Hydrobiologia **303**: 149–157, 1995.
F. Schiemer, M. Zalewski & J. E. Thorpe (eds), The Importance of Aquatic-Terrestrial Ecotones for Freshwater Fish.

An outline on lateral fish migrations within the Central Delta of the Niger River, Mali

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Key words: floodplain, hydrological cycle, aquatic-terrestrial transition zone

Abstract

The lateral migration of fishes was studied during one entire flood cycle (1991) in a typical floodplain sector of the Central Delta of Niger at Batamani, Mali. The intensity and temporal course of migrations, as well as the species and size composition of migrants, were found to be correlated with the hydrological regime (river and floodplain water levels, direction and velocity of water flow in a temporary canal). Four different types of migratory patterns were described and their typical representatives indicated. The significant role of the river as a spawning site and that of the flood plain as a nursery for most locally important fishes was also accentuated.

Introduction

The Central Delta of the Niger in Mali represents a large-scale 'aquatic/terrestrial transition zone' (ATTZ) as defined by Junk *et al.* (1989), with remarkable temporal and spatial dynamics and with extreme interchange between aquatic and terrestrial ecosystems. Its water area fluctuates from less than 1000 km^2 at the end of dry season up to a mean of 12400 km^2 (but up to nearly 36000 km^2 before '70) at the culmination of flood (Poncet, pers. comm.), with the water level fluctuating within 5–6 m, and with floods normally lasting almost 6 months. Regularly flooded biotopes play an important role in the spawning and nursery of fishes, strongly influencing their production and exploitation and having a strategic importance for the nutrition of local inhabitants. This floodplain function is associated with massive lateral migrations of fishes exerted in both directions between the main channel of the Niger and the inundated flood plain, mainly via temporary streams (locally called 'marigots'), changing its current direction in the course of the flood cycle.

The aim of the present investigation was to determine the types of migration undertaken by fish and to identify the environmental mechanism associated with the migrations. The results presented here are only an outline of our research activities on lateral fish migrations, which are a part of a multidisciplinary study of fisheries in the Central Delta of the Niger River (Bénech *et al.*, 1992).

Study area

Our observations were carried out in the course of one entire flood season, from August to

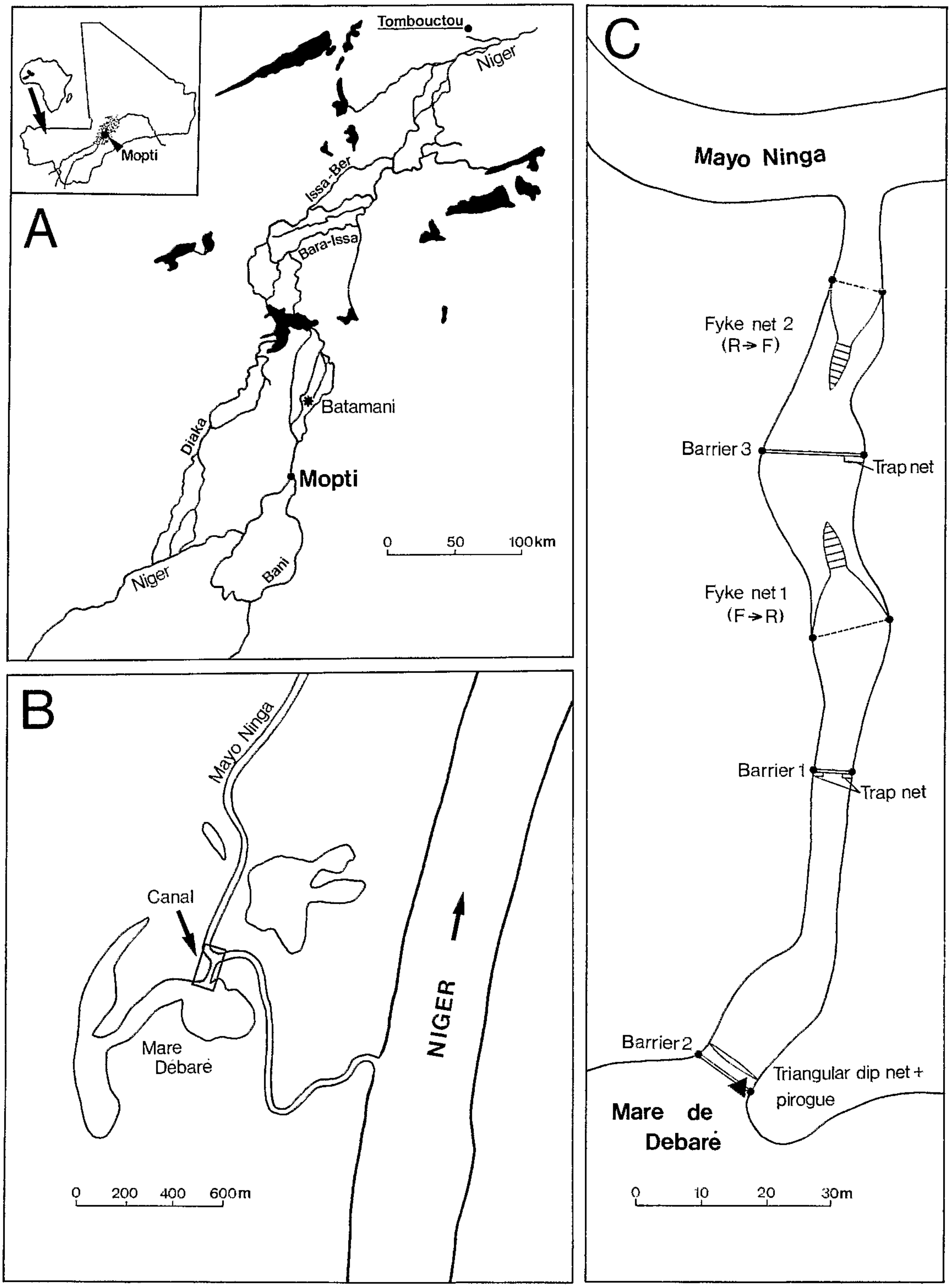

Fig. 1. A. Location of the Batamani study area in the Central Delta of the River Niger (Mali). B. Temporary canal connecting the 'Mayo Ninga' side arm of the Niger with the floodplain sector Mare de Debaré. C. The position of experimental and local fishermens' fishing devices in the canal (see text).

Table 1. Results of experimental fyke net fishings in the canal connecting the river and the flood plain. (Summarized catches during entire survey, 15 Aug.–13 Dec. 1991).

Period (direction of current in the canal	Direction of migration							
	R→F (Fyke net 2)				F→R (Fyke net 1)			
	N		W, kg		N		W, kg	
	a	b	a	b	a	b	a	b
Increasing flood 15 aug.–29 Oct. (R→F)	18077	1506	40.98	3.42	9870	987	23.28	2.33
Decreasing flood 30 Oct.–13 Dec. (F→R)	1398	155	8.53	0.95	33118	3680	402.76	44.75
All	19475	927	49.51	2.36	42988	2263	426.04	22.42

a. Overall catch during all fishings.
b. Catch per one 24-h cycle (C.P.U.E.).

December 1991, at a site located on the marigot connecting the Niger side arm Mayo Ninga with the floodplain sector 'Mare de Débaré' near the village of Batamani (Fig. 1). The study site is a relatively large and isolated floodplain sector about 70 km downstream of Mopti, with a 70 hectares of permanent lake. The lake is connected to the Niger by a single, short canal (150 m long, 3–4 m wide), which could be controlled for fish migrations with relative easy. The water in this marigot flowed from the river towards the flood plain (R→F) during the period 5 August to 29 October and reversely (F→R) during the remaining period of the flood season, 30 October 1991 to 13 December 1991.

Table 2. The species predominating in catches by fyke nets.

R→F			F→R		
Species	Relative abundance (%)	Relative biomass (%)	Species	Relative abundance (%)	Relative biomass (%)
Brycinus leuciscus	33.45	24.01	*Brycinus leuciscus*	19.50	3.88
Pellonula leonensis	26.21	9.85	*Siluranodon auritus*	15.53	11.07
Barbus spp.	10.55	22.00	*Pellonula leonensis*	8.73	0.78
Tilapia sensu lato	4.81	5.51	*Tilapia* sensu lato	7.85	6.84
Hydrocynus sp.	2.89	5.69	*Schilbe intermedius*	7.16	12.73
Micralestes elongatus	2.50	1.00	*Barbus* spp.	6.15	1.23
Schilbe intermedius	2.32	5.15	*Pollimyrus isidori*	6.06	1.71
Pollimyrus isidori	2.14	2.49	*Leptocypris niloticus*	6.02	0.79
Bagrus (*bayad*)	2.01	4.50	*Hemisynodontis membranaceus*	4.66	23.62
Siluranodon auritus	1.80	4.59	*Physalia pellucida*	2.56	0.36
Other species	11.32	15.21	Other species	15.78	36.99

Remark: the species are ordered according to the decreasing frequency.

Material and methods

A system of two fyke nets (locally called 'gangui'; mesh size 8 mm), installed facing opposite directions across the canal (R→F and F→R) and closing its entire cross sections, served as the basic fishing device to record simultaneously the two-way lateral migrations of fishes (Fig. 1). These

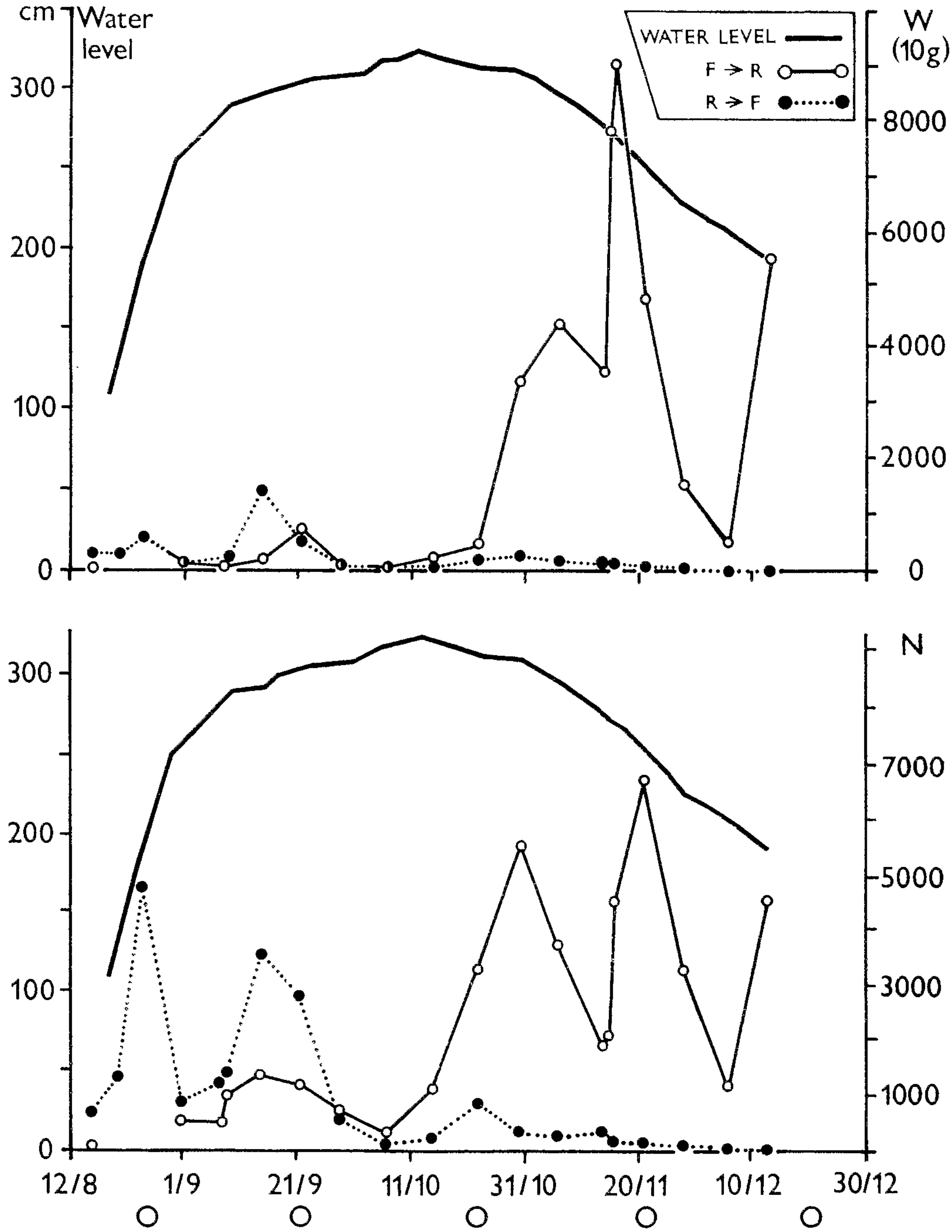

Fig. 2. Total catches obtained from fyke nets in the canal connecting the Niger and the flood plain. Ordinate – weight and number; abscisse – date. White circles indicate the days within the full moon phase.

were installed 21-times for 24-h cycles between 16 August and 13 December 1991, at a comparable lunar phase and emptied every 3 hours. One of the fyke nets (R→F) was complemented by a triangular drift net with fine mesh (mosquito net), which was exposed every 2 hours for 20 minutes in order to record the passage of fishes in early stages of development. All fish were identified, measured for SL and weighed; sex and sexual maturity of adults were recorded.

Results

In the fyke nets catches, 55 taxa of fish were identified. In total, during the whole survey, 19475 specimens (49.51 kg) of fish were captured migrating towards the flood plain and 42988 (426.04 kg) migrating in the opposite direction towards the river (Table 1).

The characid *Brycinus leuciscus* was the most abundant species migrating from the river towards the flood plain (33.45%; Table 2), followed by a small-sized clupeid species *Pellonula leonensis* and *Barbus* spp. (26.21 and 10.55%). Similarly, the biomass share was highest in these three species.

B. leuciscus, *Siluranodon auritus* and *P. leonensis* were the most abundant migrants in the opposite F→R direction, moving from flood plain towards the river (19.50, 15.53 and 8.73%). However, *Hemisynodontis membranaceus*, *Schilbe intermedius* and *S. auritus* dominated the biomass (23.62, 12.73 and 11.07%) (Table 2). The highest ratio between the biomasses of the fish migrating from and towards the flood plain (F→R/R→F) was found in *Mormyrus rume* (3131/3.47 = 902), *Citharinus citharus* (18968/25.94 = 731), *Auchenoglanis occidentalis* (36726/53.23 = 690) and *H. membranaceus* (100647/260.58 = 386).

The temporal course of migrations was correlated in most fishes with the hydrological regime (water level, direction and velocity of water current in the marigot) and, to some extent, also with the lunar cycle (Fig. 2). Sequential migratory waves of different cohorts were observed in some species (e.g. *B. leuciscus* (see Fig. 3) and *Labeo senegalensis*), whereas rather constant migratory

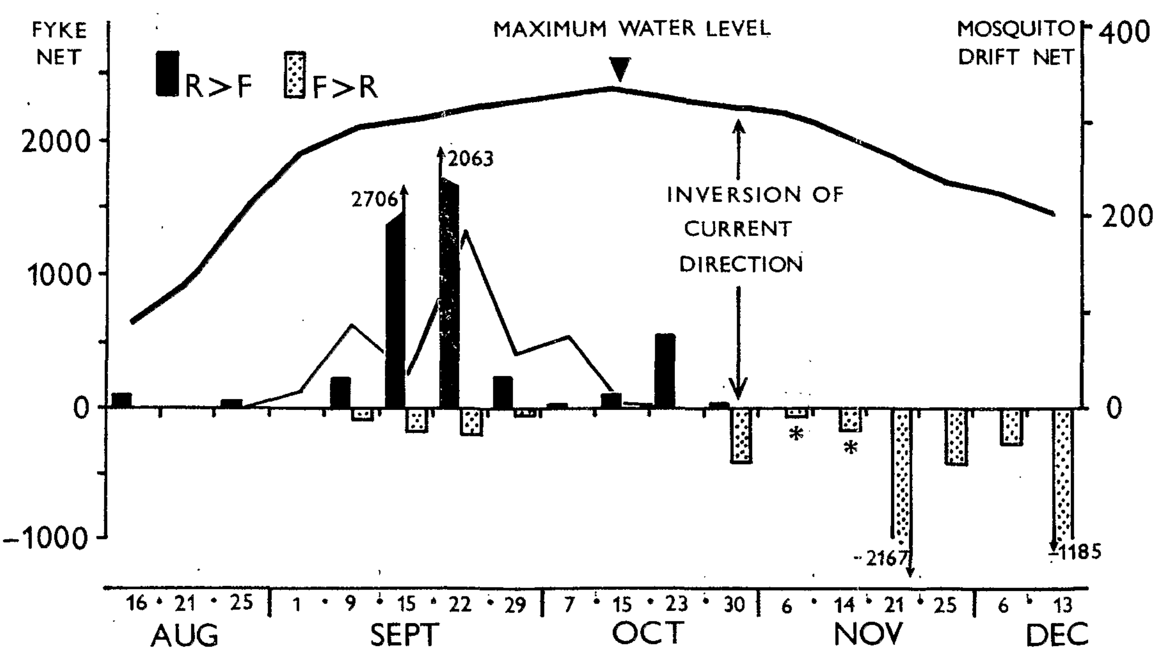

Fig. 3. Temporal course of catches of *Brycinus leuciscus* migrating in both directions through the canal connecting the Niger and the flood plain. The catches by fyke nets 1 & 2 are indicated in histograms, those by mosquito drift net as linegraphs. The days within the full moon phase are indicated in fig. 2.

patterns were observed in others (*H. membranaceus*, *Auchenoglanis* sp.).

In general, four types of migratory patterns could be recognized (Fig. 4):

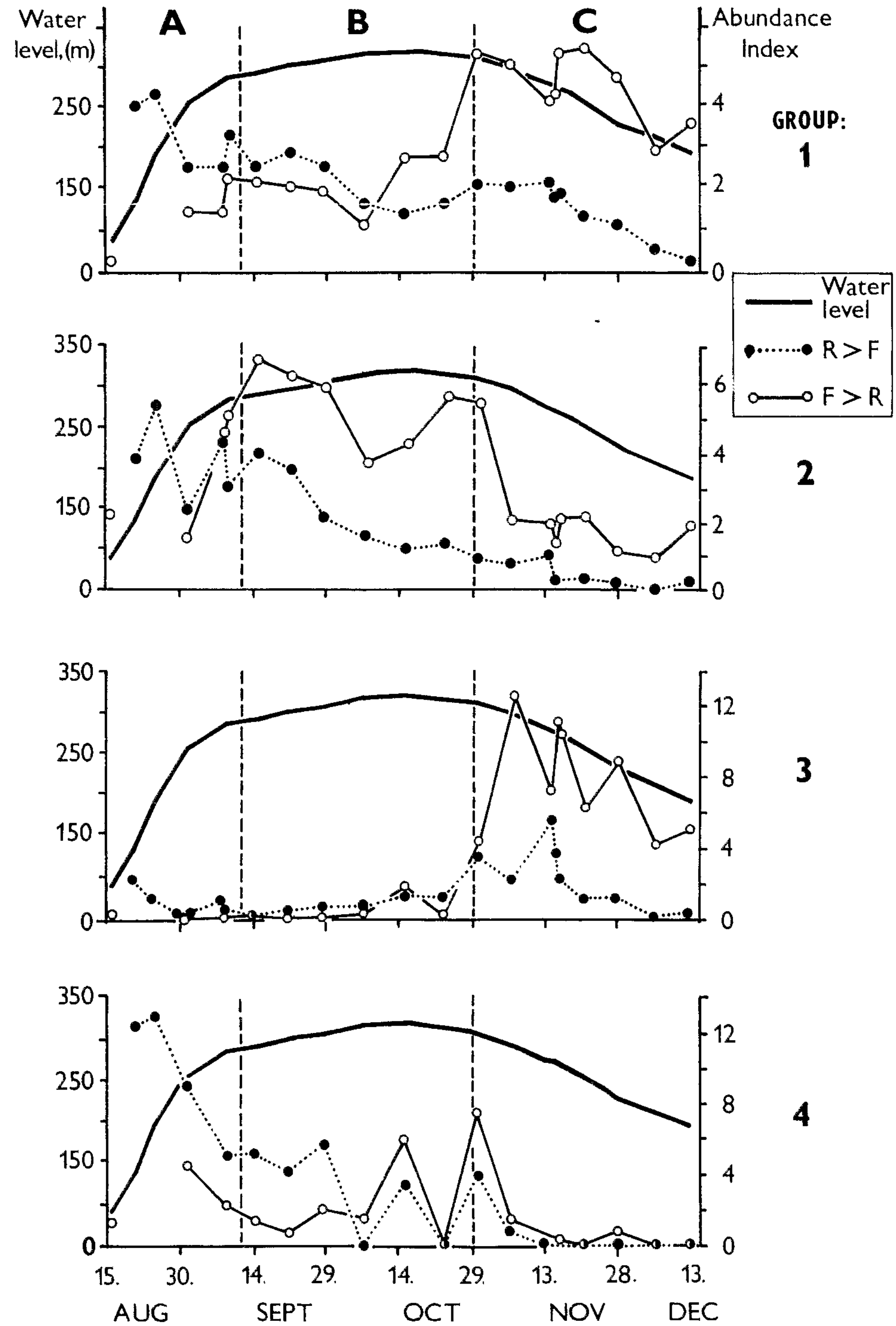

Fig. 4. Four types of migration patterns (based on fish numbers) observed in the canal connecting the Niger and the flood plain. Typical representatives belonging to each group are indicated in the text. A, B, C – phases of hydrological cycle.

Group 1. Fishes of this group were characterized by intensive migration from the river towards the flood plain (R→F) during the rather long period of rising water level. The migratory activity decreased during the flood peak but started again in the reversedirection F→R as the water level fell. Typical representatives were *B. leuciscus*, *S. intermedius*, *Tilapia* sensu lato, *L. senegalensis*, *Lates niloticus*. These migrants included only juveniles of *Labeo* and *Lates*, and both adults and juveniles in three other species.

Group 2. These fish species invaded the flood plain very early during the inundation process up to the beginning of the high water period. The return F→R migration was initiated rather early, immediately with the slackening of rise in water level and it decreases considerably just after the inversion of current. This group consisted mainly of small-sized pelagophilous fishes, such as *P. leonensis*, *Micralestes elongatus*, *Chelaethiops bibie* and also of some commercially important species (only juveniles) such as *Alestes* sp., *Brycinus nurse* and *Hydrocynus* sp. Of the two *Hydrocynus* species, only *H. brevis* entered the floodplain.

Group 3. In these fish species, only a flood plain to river migration was registered; the river to flood plain migration either did not take place or they drift undetected as larvae during the beginning of the flood (e.g. *H. membranaceus*) or they are permanent residents in flooded biotopes all-year-round, (e.g. *Brienomyrus niger*, *Clarias* sp.).

Group 4. This group is composed mainly of small-sized fish species that inhabit running waters, entering the marigot and the transient zone between river and flood plain temporarily, but never occupying the internal parts of the flood plain. They disappear from this transient zone immediately after the water starts to descend (*Nannocharax occidentalis*, *Pollimyrus petricolus*, *Raiamas senegalensis*, *Mochokus niloticus*).

Discussion

Spatially, the Central Delta of the Niger represents a giant ATTZ (Junk *et al.*, 1989) with remarkable temporal dynamics, an extreme interchange between aquatic and terrestrial ecosystems and with substantial allochthonous energetic and mineral inputs. Its complex functioning seems to be well interpreted by the flood pulse concept (Junk *et al.*, 1989, Welcomme *et al.*, 1989). The seasonal pulsing of flood flowing onto the flood plain is the driving force controlling the river-floodplain complex. As water inundates the flood plain, the flood pulse produces a 'moving littoral ecosystem unit', which prevents permanent stagnation and allows the rapid recycling of nutrients and organic matter. This prosperous function is strongly dependent upon the existence and intensity of rains and the strength of floods within the vast territory of the upstream catchment of the Niger. The flood pulse has unfortunately tended to decrease in recent years or was even lacking in some years ('Sahelian Drought' in 1972–1973). This was reflected in the decreased rate of fish production (Dansoko *et al.*, 1976; Welcomme, 1986; Laé, 1992). The lateral migration of fishes represents a fundamental mechanism that ensures the production of fish within the riverine and floodplain ecosystems, this resource being exploitated by traditional local fisheries. Our research corroborates that of a preliminary survey carried out in 1990 (Bénech *et al.*, 1992), but the present study emphasizes the significant competitive and nutritional role of highly dominant, small-sized and commercially insignificant fish species.

Our results are comparable with those from some other flood plains, especially from the Yaéré in North Cameroun (Durand, 1970, 1971; Bénech & Quensiére 1983a, b, 1987). The temporal course of migrations were found to be strongly dependent upon the hydrological cycle and, in some extent, exhibited also the biological rhythmics associated with lunar cycles. We observed a massive colonization at the end of the period characterized by the rapid flood increase during mid-September and the movements in opposite direction after the changed direction of water current during last days of October. The intensity of the return migration, flood plain-to-river, in some species, e.g. *B. leuciscus*, was considerably influenced by lunar cycles (Daget, 1952; Ghazai *et al.*, 1991). Four types of migratory pattern were distinguished, based upon two different ways of floodplain colonization: 1) Species predominantly of little size, belonging to groups 2 and 4; they inhabit the canal and the transient zone between the canal and the floodplain lake; their floodplain-to-river migration was completed immediately after the reversal of current in the marigot had occurred; 2) Species of great size (groups 1 and 3) invaded deeply into the flood plain, where they rapidly grew; their return migration F→R started relatively late during the period of decreasing flood.

Although we started our sampling on 15 August only, *i.e.* 10 days after the onset of the flood at Batamani, it was still a long time prior to the termination of the reproduction season, which in most fish species lasts till September (Bénech, 1990). Also noteworthy was the near absence of large specimens, except for several tilapias migrating into the flood plain to spawn. On the contrary, a considerable colonization of floodplain waters by the earliest juvenile stages was observed already at the beginning of the flood (August). Those fish species, being of greatest interest to fishermen, spawned mainly in the river. However, the inundated flood plain provides these species with juvenile progeny.

The surprising absence (or very low numbers only) of ripe fish migrating towards the flood plain to spawn suggests that a considerable portion of recruitment in fish populations in the flood plain originates from the main river, with larvae and young juveniles entering the flood plain for nursery and growth, as well as from fish resident in the floodplain lakes.

Finally, some imperfections perceived during the present survey should be mentioned: (1) we did not succeed in recording the migration of fish in the first ten days of the flood, a period considered important by local fishermen for some species (Mormyridae, *Clarias*, *Tilapia*); and (2) the fyke net appears to be selective, with a reduced efficiency for some species, namely for *Clarias* and *Tilapia*. This disadvantage was limited partly by the simultaneous capture of fish by other methods.

Despite these imperfections, the sampling methods used permitted us to make a comprehensive description of the lateral fish migrations patterns in relation with hydrological cycle, particularly the movements directing towards the flood plain, *i.e.* the less studied phase of migratory activity so far (Welcomme, 1979). Contrary to most other studies devoted to lateral migrations, the movements of fish were registered simultaneously in both directions during the present survey, including the small-sized species and juveniles that are usually ignored by the local commercial fishery as well by scientists

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