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AGE AND GROWTH OF THREE SPECIES OF ARIIDAE (SILURIFORMES) IN COASTAL WATERS OF GUINEA

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ABSTRACT

The growth of three West African marine catfish, *Arius heudeloti, A. parkii, A. latiscutatus* (Siluriformes, Ariidae), was studied in Guinea by examining sections of the first dorsal spine. Age and growth interpretations were possible for fish up to 40 cm and the three species reveal a similar biology. A single annulus is formed each year at the beginning of the rainy season. Growth seems to be slow, and 40 cm fork length individuals are about 6 years old. These ariids can reach large sizes (80 cm or larger), which may indicate that the natural mortality is low. This adaptativeness is probably related to their strong body protection against predators, their low fecundity and egg incubation.

Marine catfish have a high commercial value in Guinea and represent an important fishery for coastal waters. Catch was estimated to 1,000 metric tons in 1990 (COPACE, 1991). Information on growth and age is needed along with other life history information for effective management, but little is known on west African species.

Three species of marine catfish are found in Guinea, *Arius heudeloti* Valenciennes 1840, *Arius parkii* Günther 1864 and *Arius latiscutatus* Günther 1864. They live on muddy bottoms in estuaries and in the sea inside the 20 m depth line along the western coast of Africa between 20°N and 20°S. These ariids are characteristic of the Sciaenid community (Domain, 1989). *A. parkii* is more related to brackish waters and on the opposite *A. latiscutatus* prefers slightly deeper waters.

The coast of Guinea, approximately 300 km long, has low elevation, with mangroves and estuaries along its length. Tide amplitude is high (more than 4 m) and the intertidal zone is wide (up to 30 km). Water temperature is high all year round, between 25° and 29°C. The rainy season lasts from May till October with an annual rainfall usually around 4 m. Salinity varies strongly and the waters become brackish all along the coast, not only at the surface but also near the bottom. The decrease in salinity is observed everywhere inside the 20 m depth line (Fig. 1).

Sea catfish are caught throughout the year, mostly near the coast during the rainy season and in deeper waters during the dry season. Juveniles and small individuals are found in large number in areas adjacent to the coast while large fish occur in deeper areas. Most of the catch is made by canoe with lines or gill nets, but captures are also made by trawlers. Commercial value of catfish is high in Guinea, probably because it is well suited to smoking and therefore to traditional preservation.

Biological information is non-existant on the growth and reproduction of these three species but data are available on other ariids. In tropical America, on the Atlantic coasts, studies are available on *Arius spixii* (Etchevers, 1978), *Arius couma* (Lecomte et al., 1985), *Arius proops* (Lecomte et al., 1989), *Netuma barba* (Reis, 1986), and on the Pacific coast on *Galeichthys caerulescens* (Warburton, 1978). *Arius thalassinus* a species from the Indian ocean was studied by Dmitrenko (1975) in India and by Bawazeer (1987) in Kuwait.

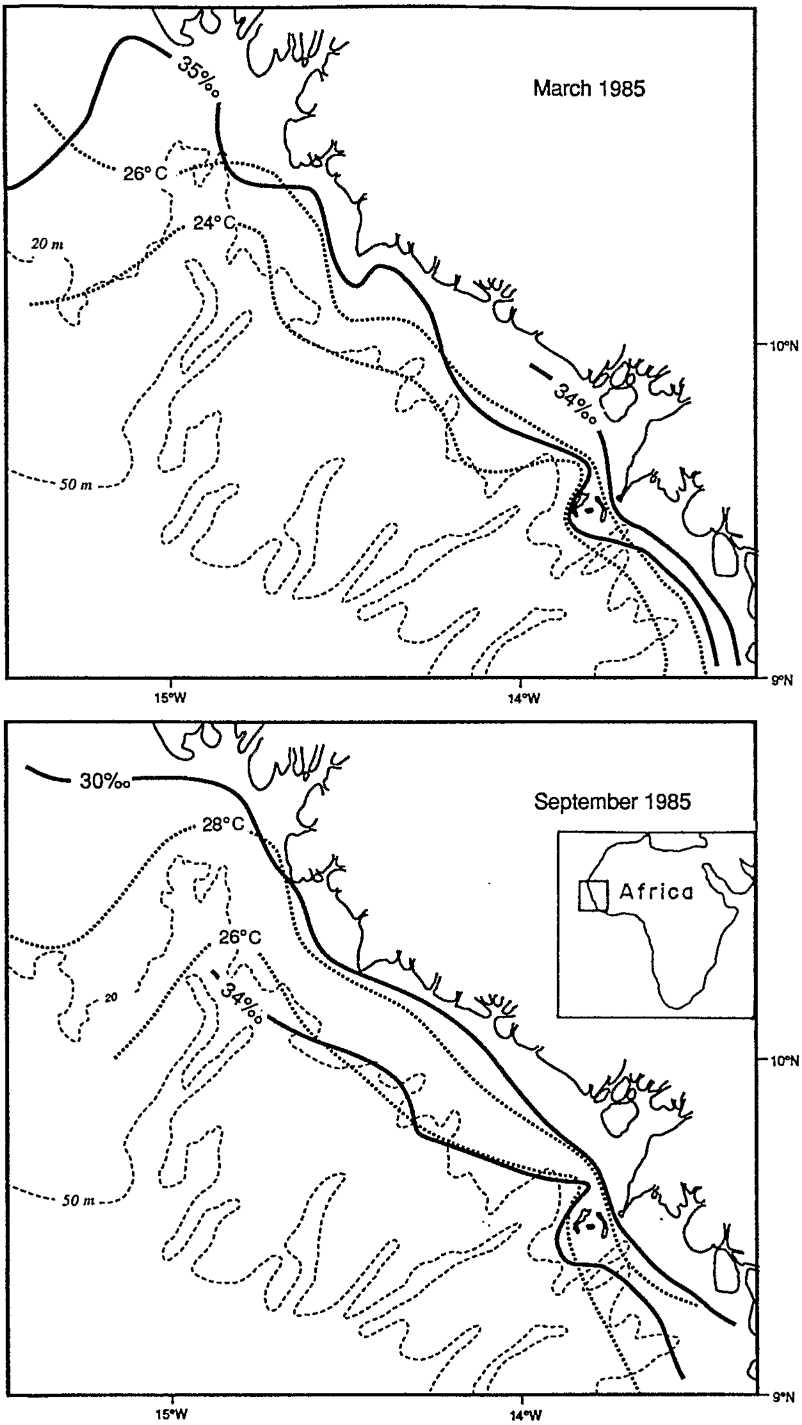

Figure 1. Isohalines near the bottom and surface temperature at the end of the dry season (March), and at the end of the monsoon (September), along the coast of Guinea.

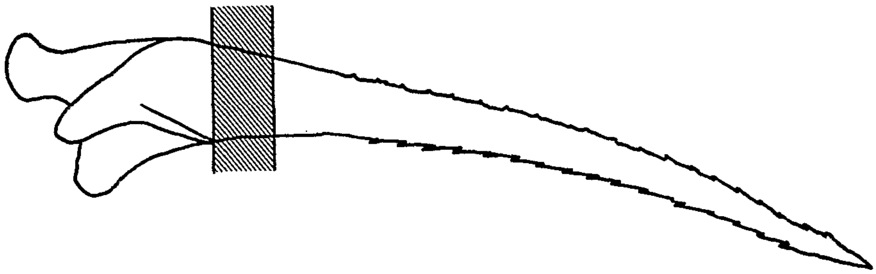

Figure 2. Lateral view of the first dorsal spine of *Arius heudeloti* showing the level of section.

Materials and Methods

Preliminary observations on length frequency distributions of Guinean marine catfish did not reveal clear information and skeletochronology was therefore used. The first dorsal spines were collected for age determination from April 1990 till April 1991, either at sea during trawling surveys or at canoe landing harbors in Conakry area. The specimens sampled were: *A. heudeloti* (218, size range 12 to 78 cm), *A. latiscutatus* (424, size range 8 to 85), *A. parkii* (211, size range 9 to 55 cm).

Fish were measured (fork length to the lower centimeter) and when possible weighed and sexed. To compare our results with other studies, the biometric relationships between fork length and total length were established from samples of each species.

Except for the spines of very small individuals, which were embedded in a polyester resin, cross sections were made directly at the distal end of the basal groove (Fig. 2), with a low speed sawing machine. The sections, about 200 μm in thickness, were mounted and observed with transmitted light through a microscope.

The marginal increment ratio represented by the ratio of the distance between the outermost annulus and the edge, to the distance between the outermost annulus and the previous to the outermost (or the birth line), was calculated for each spine section. Distances were measured on a radius, in a lateral region not far from the anterior region. This ratio was used to define the period of formation of the annulus.

Counts of annuli were made by two investigators. About 50% of the spines were considered doubtful. On the other half, about 80% agreement was obtained between the investigators and only these readings were kept for the study of growth.

The von Bertalanffy growth function,

$$L_t = L_\infty(1 - e^{-k(t-t_0)})$$

was adjusted for each species, and the parameters estimated by the method of least squares.

Results

Study of Spiny Rays.—The section of a spine appears as a wide ring of bone with a medullar cavity (Fig. 3). The examination of the bone, under transmitted light, shows alternate narrow translucent layers named annuli and wide opaque layers (Baglinière et al., 1992); narrow vascular canals can also be observed between the medular cavity and the outside. Within osteichthyes, annuli are generally laid during slow growth periods, while the opaque layers correspond to fast growth periods (Meunier, 1988). Birth for ariids occurs at a relatively large size, when the young leave the mouth cavity of the male after the incubation period. Following Lecomte et al. (1989), we have interpreted the first narrow translucent mark as the birth line.

Observations on young fish were relatively easy, but for older ones two difficulties were encountered. The medullar cavity increases with age by resorption of the tissues preventing location of the first annuli. After 5, 6 or 7 annuli, split annuli become frequent and interpretation is difficult. Spines of fish over 41 cm were therefore not used for the study of growth.

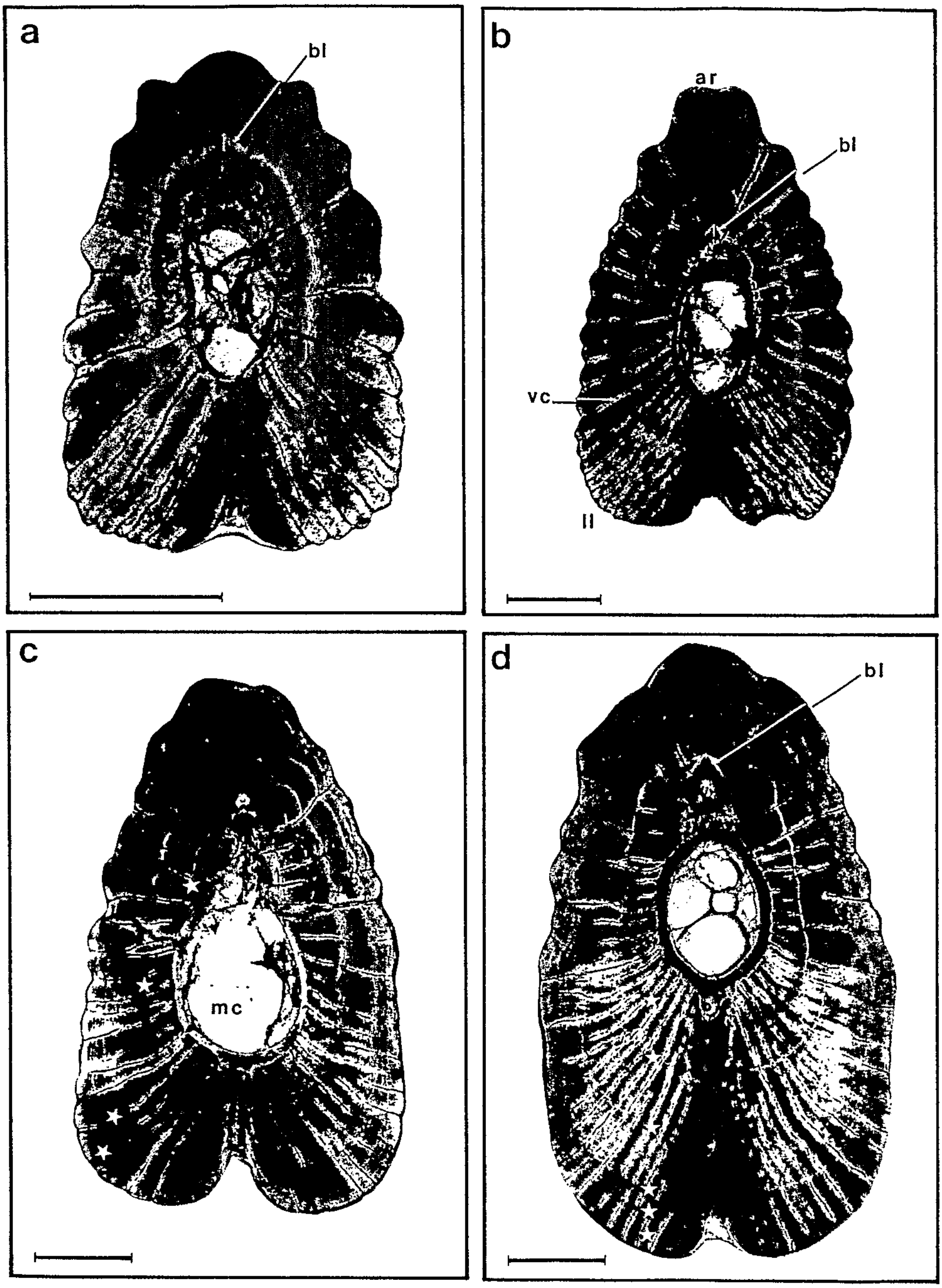

Figure 3. Cross sections of dorsal spines. a) *A. heudeloti* 17 cm; b) *A. heudeloti* 28 cm; c) *A. latiscutatus* 34 cm; d) *A. latiscutatus* 40 cm. Scale bars = 1 mm; * = annulus; ar = anterior region; bl = birth line; vc = vascular canal; ll = lateral lobe; mc = medullar cavity.

Date and Periodicity of Ring Formation.—For each species, the marginal increment ratio of individual fish was plotted on a monthly basis (Fig. 4). With a few exceptions, the ratio was low from July to November, and high from January to May. This means that the formation of the annulus occurred in June or July and that the growth was then slow until November. From this, we infer that, at least for fish under 5 or 6 years of life, one annulus was formed per year.

Growth in Length and Growth Parameters.—The growth functions were adjusted with individual observations on fork length and age. Age was given by the number of annuli augmented by the fraction of year spent between June and the date of capture of the fish. As no difference was noticed between males and females, the equations were established without separation of sexes. The resultant samples used to develop the growth equations were: 50 *A. heudeloti* (1 to 6 years old, 14 to 38 cm), 49 *A. parkii* (1 to 7 years old, 15 to 41 cm) and 53 (*A. latiscutatus* (1 to 7 years old, 13 to 40 cm).

The estimated parameters are given in Table 1. The mean length for each age, calculated from the equations, is given for the three species in Table 2.

Biometric Relationships.—The fork length (FL)/total length (TL) functions (FL = a TL + b) are given in Table 4.

Discussion

Use of Spiny Rays.—Age studies using hard structures of catfish have been based on vertebrae, spines and otoliths. Several authors consider that the spines are the most successful for age determination. On ariids, Lecomte et al. (1985, 1989) used spines, while Dmitrenko (1975), Warburton (1978) and Reis (1987) worked on otoliths. The ease of spine sampling and the fact that the fish is not damaged and keeps its commercial value lead us to choose them as our age determination structure. Preliminary observations with pectoral and dorsal spines, suggested that the dorsal spine was superior to the pectoral spine to conduct the study. Davis (1977) using an Australian catfish and Layher (1981) using an American one, reached the same conclusion as we had as to the desirability of using dorsal spines.

In this study the percentage of illegible spine sections of large size fish is higher than observed in many studies. Two hypotheses are available to discuss the consequence of this high discard rate: (1) The growth of fish with illegible spines is the same as that of fish with legible spines; illegibility occurs randomly and discarding has no effect on the results. (2) For some reason different growth patterns occur in large fish, only one of which results in legible spines; discarding would result in a biased sample and affect the results. We neither observed, nor found in literature, any indication of a radical change either in feeding behavior or in habitat for some large fish or a part of the population. The first hypothesis has therefore been given preference.

Relations between Ring Formation and the Environment.—The study showed that the annuli, which correspond to the slow growth periods, are formed at the beginning of the rainy season. Along the coast of Guinea and especially in shallow waters and estuaries, temperature is nearly constant all year round while salinity varies dramatically after the beginning of the monsoon.

The change between the dry and rainy season is correlated with the alternation of annuli and opaque layers, but the cause is unknown. Two hypotheses can be made: (1) Reproduction, we observed at this time, induces important physiological changes particularly for males which incubate eggs in their mouth and do no eat during the period. (2) Seasonal movement of the fish, from relatively deep waters

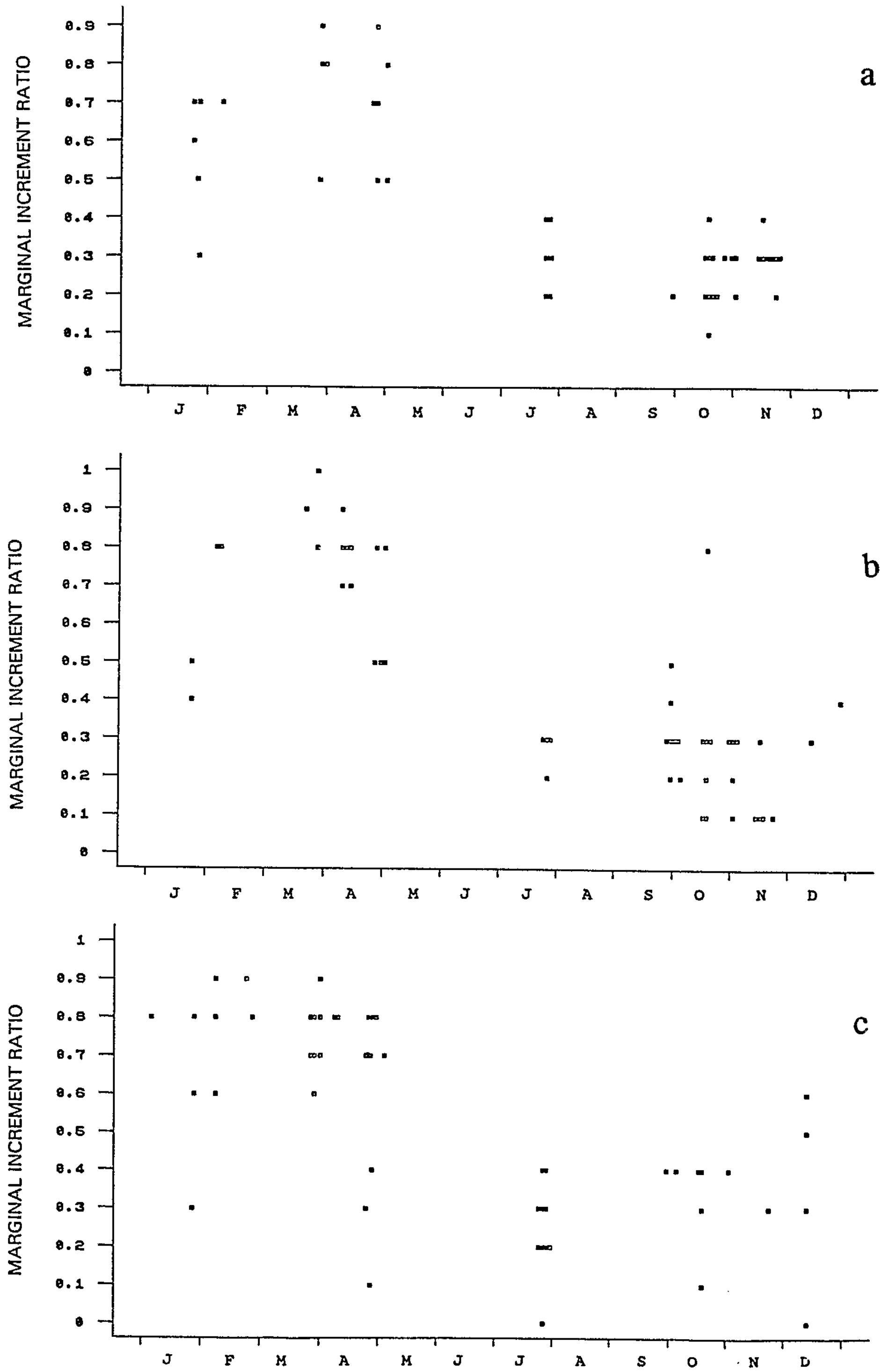

Figure 4. Annual variation of the marginal increment ratio of individual fish. a) *Arius heudeloti*; b) *A. parkii*; c) *A. latiscutatus*.

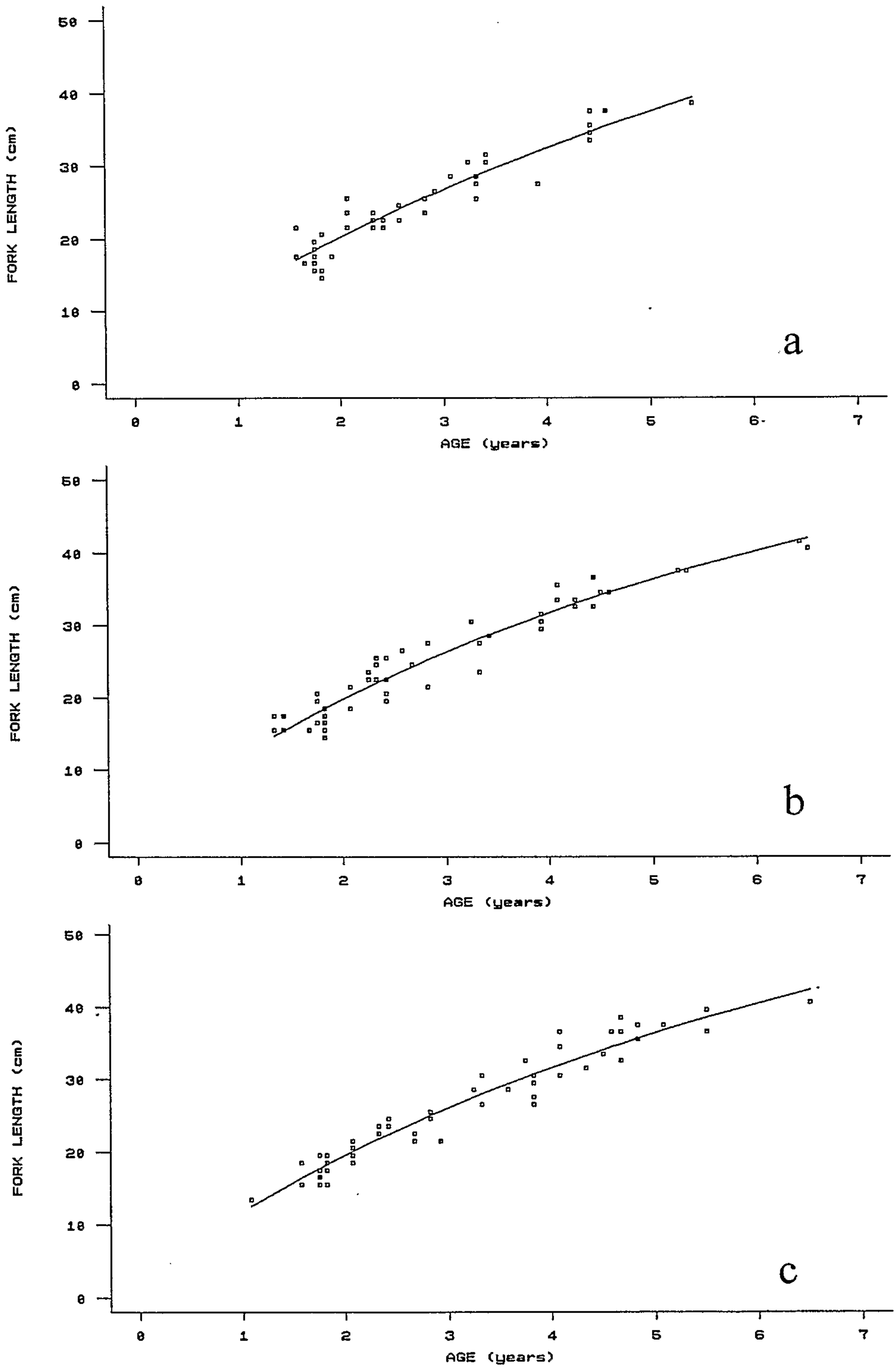

Figure 5. Von Bertalanffy growth curves. a) *Arius heudeloti*; b) *A. parkii*; c) *A. latiscutatus*.

Table 1. Von Bertalanffy growth function parameters for Guinean sea catfish

Species	L_∞ (FL cm)	K (yr^{-1})	t_0 (yr)
A. heudeloti	70.0	0.142	−0.390
A. parkii	61.2	0.171	−0.281
A. latiscutatus	65.0	0.154	−0.309

(10–20 m) during the dry season, to estuaries and very coastal areas during the monsoon occurs at this time and thus modifies nutrition and therefore fish metabolism. In addition, the migration is done in the opposite direction of the movement of the water masses, and this increases the importance of the environmental changes. The first hypothesis cannot explain the formation of the annuli in young immatures and the effect of the environment is certainly responsible for it, although the determining factor is unknown.

After the formation of the annulus, growth is slow during the rainy season and feeding conditions probably have an important effect. The effect on the metabolism of the strong siltation induced by increased river flow during the monsoon could be the explanation.

Comparison between Species.—Mean lengths calculated from the equations for each age (Table 4) indicate that the growth is similar for the three species between 1 and 7 years.

Observations on the sizes in the captures made during experimental trawling surveys along the Guinean coast between 1985 and 1988, are summarized in Table 4. It gives the mean length, the maximum length of 90% of captured fish, and the maximum length observed for each species. The largest *A. heudeloti* caught was 81 cm which is similar to the 78 cm from canoe landing observed during our collecting of spines. For *A. parkii* the trawl caught a 51 cm fish while we observed 55 cm in canoe landings and for *A. latiscutatus* we had 67 cm in the trawls and 85 cm in canoe landings. *Arius parkii,* the most brackish species, seems to grow slightly faster but to die earlier without reaching large sizes.

The von Bertalanffy growth parameters given here, ought to be used with caution as they were calculated with observations on fish only up to 41 cm, while *A. heudeloti* and *A. latiscutatus* of 60 or 70 cm are regularly found in the catches.

Several studies on ariids (Bawazeer, 1987; Reis, 1986) showed a faster growth for females. In our case no sex related difference was noticed, probably because only relatively young and small fish were analyzed.

Comparison with other Siluriformes.—In Brazil, Reis (1986) found results very similar to ours on *Netuma barba,* a fish of the Ariid family: at 7 years 40 cm, and at 15 years 52 cm for males and 62 cm for females. In the lagoons of the

Table 2. Age-length relationships calculated from the equations

Age (years)	*A. heudeloti* (FL cm)	*A. parkii* (FL cm)	*A. latiscutatus* (FL cm)
1	13	12	12
2	20	20	19
3	27	26	26
4	32	32	32
5	37	36	36
6	42	40	40
7	45	44	44

Table 3. Fork length (FL)–total length (TL) relationships. Equations are of the form FL = aTL + b; N = sample size; L_{min} and L_{max} is the observation interval; r = regression coefficient.

Species	N	L_{min}	L_{max}	a	b	r
A. heudeloti	49	17	55	1.19	0.51	0.98
A. parkii	70	11	43	1.15	0.08	0.99
A. latiscutatus	181	16	48	1.16	0.49	0.99

Pacific coast of Mexico, *Galeichthys caerulescens* is 33 cm at 4 years of age (Warburton, 1978), which is similar to the Guinean species. In Kuwait, *Arius thalassinus* reaches 57 cm at 10 years (Bawazeer, 1987). Etchevers (1978) found that in Venezuela, *Arius spixii* is 27 cm at 6 years. *Chrysichthys nigrodigitatus,* a Siluriform from fresh and brackish water from the Ivory Coast is 42 cm at 5 years (Dia, 1975). Lecomte et al. (1985, 1989) observed on *Arius proops* from French Guyana, that the annuli are laid down twice a year, the deposit being synchronized with the two annual dry seasons. The growth of this species is very fast and at 3 years fish reach 65 cm in length. With the exception of *A. proops* from French Guyana, most marine and brackish waters Siluriforms from tropical regions appear to grow slowly.

Conclusion

The three sea catfish from Guinea are slow growing species which reach 40 to 42 cm (approximately one kilogram) at 6 years. The quite frequent observation in the landings of the canoe fishery of 80 cm individuals of *A. latiscutatus* and *A. heudeloti,* which are speculated to be 20 to 30 years old, indicates that their natural mortality is low. Their morphology, with a very hard skull and strong protective spines, as well as their habitat on muddy bottoms where turbidity is strong, probably protects them from predation. Their reproductive adaptativeness, with a small number of very big eggs (ariids have the largest eggs of any teleost group) protected by mouth incubation, also allows a large reduction in the early life mortality. Such a biological strategy is also observed on sharks that are viviparous. The spiny dogfish, *Squalus acanthias,* for example, reaches 110 cm at 70 years (Beamish and McFarlane, 1985).

The slow growth of the sea catfish makes them highly vulnerable to the exploitation which might rapidly deplete large fish except those in unaccessible areas.

Acknowledgments

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Table 4. Sizes of sea catfish caught during trawling surveys off Guinean coasts between 1985 and 1988. L_{mean} = mean length of the captures; $L_{90\%}$ = maximum length of 90% of the captures; L_{max} = maximum length observed.

Species	Fish (no.)	L_{mean} (FL cm)	$L_{90\%}$ (FL cm)	L_{max} (FL cm)
A. heudeloti	8,379	25	34	81
A. parkii	1,846	23	33	51
A. latiscutatus	3,116	30	36	67

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