DISTRIBUTION AND FEEDING ECOLOGY OF THE AFRICAN TILAPIA *Oreochromis mossambicus* (TELEOSTEI, PERCIFORMES, CICHLIDAE) IN SURINAME (SOUTH AMERICA) WITH COMMENTS ON THE TILAPIA-KWIKWI *(Hoplosternum littorale)* (TELEOSTEI, SILURIFORMES, CALLICHTHYIDAE) INTERACTION

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ABSTRACT— *The geographical distribution of the African Tilapia Oreochromis mossambicus* in Suriname is restricted to a narrow strip of land along the Atlantic coast. Within the coastal plain, *O. mossambicus* occurs in brackish lagoons, oligohaline canals, and shell-sand pit lakes. Physico-chemical characteristics and phytoplankton composition of representative Tilapia water bodies are described. Blue-green algae and fine flocculent detritus are dominant food items in the diet of the Tilapia, while Rotifera and microcrustacea are also important in the diet of larvae and juveniles. Intraspecific diet overlap among ontogenetic stages of the Tilapia did not differ significantly from 1, which means that these diets showed complete overlap. Interspecific diet overlap between the Tilapia and the indigenous armoured catfish *Hoplosternum littorale* were moderate or low. The results are discussed in relation to recent developments in the Surinamese fisheries and aquaculture sector.

Key words: *Oreochromis mossambicus, Hoplosternum littorale*, distribution, diet overlap, competition, Suriname.

Distribuição e Dieta da Tilápia Africana *Oreochromis mossambicus* (Teleostei, Perciformes, Cichlidae) no Suriname (América do Sul) e Aspectos Sobre a Interação entre a Tilápia e o "Kwikwi" (*Hoplosternum littorale*) (Teleostei, Siluriformes, Callichthyidae) (Peixe-Gato Indígeno).

RESUMO — A distribuição geográfica da tilápia africana *Oreochromis mossambicus* no Suriname está limitada a uma pequena faixa de terra ao longo da costa Atlântica. Dentro desta área, *O. mossambicus* ocorre em lagoas de baixa profundidade, canais oligohalinos e em lagos arenosos. As caracteristicas fisico-quimicas e a composição em fitoplancton do meio aquático onde a tilápia ocorre são descritos. As algas azul-verde e detritos finos e floculentos são os alimentos dominantes na dieta da tilápia, enquanto que os rotíferos e os microcrustáceos são também importantes na dieta de larvas e juvenis. A sobreposição intraespecífica da dieta dentro dos estados ontogenéticos da tilápia não difere significativamente de 1, o que significa que essas dietas mostraram uma sobreposição completa. A sobreposição interespecifica da dieta entre a tilápia e o peixe-gato indígeno *Hoplosternum littorale* foi moderada ou baixa. Os resultados são discutidos em relação aos recentes desenvolvimentos nos setores da pesca e aquacultura do Suriname.

Palavras-chave: *Oreochromis mossambicus, Hoplosternum littorale*, distribuição, sobreposição de dietas, competição, Suriname.

INTRODUCTION

In 1955 the Fisheries Department of the Ministry of Agriculture introduced the African Tilapia *Oreochromis mossambicus* (Peters, 1852) in Suriname for aquaculture and for stocking natural water bodies (LIJDING, 1958). The culture of *O. mossambicus* has never been a commercial success in Suriname, but populations

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 Impresso em Maio 1996

stocked in brackish coastal plain waters expanded rapidly. However, until recently the Tilapia was not fully accepted by the Surinamese people as a food fish and major fisheries on this species only developed in the 1980's, e.g., the fisheries of the Bigi Pan lagoon (RESIDA, 1985). Three recent developments in the freshwater fisheries and aquaculture sector prompted the present investigations into the ecology and distribution of established populations of *O. mossambicus* in Suriname: 1) the collapse of the Tilapia fisheries at Bigi Pan, possibly related with a change in water quality from brackish to fresh, 2) the growing interest in the culture of the Red Tilapia (a hybrid of *O. mossambicus x O. hornorun)*, and 3) the decline in the supply of the popular armoured catfish *Hoplosternum littorale* (Hancock, 1828) (OUBOTER & MOL, 1994) and the suspected negative impact of the Tilapia on this catfish.

The Bigi Pan fisheries are described by RESIDA (1985). In the main fishing season during the dry months of September to December approximately 100 fishermen may be active in the Bigi Pan area. Tilapia is one of the major species in the catch and the harvest of this species may amount to 60.000 Kg month^{-1}. In the 1990's fishermen increasingly began to disappear from the Bigi Pan area (pers. observations). Fishermen camps were deserted and the access canal to the lagoon silted up due to neglected maintenance. VAN DER LUGT (in prep) shows that the water of the Bigi Pan slowly changed from brackish to fresh over the last decade. This change in water quality may have had a negative impact on the Tilapia stocks. In order to evaluate the effect of decreasing salinity on the Tilapia more data on the water quality of Tilapia water bodies in Suriname are needed.

Since the pioneering aquaculture trials with *O. mossambicus* in brackish water ponds at the Matapica plantation in 1956 and 1957 (LIJDING, 1958), interest in Tilapia culture rapidly declined. The main reason may have been the cold reception of the Tilapia by the Surinamese people who preferred local food fishes. The recent interest for the culture of Red Tilapia is probably incited by the potential of export of this fish and the deteriorating economy of the country. Information on the ecology of established *O. mossambicus* populations in Suriname may be useful to local entrepreneurs working with the Red Tilapia, a hybrid of *O. mossambicus* and the closely related *O. hornorun*.

After supplies of the very popular armoured catfish *H. littorale* (sur. soké kwikwi) dropped in 20 years to approximately one quarter of the pre-1970 period (OUBOTER & MOL, 1994), the introduced Tilapia was thought to have a negative impact on the Kwikwi stocks. Suspicion of a predatory behaviour of Tilapia towards young Kwikwi was probably based on the misinterpretation of the mouth-breeding habit of the Tilapia. However, both *H. littorale* (MOL, 1994) and *O. mossambicus* are limited in their distribution in Suriname to the young coastal plain and consequently asymmetric competitive interactions between the two species may have a negative impact on the *H. littorale* stocks. The ecology of *H. littorale* was studied by MOL (1993, 1994, in press a, in press b), but data on *O. mossambicus* in Suriname are not available.

This paper describes the distribution of the Tilapia *O. mossambicus* in Suriname, the characteristics of its habitat, and the composition of its diet. The objective is to shed some light on the three Tilapia-related issues in the Surinamese fisheries and aquaculture sector outlined above.

MATERIALS & METHODS

Study area

Suriname is situated in the Neotropics between 2° and 6° North Latitude. The country can be divided into three zones (Fig. 1): in the north the flat coastal plain, to the south of it the savanna belt, and the hilly interior on the Precambrium Guiana Shield. The coastal plain is covered with swamps, swamp forests and mangrove forests. The tidal influence is strong. The savanna belt is characterized by savannas and savanna forests on often very poor podzolic soils. The creeks draining this area are stained black by dissolved humic substances. They may be classified as black waters (terminology of SIOLI, 1950). The interior covers three quarters of the country and is almost completely covered with tropical rainforest. Creeks and rivers draining the Guiana Shield principally carry clear water (HARIPERSAD-MAKHANLAL & OUBOTER, 1993).

Distribution

The distribution of *O. mossambicus* in Suriname was studied based on specimens present at the National Zoological Collection of the University of Suriname (NZCS), our own collection data, and information of the Fisheries Department of the Ministry of Agriculture.

Water quality

We tentatively classified the water bodies where Tilapia were found into three groups: 1) brackish lagoons, 2) brackish or oligohaline canals, and 3) shell-sand pit lakes. Water samples were taken from representative water bodies and physico-chemical parameters were measured in the laboratory following standard methods (APHA-AWWA, 1976). We only used data from the literature to supplement our analyses when the authors clearly stated that sampling and analysis followed APHA-AWWA directives.

Taking into account the importance of filamentous blue-green algae in the diet of Tilapias of the genus *Oreochromis* (MORIARTY, 1973; MORIARTY & MORIARTY, 1973; LOWE-McCONNELL,1982; PHILIPPART & RUWET, 1982) we also collected samples of phytoplankton. Phytoplankton was studied with a Reichert Me FII inverted microscope and identified with keys in DESIKACHARY (1959), GRÖNBLAD (1945), HUBER-PESTALOZZI (1938-1963), PRESCOTT (1962), and WARD & WHIPPLE (1959).

Diet analysis

We collected "larvae" (actually young juveniles according to the terminology of BALON, 1985), juveniles and adults of *O. mossambicus* in an oligohaline canal (Boomskreek) and a shell-sand pit (Bakboord) near Paramaribo (Fig. 1). Lar-

Table 1. Physico-chemical data of selected *Oreochromis mossambicus* water bodies in the coastal plain of Suriname.

	Brackish lagoon			Oligohaline canal		Shell - sand pits	
	Bigi Pan (Nickerie) *			Boomskreek (Paramaribo) **		Gummels ***	Bakboord
	mean	min	max	rainy season	dry season		
pH	8,0	7,8	8,2	6,8	8,1	7,8	8,4
Conductivity (µS)	26500	18000	40000	860	2500	1400	693
Hardness (mg $CaCo_3$ l^{-1})	-	-	-	26	400	-	145
Alkalinity	-	-	-	-	-	-	129
Cl (mg l^{-1})	20030	3900	60000	128	713	330	218
SO_4 (mg l^{-1})	-	-	-	119	8,5	-	13,9
PO_4 (mg l^{-1})	-	-	-	0,18	1,47	0,14	0,05
NO_2 (mg l^{-1})	-	-	-	0,18	0,00	0,05	-
NO_3 (mg l^{-1})	-	-	-	0,84	0,00	0,12	0,00
NH_4 (mg l^{-1})	-	-	-	0,81	0,99	0,10	0,63
Ca (mg l^{-1})	-	-	-	5,2	23,6	46	21,6
Mg (mg l^{-1})	-	-	-	25,2	59,1	31,3	22,1
Fe (mg l^{-1})	-	-	-	-	0,1	-	0,17
SiO_2 (mg l^{-1})	2,0	0,4	4,1	13,3	18,0	-	-
O_2 (mg l^{-1})	5,0	2,0	12,2	1,1	0,4	5,9	-
BOD (mg l^{-1})	-	-	-	2,3	4,3	7,5	-
Suspened solids (mg l^{-1})	82	0	290	-	-	-	63
mean water depth (m)		0,25 - 1,0		1,5	0,75	3,5	3
area (Km^2)		10,5		-		0,64	0,11
distance to ocean (Km)		2		7		3	5
in connection with ocean		yes		no		yes	yes

* data from 1982 - 1986 (RESIDA, 1985; VAN DER STEEGE, 1991)

** data from 1987 - 1988 (MOL, unpublished)

*** data from 1985 (PERK, 1986)

vae were collected with seines in shallow water. The size of the larvae (10 mm TL; Tab. 5) shows that they had been released from the mouth-brooding female for no more than a few days (see BRUTON & BOLTT, 1975). Juveniles (13-55 mm TL) were collected with seines in slightly deeper water than the larvae. Adults were collected by cast net in deep water. All specimens were preserved in 4% formalin and measured for total length, standard length, and gape of the mouth to the nearest 0,1 mm. Fresh weight was determined to the nearest 0,1 mg for larvae and juveniles, and to the nearest 0,1 g for adults.

The alimentary tract was removed, measured to the nearest 0,1 mm, and opened under a dissecting microscope. The fullness of the stomach was estimated as 0, 5, 25, 50, 75 and 100% of a fully extended stomach. The stomach contents of larvae and juveniles were spread out on a 5x5 cm glass slide and examined systematically under a light microscope (100x and 400x). Food items were identified and their volume was estimated as a percentage of total stomach contents by determining the amount of surface of the glass slide covered for each item. Estimated volume percentages were adjusted for stomach fullness in all further calculations (HYSLOP, 1980). Frequency of occurrence was based on presence or absence of food items in the stomach and expressed as a percentage of all stomachs examined, including empty stomachs. The contents of the stomachs of adult specimens were spread out on a Petri dish and examined under a dissecting microscope following procedures described above for larvae and juveniles.

Food items were grouped into 18 categories. Detritus was defined as dead organic matter that has been altered in some way that renders it unlike its original form (BOWEN, 1983). We distinguished between coarse vegetative detritus which could be identified as detritus derived from vascular plant matter and fine flocculent detritus with uncertain origin.

For calculations of diet overlap the following food items were grouped together as algae: *Oscillatoria* sp., *Closterium* sp., Euglenophyta and Bacillariophyceae. Also grouped together were microcrustacea: Cladocera, Copepoda and Ostracoda. The remaining food categories used in the calculations of diet overlap were: difflugiids, Rotifera, Nematoda and Oligochaeta, larvae of aquatic insects, aquatic insects, Gastropoda, terrestrial Arthropoda, fish scales, invertebrate cysts, seeds/spores/flottoblasts, fine detritus, coarse detritus, chitinous remains, vegetative plant matter, and a rest group. Data on the composition of the diet of *H. littorale* were taken from MOL (in press a). Diet overlap was calculated by Horn's index (KREBS, 1989), which varies from 0, when diets are completely distinct (containing no food categories in common), to 1 when diets are identical with respect to proportional food category composition. Statistical evaluation of overlap followed ZARET & SMITH (1984). Although specimens of *H. littorale* (MOL, in press a) and *O. mossambicus* were not collected at the same locality and at the same point in time, the calculations of diet overlap provide a rough indication of the (lack of) similarity of the diets of both species.

RESULTS

Distribution and habitat

Oreochromis mossambicus occurs in the coastal plain, and is completely absent from the interior and the savanna belt (Fig. 1). Within the coastal plain it is especially abundant in the northern part, the young coastal plain. Most collection localities are located north of the 1000 mg Cl l^{-1} limit for fresh water (Fig. 1).

Table 1 shows physico-chemical characteristics of three types of water bodies in which *O. mossambicus* occurs. Brackish lagoons (e.g., the Bigi Pan) show large fluctuations in salinity, but Cl concentrations below 1000 mg l^{-1} were not found. The action of wind over large areas of open, shallow water results in high concentrations of suspended solids (silt). The phytoplankton is dominated by blue-green and green filamentous algae (Appendix 1).

In the oligohaline Boomskreek canal fluctuations in salinity followed the seasonal pattern of rainfall, although a tidal influence was also present. Upstream at Charlesburg road, Cl concentrations in the Boomskreek were well below 1000 mg l^{-1} (Tab. 1), but we expect much higher Cl levels downstream near the confluence with the Suriname river. The water was eutrophic with relatively high N and P concentrations, which may explain the large number of Euglenophyta in the phytoplankton samples (Appendix 1).

A third type of water body where healthy populations of *O. mossambicus* were found are shell-sand pits. These small lakes were created by man when

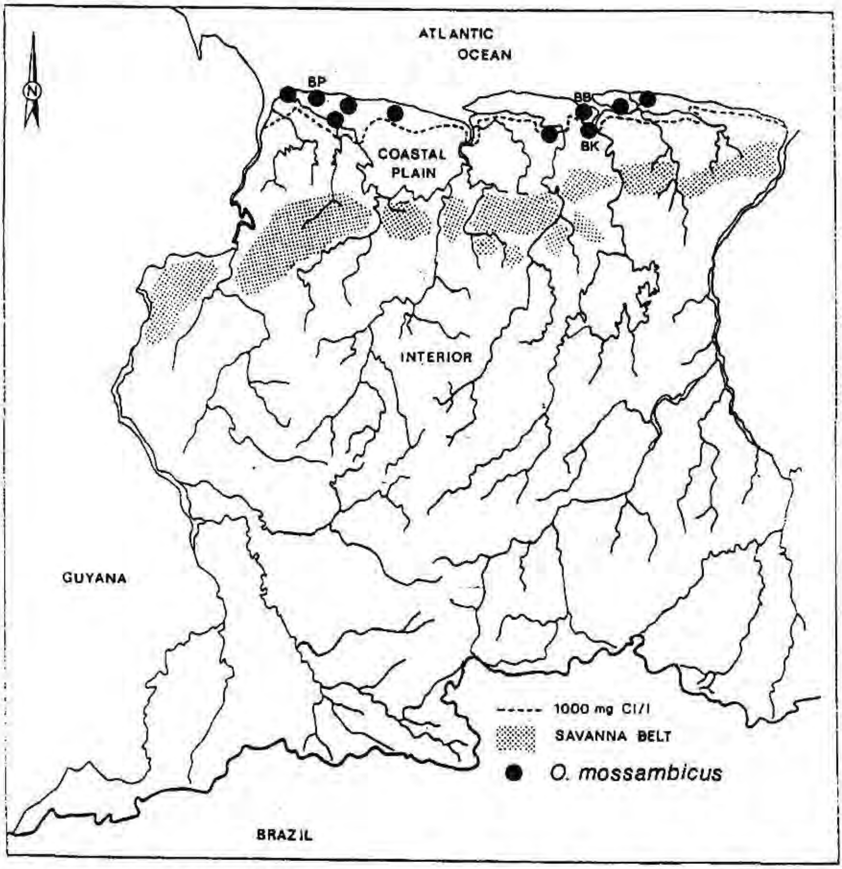

Figure 1. Distribution of *Oreochromis mossambicus* in Suriname. The 1000 mg Cl l^{-1} limit for fresh water is drawn after PONS (1964). BB = Bakboord shell-sand pit; BK = Boomskreek oligohaline canal; BP = Bigi Pan lagoon.

shell ridges were excavated for the winning of shell-sand. The lakes were deep (up to 6 m), and the water was transparent and rich in Ca and Mg (Tab. 1). The Cl concentration of the water was related to the distance of the lake to the ocean. The phytoplankton of the shell-sand pits was characterized by Euglenophyta and Scenedesmaceae, although filamentous algae were also present (e.g., *Oscillatoria*) (Appendix 1).

Diet composition and diet overlap

Dominant food items in the diet of adult *O. mossambicus* were blue-green algae (*Oscillatoria* sp.) and fine flocculent detritus, while Rotifera (*Brachionus* sp.) and microcrustacea (Cladocera and Copepoda) were important in the diet of larvae and juveniles (Tab. 2). When the stomach contents of *O. mossambicus* are compared to those of *H. littorale* (Tab. 3) it is especially the complete absence of Nematoda and Oligochaeta (note the low frequency of occurrence of seta, Tab. 2), larvae of aquatic insects (e.g., chironomid larvae), insects and fishes that draws attention.

Intraspecific diet overlap among larvae, juveniles and adults of *O. mossambicus* was high (0,844 on average) (Tab. 4). In fact pairwise diet overlap among ontogenetic stages of *O. mossambicus* did not differ significantly from 1, which means that these diets showed complete overlap. Within adult *O. mossambicus*, diets of specimens collected in the Boomskreek differed from diets of specimens of the Bakboord

Table 2. Composition of the diet of *Oreochromis mossambicus* in the coastal plain of Suriname. Frequency of occurrence (%) and mean volume (%) of stomach contents of larvae, juveniles and adults.

Food items	Larvae		Juveniles		Adults	
	freq	vol	freq	vol	freq	vol
Oscillatoria spec.	96,0	20,06	81,8	21,94	58,3	15,21
Closterium spec.	4,0	0,23	23,2	0,37	-	-
Euglenophyta	4,0	0,04	32,3	1,54	37,5	11,02
Bacillariophyceae	-	-	15,2	0,37	41,7	0,55
Difflugiids	-	-	17,2	0,07	25,0	0,05
Rotifera	100,0	7,50	80,8	21,53	54,2	2,44
Nematoda	4,0	0,17	17,2	0,32	33,3	0,15
Oligochaeta, seta	-	-	4,0	-	12,5	-
Cladocera	44,0	7,19	58,6	4,54	41,7	7,13
Copepoda	92,0	32,95	55,6	7,87	45,8	0,40
Ostracoda	4,0	0,45	3,0	0,15	20,8	0,15
Larvae of aquatic insects	-	-	6,1	0,73	8,3	0,15
Gastropoda	-	-	-	-	4,2	0,25
Seeds / flottoblasts	12,0	0,43	44,4	5,20	16,7	1,10
Fine flocculant detritus	84,0	29,66	77,8	22,21	75,0	38,50
Coarse vegetative detritus	-	-	19,2	1,04	58,3	7,98
Chitinous remains	-	-	3,0	0,37	29,2	0,55
Mud/Sand/Shells	32,0	1,31	73,7	11,89	37,5	13,37
TOTAL		99,99		100,14		99,00
No. of stomachs examined	25		99		24	
No. of empty stomachs	0		2		3	
Mean stomach fullness (%)	88		81		84	
Standard length range (mm)	7,5 - 8,8		10,5 - 47,4		69 - 180	

Table 3. Composition of the diet of *Hoplosternum littorale* in the coastal plain of Suriname. Frequency of occurence (%) and mean volume (%) of stomach contents of larvae, juveniles and adults in the rainy and dry season. Modified after MOL (in press a).

Food items	Larvae		Juveniles		Adults			
					rainy season		dry season	
	freq	vol	freq	vol	freq	vol	freq	vol
Filamentous algae	11,5	0,10	30,8	0,50	19,0	0,07	7,8	0,43
Chlorophyta	55,8	1,98	50,0	1,98	-	-	2,0	0,00
Euglenophyta	-	-	19,2	0,23	9,5	0,00	2,0	0,38
Bacillariophyceae	3,8	0,02	26,9	1,16	-	-	11,8	0,17
Difflugiids	44,2	1,19	48,1	1,29	-	-	7,8	0,17
Rotifera	94,2	21,16	67,3	8,02	4,8	0,00	13,7	0,47
Nematoda	9,6	0,78	44,2	2,30	47,6	0,81	35,3	2,67
Oligochaeta	9,6	1,75	23,1	1,42	14,3	0,14	17,6	0,96
Oligochaeta, seta	13,5	-	59,6	-	38,1	-	41,2	-
Hydracarina	-	-	7,7	0,06	9,5	0,27	2,0	0,00
Cladocera	96,2	68,89	84,6	33,59	57,1	22,04	37,2	12,59
Copepoda	15,4	2,26	75,0	5,72	42,8	0,77	37,2	6,36
Ostracoda	-	-	11,5	2,06	47,6	7,74	19,6	4,73
Palaemonetes carteri	-	-	-	-	4,8	0,02	2,0	0,64
Larvae of aquatic insects	-	-	78,8	14,95	71,4	25,31	45,1	15,24
Aquatic insects	-	-	-	-	14,3	0,68	29,4	2,47
Gastropoda	-	-	7,7	0,05	47,6	16,02	13,7	0,82
Terrestrial Arthropoda	-	-	23,1	0,92	19,0	1,36	21,6	1,24
Fish scales	-	-	19,2	0,36	4,8	0,00	27,4	3,02
Invertebrate cysts	1,9	0,05	36,5	3,21	4,8	0,09	7,8	0,00
Seeds/Spores/Flottoblasts	1,9	0,03	13,5	0,20	33,3	0,63	29,4	1,90
Coarse vegetative detritus	1,9	1,75	42,3	11,54	71,4	15,54	54,9	35,03
Chitinous remains	-	-	32,7	5,41	52,4	5,88	45,1	3,58
Vegetative plant matter	-	-	-	-	42,8	2,26	39,2	4,22
Sand	-	-	17,3	4,46	23,8	0,11	21,6	2,53
Other items	-	-	3,8	0,56	-	-	2,0	0,36
TOTAL		99,96		99,99		99,74		99,98
No. of stomachs examined		52		52		21		51
No. of empty stomachs		0		3		4		21
Mean stomach fullness (%)		77		70		53		46
Standard length range (mm)	5,6 - 7,0		13,5 - 81,4		86 - 152		86 - 158	

Table 4. Comparison of the diets of *Oreochromis mossambicus* and *Hoplosternum littorale* in Suriname using Horn's index of diet overlap. Values marked with an asterisk show complete overlap of diet ZARET & SMITH (1984) (Chi-square $X^2_{df, 0.05}$).

	Oreochromis mossambicus		Hoplosternum littorale		
	juveniles	adults	larvae	juveniles	adults
O. mossambicus					
larvae	0,8519 *	0,8039 *	0,7057	0,6007	0,3762
juveniles	-	0,8778 *	0,5477	0,5652	0,2893
adults	-	-	0,3368	0,4876	0,3136
H. littorale					
larvae	-	-	-	0,7736	0,5144
juveniles	-	-	-	-	0,7927 *
adults	-	-	-	-	-

shell-sand pit with respect to the proportion of fine detritus (90,2% and 12,5% respectively) and algae (4,6% and 50,0%).

Table 5 shows that while the ratio of mouth width to standard length did not differ significantly among larvae, juveniles and adults, ontogenetic differences in the intestinal ratio (intestine length / standard length) were highly significant (ANOVA, p<0,0001). The relation between intestine length (IL (mm)) and standard length (SL (mm)) may be expressed by the equation: IL = -84,8 + 8,5 SL (n=133; r=0,992; p<0,0001). The ontogenetic change in the intestinal ratio may be related to a need for a relatively large digestive surface in order to sustain a fish volume that changes proportionally to SL^3 with food items that are difficult to as similate, like blue-green algae (MORIARTY, 1973) and detritus (BOWEN, 1981, 1982).

Interspecific diet overlap between *O. mossambicus* and *H. littorale* was relatively high in larvae (0,706; Tab. 4), moderate in juveniles (0,565) and low in adults (0,314). Interspecific overlap among different developmental stages was moderate or low (Tab. 4).

Table 5. Selected morphological data (mean ± S. E.) on *Oreochromis mossambicus* in the coastal plain of Suriname. Ratio's were tested for normality; ANOVA was used to test for differences among developmental stages.

	Larvae	Juveniles	Adults	ANOVA	
	(n = 25)	(n = 99)	(n = 24)	F	P
Total Length (mm)	10,4 ± 0,08	26,5 ± 1,13	136,0 ± 7,49	-	-
Standard Length (mm)	7,9 ± 0,06	20,6 ± 0,89	108,1 ± 6,07	-	-
Fresh weight (mg)	10,7 ± 0,34	470,0 ± 59,2	47800 ± 9000	-	-
Mouth width (mm)	0,89 ± 0,019	2,37 ± 0,126	13,26 ± 0,897	311,0	< 0,0001
Mouth width / SL	0,11 ± 0,002	0,11 ± 0,002	0,12 ± 0,003	4,6	n. s.
Intestine length (mm)	11,1 ± 0,32	85,0 ± 6,99	863,8 ± 40,66	617,8	< 0,0001
Intestine length / SL	1,4 ± 0,04	3,4 ± 1,14	7,9 ± 0,12	196,4	< 0,0001

DISCUSSION

Distribution and habitat

O. mossambicus is an euryhaline species that is able to live and even reproduce in sea water up to 20.000 mg Cl l^{-1} (CHERVINSKI, 1982; PHILIPPART & RUWET, 1982). A map of the original distribution of *O. mossambicus* in Africa (PHILIPPART & RUWET, 1982; their Fig. 2b) shows that they occur in estuaries and lagoons along the coast of East Africa. In Suriname, *O. mossambicus* also seems restricted in its distribution to standing waters of the coastal plain (Fig. 1). RESIDA (1985) described large, dry-season mortalities of *O. mossambicus* in the Bigi Pan lagoon at salinities of 30.000 - 60.000 mg Cl l^{-1}.

The average salinity of the Bigi Pan lagoon changed from 20.000 mg Cl l^{-1} in 1982-1986 (Tab. 1) to approximately 2.000 mg Cl l^{-1} in 1992 (VAN DER LUGT, in prep). However, healthy populations of *O. mossambicus* were found in oligohaline canals and shell-sand pits at salinities as low as 200 mg Cl l^{-1} (Tab. 1). Consequently, it was not the change in the salinity of the Bigi Pan alone that caused the collapse of the Tilapia fisheries in the Bigi Pan area. At the time of decreasing salinities in the Bigi Pan we also observed a substantial ingrowth of aquatic macrophytes, a stagnation of water movements between different parts of the lagoon, an accumulation of humic substances, and, in general, a change in the physiognomy of the Bigi Pan from an open water lagoon towards a freshwater swamp (e.g., in August 1993 the colour of the water was black with pH 6,0). Recently, a small lagoon 15 km northwest of the Bigi Pan was found to be very productive with respect to Tilapia catches. Future investigations in this small lagoon may help us to explain the decline in catches at the Bigi Pan.

In Suriname, *O. mossambicus* is absent from large parts of the country. It is not only absent from black water creeks of the savanna belt and clear waters in the interior (OUBOTER & MOL, 1993), but also does not occur in swamps and freshwater canals of the coastal plain (MOL & OUBOTER, in prep). Thus, suitable sites for the culture of the Red Tilapia are probably restricted to a very narrow strip of land along the Atlantic coast. We think that a cage-culture of Red Tilapia in deep shell-sand pits may offer good commercial perspectives.

When the distribution of *O. mossambicus* in Suriname (Fig. 1) is compared with that of *H. littorale* (MOL, 1994; his Fig. 1) the overlap in geographical range is almost complete. Both *O. mossambicus* and *H. littorale* are rarely collected south of the 1.000 mg Cl l^{-1} limit for fresh water. However, within the coastal plain area *H. littorale* seems to prefer a very different habitat than *O. mossambicus*. *Hoplosternum littorale* is found in shallow swamps with a dense vegetation of macrophytes, while *O. mossambicus* was collected in shallow, open-water lagoons, deep canals (with floating vegetation), and deep lakes. Only in the dry season, when the swamps dry up and *H. littorale* retreats into deep canals (and dry season pools) is interaction between the species possible.

Diet

The importance of blue-green algae and fine, flocculent detritus in the diet of Tilapias of the genus *Oreochromis* is well-known after the classic studies of MORIARTY (1973) and BOWEN (1980, 1981). The extremely low pH of fluids in an actively digesting stomach (1,0-1,25) and the long intestine allow Tilapias to digest and assimilate these nutritional resources (BOWEN, 1982). Young juveniles ("larvae") of *O. mossambicus* (10,4 mm TL) already consumed large quantities of *Oscillatoria* and fine detritus. Few fish species in Suriname are able to feed as herbivores or detritivores, and in this respect *O. mossambicus* may be thought of as "filling a vacant niche" in coastal plain water bodies.

The moderate to low interspecific diet overlap between *O. mossambicus* and *H. littorale* indicates that competition for food is probably not strong, except possibly in larvae. However, larvae of both species are separated spatially, because *H. littorale* spawns in swamps (MOL, 1993, in press b) and *O. mossambicus* prefers open water spawning grounds (BRUTON & BOLTT, 1975). Adult *H. littorale* have a short intestine (intestinal ratio 1,4: MOL, in press a), with the larger posterior part structurally adapted to a respiratory function (HUEBNER & CHEE, 1978). MOL (in press a) argues that *H. littorale* is probably not able to assimilate detritus, but accidently consumes large amounts of detritus when foraging on benthic chironomid larvae and Oligochaeta.

Tilapia - Kwikwi interaction

Although the geographical distribution of *O. mossambicus* and *H. littorale* in Suriname largely coincides, strong interaction between the species seems unlikely at present. The two species do not share the same habitat for most of the time nor do they share the same food. Predation of *O. mossambicus* on *H. littorale* is probably also not important, since stomach contents analysis did not reveal fish in the diet of *O. mossambicus* (Tab. 2). Destruction of the (swamp) habitat of the Kwikwi by the Tilapia is hard to imagine because *O. mossambicus* does not feed on macrophytes (PULLIN & LOWE-McCONNELL, 1982).

Does the decline in the supply of Kwikwi reflect a bad condition of the stocks or does an increase in fishing activities by anglers and a growing rural population force professional fishermen to travel long distances and reduce their Catch Per Unit Effort? More people are fishing the Kwikwi and the catch per fisherman is often not large enough to make it worth selling the fish at the markets. More research is needed if we want to evaluate the potential problem of overfishing and the effect of modern agricultural activities on the habitat and stocks of the Kwikwi.

ACKNOWLEDGEMENTS

We thank Paul Ouboter and two anonymous referees for their comments on an earlier draft of the manuscript. We also thank Asha Haripersad-Makhanlal for her help with the identification of phytoplankton.

Literature cited

APHA-AWWA. 1976. *Standard Methods for the Examination of Water and WasteWater.* (14th ed.). American Public Health Association, Washington D.C., 1193 p.

BALON, E.K. 1985. The theory of saltatory ontogeny and life history models revisited. *In*: E.K. BALON. *Early Life Histories of Fishes. New Developmental, Ecological and Evolutionary Perspectives.* Dr.W.Junk Publishers, Dordrecht, The Netherlands, p13-30.

BOWEN, S.H. 1980. Detrital nonprotein amino acids are the key to rapid growth of Tilapia in Lake Valencia, Venezuela. *Science*, 207: 1216-1218.

BOWEN, S.H. 1981. Digestion and assimilation of periphytic detrital aggregate by *Tilapia mossambica. Transactions of the American Fisheries Society*, 110:239-245.

BOWEN, S.H. 1982. Feeding, digestion and growth: qualitative considerations. *In*: R.S.V. PULLIN; R.H. LOWE-McCONNELL (eds.). *The Biology and Culture of Tilapias.* ICLARM, Manila, p141-156.

BOWEN, S.H. 1983. Detritivory in neotropical fish communities. *Environmental Biology of Fishes*, 9: 137-144.

BRUTON, M.N.; BOLTT, R.E. 1975. Aspects of the biology of *Tilapia mossambica* Peters (Pisces: Cichlidae) in a natural freshwater lake (Lake Sibaya, South Africa). *Journal of Fish Biology*, 7: 423-446.

CHERVINSKI, J. 1982. Environmental physiology of Tilapias. *In*: R.S.V. PULLIN; R.H. LOWE-McCONNELL (eds.). *The Biology and Culture of Tilapias.* ICLARM, Manila: 119-128.

DESIKACHARY, T.V. 1959. *Cyanophyta.* Indian Council of Agricultural Research, New Delhi.

GRÖNBLAD, R. 1945. De algis brasiliensibus. *Acta Soc. Sci. Fenn*, B 2,6.

HARIPERSAD-MAKHANLAL, A.; OUBOTER, P.E. 1993. Limnology: physico-chemical parameters and phytoplankton. *In*: P.E. OUBOTER (ed.). *The Freshwater Ecosystems of Suriname.* Kluwer Academic Publishers, Dordrecht, The Netherlands, p53-75.

HUBER-PESTALOZZI, G. 1938/1961. Das Phytoplankton des Süsswassers. *In*: A. THIENEMANN (ed.). *Die Binnengewässer.* Vol. 16, Pts. 1-5. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart.

HUEBNER, E.; CHEE, G. 1978. Histological and ultrastructural specialization of the digestive tract of the intestinal air-breather *Hoplosternum thoracatum* (Teleost). *Journal of Morphology*, 157: 301-328.

HYSLOP, E.J. 1980. Stomach contents analysis: a review of methods and their application. *Journal of Fish Biology*, 17: 411-429.

KREBS, C.J. 1989. *Ecological Methodology.* Harper & Row, New York, 650 p.

LIJDING, H.W. 1958. Proeven met Tilapia in Suriname. (Experimental breeding of Tilapia in Suriname). *De Surinaamse Landbouw*, 6: 183-194. (in Dutch with English summary)

LOWE-McCONNELL, R.H. 1982. Tilapias in fish communities. *In*: R.S.V. PULLIN; R.H. LOWE-McCONNELL (eds.). *The Biology and Culture of Tilapias.* ICLARM, Manila: 83-117.

MOL, J.H. 1993. Structure and function of floating bubble nests of three armoured catfishes (Callichthyidae) in relation to the aquatic environment. *In*: P.E. OUBOTER (ed.). *The Freshwater Ecosystems of Suriname.* Kluwer Academic Publishers, Dordrecht, The Netherlands: 167-197.

MOL, J.H. 1994. Effects of salinity on distribution, growth and survival of three neotropical armoured catfishes (Siluriformes - Callichthyidae). *Journal of Fish Biology*, 45: 763-776.

MOL, J.H. in press a. Ontogenetic diet shifts and diet overlap among three closely related neotropical armoured catfishes. *Journal of Fish Biology.*

MOL, J.H. in press b. Reproductive seasonality and nest-site differentiation in three closely related armoured catfishes. *Environmental Biology of Fishes.*

MORIARTY, D.J.W. 1973. The physiology of digestion of blue-green algae in the cichlid fish *Tilapia nilotica. Journal of Zoology*, 171: 25-40.

MORIARTY, D.J.W.; MORIARTY, C.M. 1973. The assimilation of carbon from phytoplankton by two herbivorous fishes: *Tilapia nilotica and Haplochromis nigripinnis*. *Journal of Zoology*, 171: 41-56.

OUBOTER, P.E.; MOL, J.H. 1993. The fish fauna of Suriname. *In*: P.E. OUBOTER (ed.). *The Freshwater Ecosystems of Suriname*. Kluwer Academic Publishers, Dordrecht, The Netherlands: 133-154.

OUBOTER, P.E.; MOL, J.H. 1994. Ex-situ sustainable use of fish and wildlife in Suriname. *Interactie*, 2: 5-18.

PERK, E.I.M. 1986. *Verspreidingsgebied en Habitatpreferentie van Biomphalaria glabrata in Suriname*. Unpublished report Instituut Opleiding Leraren, Paramaribo, 27 p. (in Dutch).

PHILIPPART, J.Cl.; RUWET, J.Cl. 1982. Ecology and distribution of Tilapias. *In*: R.S.V. PULLIN; R.H. LOWE-McCONNELL (eds.). *The Biology and Culture of Tilapias*. ICLARM, Manila: 15-59.

PONS, L.J. 1964. *Report on a Preliminary Soil Salinity Map of the Young Coastal Plain of Suriname (1:500,000)*. Unpublished report Dienst Bodemkartering, Paramaribo, 14 p. (in Dutch with English summary).

PRESCOTT, G.W. 1962. *Algae of the Western Great Lakes Area*. Cranbook Institute of Science, Bulletin 31.

PULLIN, R.S.V.; LOWE-McCONNELL, R.H. (eds.) 1982. *The Biology and Culture of Tilapias*. ICLARM Conference proceedings 7. International Center for Living Aquatic Resources Management, Manila, 432 p.

RESIDA, D. 1985. *Studie van de Waterhuishouding, de Waterkwaliteit en de Visstand in het Bigi Pan Gebied*. Unpublished report Instituut Opleiding Leraren, Paramaribo, 206 p. (in Dutch)

SIOLI, H. 1950. Das Wasser im Amazonasgebiet. *Forschung und Fortschritt*, 26:274-280.

VAN DER STEEGE, J.G. 1991. *The Water quality of the Water from the Bigi Pan Area (Nickerie District) in Suriname (1983-1986)*. Unpublished report Dienst Lands Bosbeheer, Paramaribo, 211 p. (in Dutch with English summary).

WARD, H.W.; WHIPPLE, G.C. 1959. *Freshwater Biology*. Wiley, New York, 1248 p.

ZARET, T.M.; SMITH, E.P. 1984. On measuring niches and not measuring them. *In*: T.M. ZARET (ed.). *Evolutionary Ecology of Neotropical Freshwater Fishes*. Dr.Junk Publishers, The Hague, The Netherlands: 127-137.

Aceito para publicão em 02.08.95

Appendix 1. Phytoplankton of selected *Oreochrimis mossambicus* water bodies in the coastal plain of Suriname. Filamentous algae are marked with an asterisk.

Species	Brackish lagoons	Oligohaline canals	Shell-sand pits
CYANOPHYTA			
Agmenellum (= Merismopedia) spec.	X		
Anabaena ambigua *	X		
Anabaenopsis raciborskii *			X
Anacystis (= Aphanocapsa) spec.	X		
Anacystis (Microcystis) aeruginosa			X
Beggiatoa alba		X	
Calothrix marchica *	X		
Lyngbia martenciana *	X		
Lyngbia spec. *	X		
Lyngbia spirulina *	X		
Oscillatoria laete-virens *			X
Oscillatoria limnetica *	X		X
Oscillatoria spec. *	X	X	
Raphidiopsis curvata *			X
Raphidiopsis mediterranea *			X
Spirulina gigantia *	X		
Spirulina spec. *	X		
RHODOPHYTA			
Camposopogan coeruleus *	X		
EUGLENOPHYTA			
Astasia klebsii		X	
Colacium spec		X	
Euglena acus		X	X
Euglena caudata			X
Euglena oxyuris		X	
Euglena tuberculata			X
Euglena spec.			X
Lepocinclis fusiformis		X	
Lepocinclis lefevrei			X
Lepocinclis ovum var angulata		X	
Lepocinclis salina		X	X
Phacus acuminatus		X	X
Phacus angulatus		X	
Phacus longicauda			X
Phacus orbicularis		X	
Phacus platalea			X
Phacus stokesii		X	
Phacus tortus			X
Strombomonas ensifera			X
Strombomonas urceolata			X
Strombomonas verrucosa			X

cont. Appendix 1.

Trachelomonas volvocina		X	X
Trachelomonas spec.		X	X
CHLOROPHYTA (SCENEDESMACEAE)			
Actinastrum hantzschii		X	X
Crucigenia quadrata			X
Crucigenia rectangularis		X	
Crucigenia tetrapedia		X	X
Scenedesmus armatus			X
Scenedesmus bijuga			X
Scenedesmus dimorphus			X
Scenedesmus ecornis			X
Scenedesmus falcatus			X
Scenedesmus quadrata			X
Scenedesmus quadricauda		X	X
Scenedesmus spec.		X	
Tetrastrum heterocanthum		X	X
CHLOROPHYTA			
Cladophora fracta *	X		
Cladophora spec. *	X		
Closterium spec.			X
Dictyosphaerium pulchellum			X
Enteromorpha spec. *	X		
Pediastrum tetras			X
Pyrobotrys gracilis		X	
Rhizoclonium gigantea *	X		
Spirogyra spec. *	X		
Staurastrum americanum	X		
Tetraedron gracile			X
Tetraedron trigonum		X	X
Ulothrix cylindricum *	X		
Ulothrix spec. *	X		
BACILLARIOPHYCEAE(=DIATOMAE)			
Cyclotella spec.		X	
Eunotia spec.			X
Gomphonema augur		X	X
Gyrosigma spec.	X		
Melosira spec.	X		
Nitzschia acicularis			X
Nitzschia obtusa		X	
Nitzschia spec.	X	X	X
Pinnularia gibba			X
Pinnularia spec.		X	
Pleurosigma epec.	X		