginal blue band (vs. absence of the blue band in *C. splendopleure* and *C. cf. splendopleure*). See Eberl (1996) for further details.

Chromaphyosemion poliaki (Amiet, 1991)

Terra typica: Cameroun: Province du Sud-Ouest: Tamben, [Cameroon: South west province: Tamben]

Synonyms : *Aphyosemion bivittatum* (Scheel 1968, in part) - *Aphyosemion poliaki* Amiet, 1991 (Eberl 1996, Huber 1996, 1998a,b, Seegers 1997) - *Aphyosemion volcanum* (Radda 1997, Radda & Pürzl 1987, in part)

Examined material: ZFMK 22012 - 22013, Ekona, Cameroon; ZFMK22014-22015, Mile 29, Cameroon

Pictures: Amiet 1987 [plate 38, fig. 20-22], 1991 [p.90, 91]; Eberl 1996 [p. 55, Ekona; p. 56 Mile 29]; Radda & Pürzl 1987, [p. 72, Monea]; Seegers 1997 [p. 114, AO3462-4 and AO3463-4; p. 122, AO3942-4]

Distribution: Only known from the southern and southeastern slopes of Mount Cameroon. In the coastal lowlands it is replaced by *C. splendopleure* and *C. cf. splendopleure*.

Remarks : Easy to distinguish from the surrounding populations of other species. Very dark fish with a brown body colour and very dark blue or violet to blackish unpaired fins. Sometimes up to four rows of metallic shining scales on the dorsal part of the sides. See Amiet (1991) for a detailed description.

Chromaphyosemion riggenbachi (Ahl, 1924)

Terra typica : Quelle bei Jahassi (Kamerun), [spring near Yabassi, Cameroon]

Synonyms : *Fundulus riggenbachi* Ahl, 1924 - *Aphyosemion riggenbachi* (Amiet 1987, Eberl 1996, Huber 1996, 1998a,b, Radda 1971a,b, Radda & Pürzl 1987, Scheel 1974, 1990, Seegers 1981, 1986, 1997) - *A. bivittatum* (Scheel 1968, in part)

Examined material: ZFMK22016-22017, Nkwo, Cameroon; ZFMK22018-22019, Cellucam (KEK 98/21), Cameroon

Pictures: Amiet 1987 [plate 33, Fig. 1-4]; Eberl 1996 [p. 27, C 89/19; p. 30, female C 89/23, male Nkapa; p. 33, HJK 92/18 and C89/18]; Radda & Pürzl 1987 [p.73, near Yabassi, Cameroon]; Seegers 1997 [p. 117, AO3482-4 and A0348 1-3]

Distribution: This species has one of the largest ranges. In the north it is limited by the foothills of the Bamileke Plateau. In the west it borders the area of the coastal forms between the Mungo and the Wouri. In the east the river Ouem and in the south the Sanaga are the assumed borders (Amiet 1987).

Remarks : Body coloration pale blue to blue-green, unpaired fins blue-grey to blue-yellow, streamers in most cases white or pale blue, in some populations yellow. The typical two lateral black bands are in most cases not seen in this species. It is the biggest species in this genus and can reach about 70 mm total length.

Chromaphyosemion loennbergii (Boulenger, 1903)

Terra typica: Kribi River [now Kienke River, Cameroon]

Synonyms : *Aphyosemion bivittatum* (Scheel 1968, in part) - *Aphyosemion loennbergii* (Amiet 1987, Eberl 1996, Huber 1996, 1998a,b, Legros 1999, Radda 1971a,b, Radda & Pürzl 1987, Scheel 1974, 1990, Seegers 1981, 1986, 1997)

Examined material: ZFMK 22020 - 22021, KEK98/7, Cameroon

Pictures : Amiet 1987 [plate 34, fig. 7-8, plate 35, fig. 9-12]; Eberl 1996 [p. 40, Bipindi; p. 44 C 89/21, pair: p. 84 lower picture, Makondo]; Radda & Pürzl 1987 [p.74, near Kribi]; Seegers 1997 [p. 101, AO3390-4 - AO3394-4, AO3901-4 - AO3902-4]

Distribution: This species is found south of the Sanaga in the coastal plains. Its western limit seems to follow approximately the road from Edéa to Kribi. The Kienke River system seems to be the southern limit.

Remarks : *C. loennbergii* was collected syntopic with *C. sp. 06* on the road from Akom II to Bipindi. The caudal fin shows red flames on a blue groundcolour. The metallic sheen on the dorsolateral part of the body is golden to copper, throat can be blue or orange.

Amiet (1987) gives locality data of *C. loennbergii* north of the area of *C. riggenbachi*. Fish from one population (Chûtes d'Ekoum, see question mark on fig. 1) were introduced to Europe in spring 1999. An F1 pair was examined in August. They differ from all known *C. loennbergii* populations, but further investigations are required.

Chromaphyosemion sp. 06

Synonyms : *Aphyosemion* aff. *lugens* (Vlaaming 1998)

Examined material: ZFMK 22022 - 22023 (KEK 98/9); ZFMK 22024 - 22025 (KEK 98/10)

Pictures : Vlaaming 1998, [p. 72, Mb607, ca. 25 km south of Bipindi, Cameroon]

Distribution: This fish was caught in 1997 by Vlaaming and 1998 by Eberl, Kämpf and Kliesch by the road between Akok and Akom and further north to Bipindi, where this species is syntopic with *C. loennbergii*.

Remarks : Together with *C. lugens* and *C. bivittatum* it forms a group of species with a very disjunct distribution. These three species are very similar in many unique aspects of coloration.

C. sp. 06 can be distinguished from *C. lugens* by the orange throat and the orange dorsal fin in both sexes (vs. absence in *C. lugens*). From *C. bivittatum* it can be distinguished by more regular lateral markings and the absence of the characteristic red dot at the base of the caudal fin.

Chromaphyosemion sp. 07

Synonyms : *Aphyosemion bivittatum* (Scheel 1968, 1990) - *A. loennbergii* (Radda 1971a, Scheel 1990, in part) - *A. sp. 07* (Legros 1999)

Examined material: ZFMK 22026 - 22027, KEK 98/6 (02°48'25"N, 10°02' 10"E), Cameroon

Pictures : Scheel 1990 [p. 265, as *A. loenbergii*, Kribi, Cameroon; p. 373, as *A. bivittatum*, Lobe, Cameroon]

Distribution : Live specimens were caught in January 1998 by the road from Kribi to Ebolowa not far from Kribi. Pictures in Scheel (1990) show similar fish from the Kribi area. Further north it is replaced by *C. sp. aff. splendopleure* 'Dizangué' and in the south along the road to Campo by *C. sp.* 'Likado'. Further to the east only *C. loenbergii* and *C. sp. 06* are known.

Remarks: *C. sp. 07* differs from all other species in many coloration characteristics which are unique in their combination within *Chromaphyosemion*, possibly with the exception of *C. sp. 04*. The caudal fin shows red spots on a dark groundcolour (vs. flames in *C. loenbergii* (with blue groundcolour) and *C. sp. aff. splendopleure* 'Dizangué'). Adult specimens sometimes show a dark green coloration on the body (vs. light brown (beige) in *C. sp. aff. splendopleure* 'Dizangué' and orange to golden in *C. loenbergii*). The lower lateral black band can be very conspicuous while the upper band disappears (vs. both present or absent in all other species),

Chromaphyosemion lugens (Amiet, 199 1)

Terra typica: Cameroun: Province du Littoral: Afan Essokié, [Afan Essokié, Cameroon]

Synonyms: *Aphyosemion lugens* Amiet, 1991 (Eberl 1996, Huber 1996, 1998a,b)

Examined material : ZFMK 22028 - 22029, near Afan Essokié (KEK 98/5), Cameroon

Pictures : Amiet 199 1 [p.86, 87]; Eberl 1996 [p. 59 and p. 62, Afan Essokié]

Distribution : This species is only known from the Campo National Park around Afan Essokié (Terra typica) and the Massif des Mamelles, about 20 km to the north of there.

Remarks : *C. lugens* can be distinguished from its closest relatives *C. bivittatum* and *C. sp. 06* by the absence of orange colours on fins and body and the absence of the red dot at the base of the caudal fin which is characteristic of *C. bivittatum*.

Chromaphyosemion sp. 04

Synonyms : *A. splendopleure* (Seegers 1997, in part) - *A. sp. 04* (Eberl 1996, Legros 1999)

Examined material: ZFMK 22030 - 22031, Bibabivotou (HJRK 92/16), Cameroon

Pictures: Eberl 1996 [p. 71 and p. 81 upper picture]; Seegers 1997 [p.123, A0395 1-4]

Distribution: This species was caught near the village of Nazareth on the Bibabivotou river.

Remarks : In some characters *C. sp. 04* resembles *C. sp. 07* but before inclusion in this species further collections between the known localities are needed. This population does not show the dark green body colour. The dark lower lateral band is only seldom shown in dominant fish, as described for *C. sp. 07*. All unpaired fins

are identically coloured, except for a submarginal red and a marginal blue band in the caudal and anal fin. They show many red dots on a green-blue groundcolour (vs. different colour patterns between unpaired fins, flames or the absence of dots (mostly on the anal fin) in other species).

Chromaphyosemion sp. 'Likado'

Synonyms : *Aphyosemion splendopleure* (Brüning 1929), (Eberl 1996, Langton 1996, in part)

Examined material: ZFMK 22032 - 22033, Likado River, Cameroon,

Distribution : These fish were caught on the Likado River, along the road from Kribi to Campo. A similar population is known from Campo (Eberl 1996, Langton 1996).

Remarks: *C.* sp. 'Likado' shows a blue (Likado population) to green-blue (Campo population) colour on the dorsolateral part of the body which can change to brown in old individuals. Ventrally, the body is yellow to beige (vs. yellow only in the anterior part, or not yellow). The fins are yellow-green (Likado population) to green-blue (Campo population) with red dots.

Chromaphyosemion alpha (Huber, 1998)

Terra typica: PK 17,1 an der Straße vom Flugplatz Libreville (Hotel Gamba) zum Cap Estérias ,....., nordwestliches Gabun [PK 17.1 by the road from the airport Libreville (Hotel Gamba) to Cap Estérias, northwestern Gabon]

Synonyms : *Aphyosemion splendopleure* (Huber, 1994, Radda & Huber 1976, Radda & Pürzl 1987, Seegers 1997, in part) - *Aphyosemion* sp. 02 (Eberl 1996) - *Aphyosemion alpha* Huber, 1998

Examined material: ZFMK 22034 - 22035, Cap Estérias (LEC 93/26), Gabon
Pictures: Eberl 1996 [p. 66 and 67, Cap Estérias]; Seegers 1997 [p. 123, AO3952-3]; Huber 1998 [p. 17, 23]

Distribution: This species is only known from Cap Estérias, Gabon.

Remarks: *C. alpha* has a very unique coloration and at present no similar phenotype is known. For a detailed description of the coloration see Huber (1998a).

Chromaphyosemion kouamense (Legros, 1999)

Terra typica: 2,5 km nördlich von Nzog Bizeng (O°25'N, 10°04'E) [2,5 km north of Nzog Bizeng]

Synonyms : *Aphyosemion* aff. *loennbergii* (Huber 1998a) - *Aphyosemion kouamense* Legros, 1999 (Eigelshofen & Sonnenberg 1999) - *Aphyosemion* sp. 05 (Eberl 1996)

Examined material: ZFMK 22036 - 22037, Engong Kouame (LEC 93/24), Gabon

Pictures: Eberl, 1996 [p. 74, LEC 93/24; p. 77, PEG 94/ 48, LEC 93/24 female]; Legros, 1999 [p.35]

Distribution: This species is known only from localities on the road approximately between Mbèl Alen and Mveng Ayong at the foot of the Monts de Cristal.

Remarks : The specimens from the locality PEG 94/48 (near Mveng Ayong) differ in many aspects from the population of the type locality. Here we preliminarily follow the description and include them in this species. For a detailed description see Legros (1999), but note the remarks of Eigelshofen & Sonnenberg (1999).

Discussion

In this paper 16 forms are considered, many of them agree with already named taxa. *C. splendopleure* and *C. volcanum* are preliminarily treated as one species (but see under species accounts). The differences between them are considered to be an indication of a limited gene flow between these groups of populations, caused either by geographical or biological factors. A number of undescribed populations in Cameroon need further investigation before taxonomic conclusions can be drawn. The taxon *Chromaphyosemion splendopleure* is possibly a 'wastebin' of four species.

The species *C. pappenheimi* (Ahl, 1924) and *C. unistrigatum* (Ahl, 1935) are regarded as synonyms of *C. loennbergii* (Boulenger, 1903) (see Seegers 1986); however Scheel (1990) revalidated *C. pappenheimi*. It differs in coloration from *C. loennbergii* (Legros, pers. comm.; Scheel 1974), but there is no picture available for this population. Scheel's preserved material is deposited in Tervuren but could not be studied. Therefore in this paper *C. pappenheimi* is regarded as a synonym of *C. loennbergii*. This decision is supported by the fact that *C. pappenheimi* and *C. unistrigatum* are said to come from Bipindi (Ahl 1924, 1935), where today only *C. loennbergii* is found, whereas Scheel's population stems from a location east of Bipindi (Scheel 1974, 1990), so it is doubtful if this population represents one of the described species. The populations of Equatorial Guinea and Isla de Bioco are not included in this study because the only available data are given by Roman (1971), Scheel (1972, 1974) and Thys van den Audenaerde (1967, 1968) but none of them published a picture of live specimens.

About half of the range of the genus *Chromaphyosemion* (Togo to Niger delta) is inhabited by only one species, *C. bitaeniatum*, whereas the highest diversity is found in the relatively small area of the coastal plains of Cameroon. In Gabon only two species are found. The diversity reaches its maximum between the River Cross (Nigeria / Cameroon) and the River Ntem (Cameroon / Equatorial Guinea) with 13 species. Especially north of the Sanaga and south of the Kienke the diversity of species is very high, which correlates with the assumed forest refuges in the northern and southern part of Cameroon (Hamilton & Taylor 1991, Maley 1991). The postulated correlation between the assumed rainforest refuges in that area (Lèvêque 1997, Maley 1991) and diversity of species can be confirmed. The diversity north of the Sanaga to the Cross (7 species) can be explained by the rainforest refuge which is postulated by Maley (1991). It was possibly subdivided at the western slopes of the Cameroon backbone and at Mount Cameroon into small rainforest pockets. South of the Kienke six species are found. Maley (1991, fig.6) and Hamilton & Taylor (1991, fig.4) indicate a refuge south of the Sanaga reaching the border of Equatorial Guinea. This area is geographically more structured than

the part between the Sanaga and the Kienke, which could contribute to isolated pockets of rainforest where the species were separated (Amiet 1987, plates 1 and 2). The species expanding in the area between the Sanaga and the Kienke are *C. sp. aff. splendopleure* 'Dizangué', which is at present only known from around Douala to the north of the Kienke, and *C. loennbergii*, which reaches the Sanaga as the northern border of its range. Both populations from the north of the *C. riggenbachi* area (Amiet 1987) need to be studied to verify their inclusion in *C. loennbergii*.

Hamilton & Taylor (1991) postulate a forest refuge in the Niger delta, in which *C. bitaeniatum* could have survived during glacial times and later expanded to the west. The small variation throughout this huge distribution area may indicate a very recent recolonization.

In Gabon, the species might have survived in forest refuges on the slopes of the Monts de Cristal (Hamilton & Taylor 1991, Maley 1991).

If we assume that *C. bivittatum*, *C. sp. 06* and *C. lugens* are closely related species than we can observe two different patterns of isolation / speciation. *C. lugens* and *C. sp. 06* are found in the area of one assumed rainforest refuge which, at least for these species, seems to be subdivided, thus allowing the separation into different species. On the other hand *C. bivittatum* has also split, but in a different refuge. This implies an ancient distribution area between both forest refuges in the north and in the south, which in glacial times was interrupted and afterwards only partly recolonized. It will be of interest to know if species pairs are more common between or within rainforest refuges.

The distribution data show a considerable correlation between areas of species diversity and assumed rainforest refuges, at least in the area of Cameroon. An ongoing study of the phylogeny and biogeography of this genus should give further insight into the structure of the refuges and their influence on speciation.

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