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Juvenile fish assemblages in the creeks of the Gambia Estuary

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Abstract – A fyke net survey of the juvenile and small fish assemblage of the Gambia estuary was conducted on three sampling occasions during the maximum recruitment season, from May to November 2002. This is the first detailed description of that particular component of the fish community in the Gambia estuary. The overall fyke net fish assemblage comprised 51 species, with a majority of young individuals of large and medium size species and the adults of small species. This assemblage is defined as the "small fish component of the mangrove channels". The assemblage is dominated by true estuarine and certain marine species, all able to complete their life cycle within the estuary. The sea spawning species whose juveniles use the estuary mainly as a nursery ground, are not very diverse or abundant during the recruitment season. They are limited to the lowest part of the estuary due to the low salinity prevailing in the middle and upper reaches during the rainy season. This suggests that extreme seasonal variability (river flooding) in certain West African tropical estuaries at the time of maximum recruitment by certain marine species may reduce the nursery ground value for these taxa.

Key words: Estuary / Mangrove / Juvenile fish / Nursery / Match-mismatch / West Africa

Résumé – La communauté des juvéniles de poissons dans l'estuaire de la Gambie. Le peuplement de poissons juvéniles de l'estuaire de la Gambie a fait l'objet de trois campagnes d'échantillonnage au cours de la saison de recrutement maximal de mai à novembre 2002. Ceci constitue la première description détaillée de cette composante particulière du peuplement de poissons de l'estuaire de la Gambie. L'échantillonnage à l'aide de verveux a révélé un assemblage composé de 51 espèces, dominé par de jeunes individus d'espèces de tailles moyenne à grande et d'adultes de petites espèces. Cette fraction du peuplement est définie comme la « communauté à juvéniles des chenaux de mangrove ». Elle est dominée par les espèces capables de réaliser la totalité de leur cycle vital en estuaire : espèces strictement estuariennes et espèces d'origine marine à forte affinité estuarienne. Les espèces dont la reproduction s'effectue en mer et dont les juvéniles utilisent l'estuaire comme nursery ne sont ni très diversifiées ni abondantes pendant la saison de recrutement. Les individus sont cantonnés à la partie inférieure de l'estuaire en raison des faibles salinités qui prévalent dans les biefs amont et moyen pendant la saison des pluies.

1 Introduction

The importance of estuaries in the reproduction of fishes and /or the nursery role they perform for early recruited juveniles are well known (Day and Deegan 1988; Laegdsgaard and Johnson 2001; Miller and Reed 1982; 1985; Potter et al. 1990; Ross and Epperly, Sasekumar et al. 1992; Whitfield 1999). In West Africa, however, knowledge on "early life ecology" and in particular on the nursery role of estuarine ecosystems is still limited (Vidy 2000).

Recent West African regional climatic changes, especially the increase in droughts during the past 30 years, has led to a deterioration in estuarine environmental conditions (Savenije and Pages 1992). The reduced rainfall and increasing demands of freshwater supplies for economic purposes has resulted in major ecological impacts on estuaries.

In the northern part of the West African coast (north of 12°N), the Gambia River estuary is the last "classical", non-impacted estuary. The catchment streams arise in the Fouta Djalon, a wet southern region that still receives significant amounts of fresh water. This river water enters the Gambia estuary and provides the region with a "last chance" to host a natural, unstressed estuarine nursery zone, a crucial point when considering the importance of coastal and estuarine small-scale fisheries in the region.

Apart from a preliminary survey of the juvenile fish assemblage in 1983/84 (Dorr et al. 1985), little is known about that particular component of the fish community of the Gambia River estuary. The current study is the first detailed description

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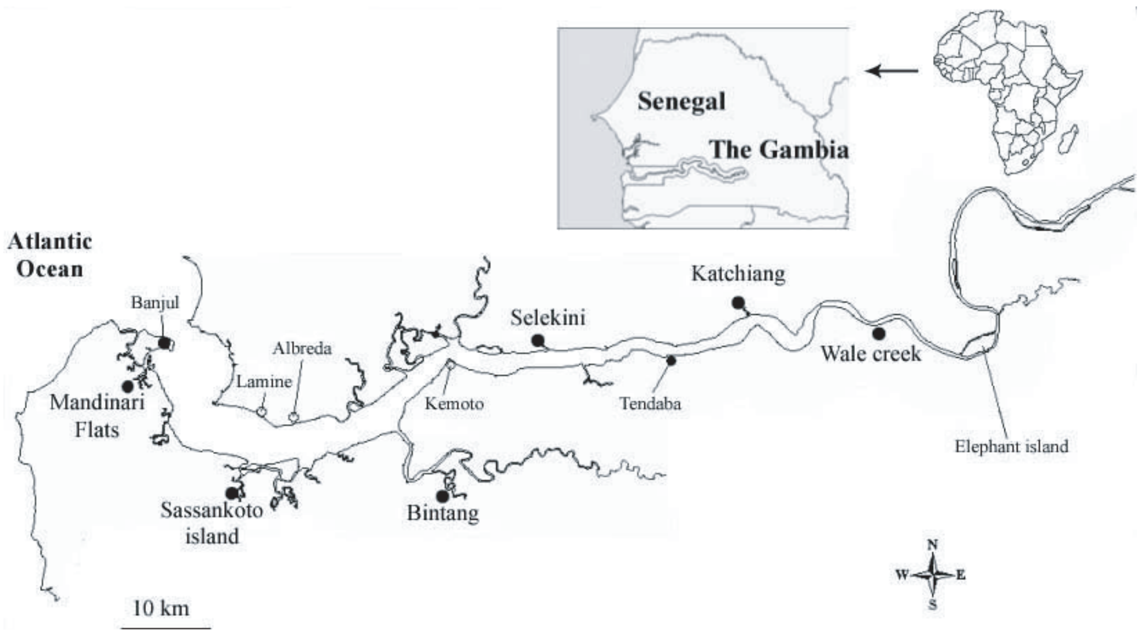

Fig. 1. Map of Gambia River estuary and location of sampling stations.

of the juvenile fish assemblage occupying the lateral mangrove channels of the estuary.

2 Materials and methods

2.1 Sampling stations

Six stations were selected between the estuary mouth and 130 km upstream (Fig. 1). Representation of lower reaches in the dataset was increased by approximately doubling the distance between each consecutive station in an upstream direction. All the sampling stations were sited in lateral channels (bolons) and were located at Mandinari (7 km from the sea), Sassankoto (24 km from the sea), Bintang (45 km from the sea), Selekini (77 km from the sea), Katchiang (105 km from the sea) and Wale creek (128 km from the sea).

2.2 Sampling gear

The survey of the juvenile and small fish assemblage was conducted using small meshed fyke-nets. The gear consists of two parts; a wall (or leader) 8 m long and 3 m deep made of 8 mm nylon mesh and a fyke-net or trap 3 m long, 0.4 m in diameter, with two 2.5 m wings. The first half of the trap was enclosed by 8 mm mesh netting and the last half by 6 mm mesh netting.

2.3 Sampling periodicity

Three field expeditions were undertaken during 2002, timed to coincide with the periods of maximum juvenile fish recruitment as recorded for the nearby Sine Saloum estuary (Vidy 2000).

The first survey was conducted in May, a period representative of the end of the dry season. The second was in September, representative of middle of the rainy season. The third was in November, representative of the end of the rainy and flooding season.

2.4 Sampling operations

Nets were set at night in channels adjacent to the main channel of the estuary. The sampling period was chosen, as far as possible, to coincide with the new moon phase (less light) and an evening flood tide (assuming that juvenile fish enter the mangrove area with the tide). Eight nets were used each night. They were set in a range of habitats through each station either on the fringe of the mangrove trees, over mud flats or in small corridors through the mangrove forest, in order to trap the fish returning to the main channel during the ebb tide. The catch of the eight nets is summed to constitute the assemblage sample.

Environmental parameters recorded in the field included salinity (psu) and surface water and air temperatures (°C). Measurements at each station were recorded at approximately 07 h 00. In addition, the state of the tide and prevailing weather were noted.

2.5 Statistical analysis

The catches of the eight nets were summed to constitute the assemblage sample for each station/date. The bio-ecological categories from Albaret (1999) were used to describe the fish assemblages (Table 1).

Descriptions of the fish assemblage structure and seasonal variations were based on a contingency table comprising the most common and frequently recorded species. The criteria for selection included species comprising 99% of the total

Table 1. Definitions applicable to the fish bio-ecological categories used in this study (from Albaret 1999).

	Continental		Estuarine				Marine	
Category	Occasional	Estuarine affinity	From Continental origin	True marine	From estuarine origin	Marine affinity	Accessory	Occasional
Code	Co	Ce	Ec	Es	Em	ME	Ma	Mo
Abundance	Rare	Rare to abundant	Very abundant	Very abundant	Very abundant	Abundant to very abundant	Rare	rare
Repartition	Limited	Limited	Wide	Wide	Wide	Wide	Limited	Limited
Presence	-	Seasonal	Permanent	Permanent	Permanent	Permanent	Seasonal	-
Estuarine reproduction	No	Rare	Yes	Yes	Yes	No	No	No
Euryhalinity	Low	Low	Good	Good to Excellent	Excellent	Good	Low	Low

catch when classified in decreasing order of abundance, or >10% occurrence in the total number of individual samples. *Aplocheilichtys spilauchen* was added to the list even though the occurrence of this species was slightly <10%.

3 Results

3.1 Environmental parameters

Salinity varied from zero at Wale Creek, the most upstream station, in September and November, to 47 at Mandinari Flats, the lowest station, in May. During this survey, salinity was frequently higher in the lateral channels than in the main estuary, especially during May at the three lowest stations, Mandinari Flats, Sassankoto Island and Bintang (Fig. 2a).

Different ranges in seasonal salinity variations were recorded at each station, with the three lowest stations, Mandinari Flats, Sassankoto Island and Bintang exhibiting moderate variations (8−13) over time, with average values always >30. The upper stations exhibited largest salinity variations (17−21), with average values always <32. During the 2002 season, the amount of rain was markedly lower than the previous season, with high salinities prevailing during November and zero recorded only at Wale creek.

Temperatures did not vary markedly either between stations or between sampling occasions (Fig. 2b), ranging between 26.3 °C and 29.2 °C. September was slightly warmer than other seasons, with variations between stations mainly due to overnight rainfall.

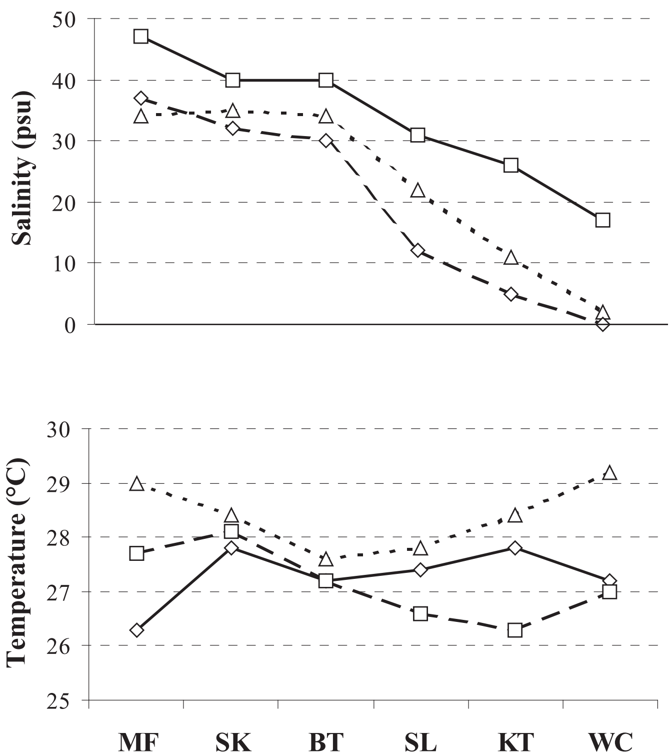

Fig. 2. Spatial and temporal variation of environmental parameters in Gambia estuary during 2002: a) salinity; b) temperature. (solid line = May; small dotted line = September; large dotted line = November).

3.2 Fish community composition

A total of 4366 individuals, comprising 47 species and representing 26 families (Table 2) were captured in 2002. Fourteen species contributed 90% of the total catch. Four species contributed more than 10% of the total catch by number: *Liza grandisquamis* (15.0%), *Monodactylus sebae* (13.4%), *Pseudotolithus elongatus* (12.3%) and *Ethmalosa fimbriata* (10.2%). Four additional species were caught during preliminary surveys in 2001, each represented by only one individual: *Alestes baremoze, Mugil curema, Pomadasys incisus* and *Pseudotolithus senegalensis.*

When considering families (including the species caught in 2001), the Mugilidae were represented by 5 species; four families, Cichlidae, Clupeidae, Haemulidae, Sciaenidae, are each represented by 4 species; and three others, Bagridae, Gobiidae and Tetrodontidae by three species. The Carangidae, Eleotridae, Gerreidae, Polynemidae each comprised 2 species.

All bio-ecological groups are represented in the sampled fish assemblage and tend to follow a typical "classical" estuary pattern (Albaret 1994; Diouf 1994). Species belonging to the marine origin group (Em) dominate both in species richness (15 species) and number (48% of total catch) (Table 3). The true estuarine species group (Es) is also diverse with 11 species and ranks second in number of individuals, representing 27% of the total catch. In terms of abundance, the estuarine species

Table 2. Composition, abundance and bio-ecological categories of the total fish catch (2002).

Cat	Species name	code	Mandinari Flats			Sassankoto Island			Bintang			Selekini			Katchiang			Wale Creek		
			May	Sep.	Nov.	May	Sep.	Nov.	May	Sep.	Nov.	May	Sep.	Nov.	May	Sep.	Nov.	May	Sep.	Nov.
Ce	*Chrysichthys johnelsi*	CJO	-	-	-	-	-	-	-	-	-	-	1	-	-	2	2	1	1	1
Co	*Hepsetus odoe*	HOD	-	-	-	-	-	-	-	-	-	-	1	3	-	-	-	-	-	-
	Schilbe intermedius	SIN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
	Synodontis gambiensis	SYG	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Ec	*Chrysichthys maurus*	CWA	-	-	-	5	-	2	-	14	2	1	15	4	5	5	2	22	92	24
	Chrysichthys nigrodigitatus	CNI	-	-	-	-	-	-	-	-	-	-	-	2	2	-	1	-	-	1
	Hemichromis fasciatus	HFA	-	11	32	-	-	-	3	31	4	-	21	6	-	-	2	-	10	10
	Pellonula leonensis	PEF	-	8	1	3	70	7	11	76	29	8	26	10	-	-	-	31	24	6
Em	*Citarichthys stampfli*	CST	1	3	1	-	1	-	1	-	-	-	-	-	-	-	-	-	1	-
	Cynoglossus senegalensis	CYS	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
	Ethmalosa fimbriata	EFI	11	74	238	-	33	28	2	21	4	12	9	6	1	-	1	6	-	-
	Hyporhamphus picarti	HPI	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-
	Ilisha africana	IAF	3	6	57	-	40	20	-	3	-	-	4	1	-	-	-	-	-	-
	Liza dumerili	LDU	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
	Liza falcipinnis	LFA	7	14	2	1	16	1	1	1	-	-	2	2	-	-	-	1	26	10
	Liza grandisquamis	LGR	2	40	7	43	62	27	16	63	34	2	87	49	32	16	3	8	51	114
	Plectorhinchus macrolepis	PLM	-	1	1	-	1	-	-	-	-	-	3	4	-	-	-	-	-	-
	Pomadasys jubelini	PJU	-	-	5	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-
	Pomadasys perotaei	PPE	5	84	22	13	4	1	5	8	1	-	1	-	5	1	-	1	-	1
	Pseudotolithus elongatus	PEL	-	-	2	9	87	131	-	63	18	4	21	151	3	13	7	7	13	9
	Strongylura senegalensis	SMA	22	28	12	8	1	-	2	-	4	-	3	1	-	-	-	1	1	1
	Trachinotus teraia	TFA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Es	*Aplocheilichthys spilauchen*	ASP	2	7	4	-	-	-	-	-	-	-	2	9	2	-	-	-	-	1
	Bostrychus africanus	HAF	2	2	-	-	1	-	1	1	-	-	-	-	-	-	-	1	2	2
	Dormitator lebretoni	BLB	-	-	-	-	2	10	-	4	2	-	-	2	-	-	-	-	-	-
	Gerres nigri	GNI	-	73	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Gobionellus occidentalis	OOC	-	-	-	-	-	1	-	-	-	-	1	-	-	1	-	-	-	-
	Periophtalmus barbarus	PBA	-	4	3	2	-	-	10	1	-	12	1	-	2	-	-	-	3	-
	Porogobius schlegelii	ASC	-	4	4	1	11	22	-	7	16	1	6	52	2	1	-	-	-	1
	Psettias sebae	PSB	4	54	86	40	99	21	-	31	33	4	50	125	8	10	-	2	16	2
	Sarotherodon melanotheron	SME	1	29	7	4	1	-	1	11	7	-	33	26	-	16	8	1	19	84
	Tilapia guineensis	TGU	1	-	11	-	-	-	1	-	-	-	-	4	1	3	3	-	1	22
	Tylochromis jentinki	TJE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
ME	*Arius parkii*	APA	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-
	Caranx hippos	CHI	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Elops lacerta	ELA	-	-	1	2	3	1	1	3	3	-	-	3	-	-	-	-	-	1
	Ephippion guttiferum	EGU	-	-	-	-	12	3	-	-	-	-	1	-	-	-	-	-	-	-
	Epinephelus aeneus	EAE	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Eucinostomus melanopterus	GME	3	119	113	4	5	16	9	5	-	-	1	-	-	-	-	-	-	-
	Galeoides decatactylus	GDE	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mugil bananensis	MBA	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
	Polydactylus quadrifilis	POQ	1	-	-	1	1	-	-	1	-	-	1	6	-	3	1	-	7	8
	Pseudotolithus brachygnathus	PBR	1	2	3	2	4	2	-	2	1	-	-	3	-	2	-	-	-	-
	Sardinella maderensis	SMA	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
	Sphoeroides spengleri	SSP	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Sphyraena afra	SPI	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-
Mo	*Pisonodophis semicinctus*	PSE	1	2	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-

Table 3. Overall fish species richness and abundance in the Gambia estuary during 2002, based upon bio-ecological categories.

Category	Taxa	Number
Co	2	6
Ce	2	10
Ec	4	639
Es	11	1205
Em	14	2126
ME	12	372
Ma	0	0
Mo	2	8

of continental origin (Ec) ranked third with 15% of the total catch but only four species. In terms of richness, the marine estuarine species ranked second with 12 species but fourth in terms of abundance, with only 9% of the catch. The last four groups, occasional (Mo) and accessory marine species (Me), continental with estuarine affinities (Ce) and occasional continental species (Co) were represented by fewer species and individuals.

When comparing the structure between sampling periods, no dramatic changes can be detected. This was due to the dominance of the Em and Es groups that do not respond to salinity variations. The other groups, mainly ME, Co and Ce appear at different stages of the hydrological cycle (Table 4), and were neither species rich nor sufficiently abundant to markedly influence the relative contribution of the different bio-ecological groups to the overall community.

3.3 Spatial and temporal structure of fish assemblages

The factorial analysis applied to the table of selected species (Table 5) led to a factorial mapping of station/season (Fig. 3a) and species (Fig. 3b). The first axis of each factorial analysis accounted for 31.3% and 19.6% of the total inertia respectively.

The samples from Mandinari Flats in September and November appeared at the negative end of the first axis (Fig. 4). The samples from Wale Creek in the same months were located at the positive end. The other stations were roughly arranged along the first axis of the factorial map in a downstream (left) to upstream (right) order.

The second axis is defined by the contribution of the Wale Creek samples from September and November, and samples from Selekini and Sassankoto Island during September. For all other samples, except Mandinari Flats, the relative positions of each sample on the second axis are in a downstream to upstream order, with a sharp slope that probably reflects the accentuated salinity gradient during the end of the flooding season.

Whatever the sampling date, the samples from Mandinari Flats are clearly separated from the other samples and showed little seasonal variation. All May samples had a poor absolute contribution to both axes. The samples from Wale Creek and Katchiang had a good relative contribution to the first axis but no obvious organisation can be detected for that period.

On the species factorial map, *Eucinostomus melanopterus* and *Ethmalosa fimbriata* made large absolute and relative

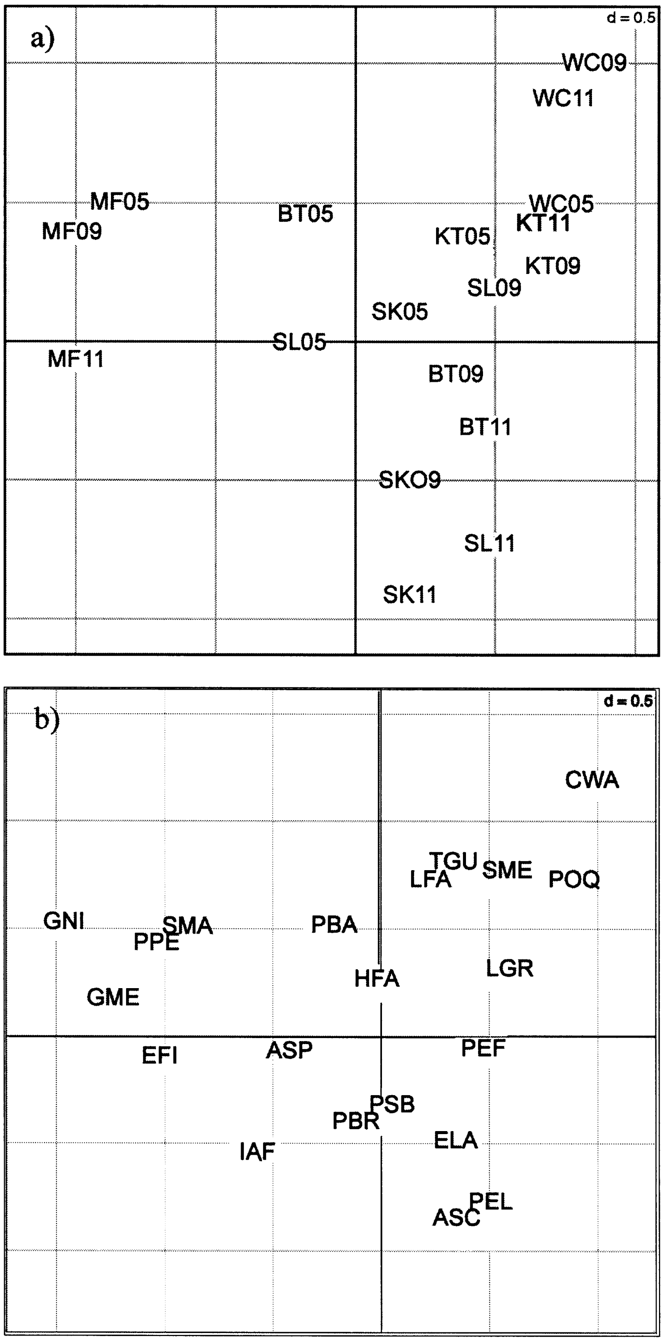

Fig. 3. Factorial analysis maps: a) the survey stations; b) the fish species.

contributions to the first axis (Fig. 5). These species were located on the negative end of the first axis in the same area that of the Mandinary Flat station. Other species with good relative contributions are, in decreasing order, *Gerres nigri*, *Liza grandisquamis*, *Polydactylus quadrifilis* and *Chrysichthys maurus*. *G. nigri* was associated with the downstream area of the map and the last three species with the upstream area.

The second axis received a large relative contribution from *Pseudotolithus elongatus* followed by *Porogobius schlegelii*, *Monodactylus sebae*, *Chrysichthys maurus*,

Table 4. Spatial and temporal fish species richness (a) and abundance (b) within the different bio-ecological categories.

a)	MF05	MF09	MF11	SK05	SK09	SK11	BT05	BT09	BT11	SL05	SL09	SL11	KT05	KT09	KT11	WC05	WC09	WC11
Co											1	1						
Ce											1			1	2	1	1	3
Ec		2	2	2	1	2	2	3	3	2	3	4	1	1	3	2	3	4
Es	5	7	7	4	5	4	4	6	4	3	6	6	5	5	2	3	6	6
Em	7	8	11	5	11	6	6	7	5	3	8	7	5	4	3	7	6	5
ME	3	4	4	5	7	4	2	5	3		4	3	1	2	1		1	2
Ma																		
Mo	1	1	1			1												
	16	22	25	16	24	17	14	21	15	8	23	21	12	13	11	13	17	20

b)	MF05	MF09	MF11	SK05	SK09	SK11	BT05	BT09	BT11	SL05	SL09	SL11	KT05	KT09	KT11	WC05	WC09	WC11
Co											1	3						
Ce											1			2	3	1	1	4
Ec		19	33	8	70	9	14	121	35	9	62	22	7	4	5	53	125	41
Es	10	173	138	47	114	54	13	55	58	17	93	218	15	32	11	4	43	112
Em	51	250	348	74	247	208	27	160	61	18	130	214	41	33	11	25	93	135
ME	5	124	118	10	28	22	10	12	5		4	12	1	5	1		7	9
Ma																		
Mo	1	2	3			1												
	67	568	640	139	459	294	64	348	159	44	291	469	64	76	31	83	269	301

Table 5. Abundance of selected fish species used for the factorial analysis.

	MF05	MF09	MF11	SK05	SK09	SK11	BT05	BT09	BT11	SL05	SL09	SL11	KT05	KY09	KT11	WC05	WC09	WC11
LFA	2	40	7	43	62	27	16	63	34	2	87	49	32	16	3	8	51	114
PSB	4	54	86	40	99	21	0	31	33	4	50	125	8	10	0	2	16	2
PEL	0	0	2	9	87	131	0	63	18	4	21	151	3	13	7	7	13	9
EFI	11	74	238	0	33	28	2	21	4	12	9	6	1	0	1	6	0	0
PEF	0	8	1	3	70	7	11	76	29	8	26	10	0	0	0	31	24	6
GME	3	119	113	4	5	16	9	5	0	0	1	0	0	0	0	0	0	0
SME	1	29	7	4	1	0	1	11	7	0	33	26	0	16	8	1	19	84
CWA	0	0	0	5	0	2	0	14	2	1	15	4	5	5	2	22	92	24
PPE	5	84	22	13	4	1	5	8	1	0	1	0	5	1	0	1	0	1
IAF	3	6	57	0	40	20	0	3	0	0	4	1	0	0	0	0	0	0
HFA	0	11	32	0	0	0	3	31	4	0	21	6	0	0	2	0	10	10
ASC	0	4	4	1	11	22	0	7	16	1	6	52	2	1	0	0	0	1
GNI	0	73	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LFA	7	14	2	1	16	1	1	1	0	0	2	2	0	0	0	1	26	10
SMA	22	28	12	8	1	0	2	0	4	0	3	1	0	0	0	1	1	1
TGU	1	0	11	0	0	0	1	0	0	0	0	4	1	3	3	0	1	22
PBA	0	4	3	2	0	0	10	1	0	12	1	0	2	0	0	0	3	0
POQ	1	0	0	1	1	0	0	1	0	0	1	6	0	3	1	0	7	8
ASP	2	7	4	0	0	0	0	0	0	0	2	9	2	0	0	0	0	1
PBR	1	2	3	2	4	2	0	2	1	0	0	3	0	2	0	0	0	0
ELA	0	0	1	2	3	1	1	3	3	0	0	3	0	0	0	0	0	1

Polydactylus quadrifilis and *Sarotherodon melanotheron*. *P. elongatus*, *P. schlegelii* and *M. sebae* appeared in the negative zone of the second axis with *C. maurus* and *P. quadrifilis* at the positive end.

3.4 Size structure of sampled fish assemblages

The sampling technique targeted small fish and this is reflected in the small mean size of most species (Table 6). Although small species (*Pellonula leonensis*, *Porogobius schlegelii* or *Monodactylus sebae*) were recorded, they were not abundant. This indicates that juveniles of larger species were dominant in that part of the mangrove channels sampled with fyke-nets. When considering the species that contributed up to 90% of the total catch, 63% (60−65) of the individuals were less than 100 mm (FL) and 83% (80−85) were less than 150 mm. The latter figure increased slightly between May and November 2002, probably linked to the growth of newly recruited juveniles. The almost four-fold numerical increase between May and November is mainly due to 0+ juveniles entering the community.

Table 6. Number and size parameters of fish species captured during the 2001 and 2002 surveys.

Species	Number	Mean size (mm)	Minimum	Maximum
Liza grandisquamis	817	101.6	24	277
Monodactylus sebae	580	90.6	17	163
Pseudotolithus elongatus	517	118.5	16	390
Ethmalosa fimbriata	387	67.1	27	160
Eucinostomus melanopterus	304	53.1	25	105
Pellonula leonensis	274	58.6	22	115
Sarotherodon melanotheron	252	122.8	17	202
Chrysichthys maurus	250	123.6	32	368
Pomadasys perotaei	170	77.8	42	149
Porogobius schlegelii	158	63.2	25	134
Hemichromis fasciatus	144	193.1	70	270
Ilisha africana	122	82.0	9	168
Gerres nigri	89	53.2	26	112
Strongylura senegalensis	89	273.3	170	392
Liza falcipinnis	82	134.4	57	222
Tilapia guineensis	69	114.9	35	265
Polydactylus quadrifilis	37	158.0	41	276
Periophtalmus barbarus	35	92.6	56	167
Schilbe intermedius	30	136.9	100	192
Dormitator lebretoni	29	57.5	32	77
Bostrychus africanus	28	135.8	73	191
Aplocheilichthys spilauchen	27	44.6	3	57
Pseudotolithus brachygnathus	22	163.7	85	235
Chrysichthys nigrodigitatus	19	212.6	68	313
Elops lacerta	17	167.2	68	243
Ephippion guttiferum	16	62.9	29	115
Citarichthys stampfli	12	112.6	77	130
Plectorhinchus macrolepis	11	324.0	182	522
Chrysichthys johnelsi	10	148.4	115	195
Pisonodophis semicinctus	9	610.9	335	772
Sardinella maderensis	8	50.9	23	71
Pomadasys jubelini	7	89.1	54	122
Arius parkii	4	272.0	240	305
Hepsetus odoe	4	359.0	276	440
Mugil curema	3	60.7	35	92
Gobionellus occidentalis	3	78.0	58	90
Synodontis gambiensis	3	169.3	162	178
Sphyraena afra	3	214.7	107	344
Caranx hippos	2	-	120	139
Cynoglossus senegalensis	2	-	63	163
Hyporhamphus picarti	2	-	96	108
Mugil bananensis	2	-	125	135
Pomadasys incisus	2	-	67	81
Trachinotus teraia	2	-	29	57
Tylochromis jentinki	2	-	83	195
Alestes baremoze	1	-	-	65
Epinephelus aeneus	1	-	-	300
Galeoides decatactylus	1	-	-	75
Liza dumerili	1	-	-	84
Pseudotolithus senegalensis	1	-	-	144
Sphoeroides spengleri	1	-	-	107

4 Discussion

Fish assemblages from the inner mangroves, as indicated by fyke net sampling, was composed of a moderate number of species that was similar to the community associated with the main channel (Albaret et al. 2004). The size structure was dominated by the juveniles of large species and the adults of small species, with few adults of large resident species, e.g. *Plectorhinchus macrolepis*. The Es and Em groups were largely dominant in terms of species and abundance throughout the recruitment season. This reflects the "normal" status of the Gambia estuary and confirms the structural scheme proposed for that type of estuary (Albaret and Diouf 1994).

The overall community structure, as expressed by the richness of each bio-ecological group, seemed to remain spatially and temporally stable. The dominance of the Es and Em groups of species, that were mainly resident species, is one of the reasons for such apparent stability. Variations in abundance were linked to recruitment seasons and related to the entry of 0+ juveniles into the populations. An example is *P. elongatus* where high numbers of small juveniles were recruited in September and November.

The data also showed the modification in fish assemblage structure related to increasing floods in September and November. The contrast between the assemblage in the lower and upper stations was accentuated by the appearance of newly hatched *P. elongatus* and *C. maurus*, and the arrival of new *P. quadrifilis* recruits. *P. quadrifilis* was the only sea spawning species whose juveniles were found in the upper stations where they cope with very low salinity water. For the other species of the ME group, whose adults spawn at sea, the increase in abundance on the lowest station from May to September-November suggests a breeding season similar to that of the resident species. The young were recruited into the estuary soon after spawning and were subjected to low salinity during the rainy/flooding season. Most of these 0+ juveniles were restricted to the lowest part of the estuary where salinity was above 10, even during the rainy season. A threshold of 10 has already been proposed in the literature for this group of species (Wagner 1999).

Although juvenile fishes do enter estuaries in search of food and shelter, there are limitations according to prevailing environmental conditions (especially salinity) and individual species tolerances. This is rarely taken into consideration when describing the role of tropical estuaries as nursery grounds and their contribution to local fish abundance (Whitfield 1983). In Guinea, especially in the Fatala River, another type of limitation appears when juvenile fishes are likely to be "washed out" of the estuary by the river flood (F. Domain, pers. comm.). Are these juveniles able to survive in the marine environment where they lack the shelter (apart from turbidity) and typical food resources found within estuaries? Future research needs to focus on answering these and related questions around estuarine "dependence" by fishes.

Although extended reproduction seasons are known for some species in the region (Albaret 1994), reproduction occurs mainly during the rainy season within the Gambia estuary, as indicated by the recruitment of numerous 0+ juveniles during this period. Similar timing has been observed for the Sine Saloum estuary (Vidy 2000) which has a completely different hydrological regime. Sea spawning species are probably influenced by other factors, such as the time and strength of marine upwelling. Nevertheless, recruitment of 0+ juveniles of sea spawning species indicated that the spawning season begins just before the rainy season (May-June) and lasts until November for most of species, thus matching that of other bio-ecological groups.

5 Conclusion

The juvenile fish assemblage of the Gambia estuary is typical of that found in a "normal" estuary, dominated by the species of the resident groups (Es and Em) The limited number of juveniles of the marine spawning species belonging to the ME group seems to be linked to the low salinities prevailing during the rainy season. Low salinities probably limit the access to the estuary by these juveniles in search of a nursery ground. Further research is required to confirm this view.

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