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THE BIOLOGY, FISHERY AND POTENTIAL FOR AQUACULTURE OF *TILAPIA MELANOTHERON* IN A SMALL WEST AFRICAN LAGOON

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ABSTRACT

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(1) The biology, especially the food and feeding habits of the cichlid fish *Tilapia melanotheron* Rüppel 1852 in a small West African lagoon is analysed. The food consists of bottom mud, which has an organic content of 30% and a calorific content of 1.2 Kcal/g. The daily food intake per fish weighing 20 g (fresh weight) was estimated to be 1.5 g (dry weight) and the calorific assimilation a minimum of 900 cal/day. Reproduction seemed to occur throughout the whole year, parasitism was low, due to varying salinity of the lagoon.

(2) The small artisanal lagoon fishery produces about 150 kg fish per ha per year, with a fish catch per unit of effort of up to 1 kg/man-h. The fishing intensity was 70 man-h/km^2. Gill nets, seines and cast nets are used and over 90% of the catch consisted of *T. melanotheron*.

(3) Three alternative methods to increase the quantity of the fish caught in the lagoon are briefly discussed: (a) setting up of an "acadja" fishery; (b) stocking with juvenile *T. melanotheron*; (c) stocking with *Mugil* spp. fry (*Tilapia/Mugil* polyculture). The availability of *Mugil* spp. fry along the coast makes the latter alternative look like the most promising one, being the cheapest and easiest to implement on a large scale.

INTRODUCTION

Today, no review on fishes used in tropical aquaculture is complete without mention of the genus *Tilapia*. It appears, however, that most of this literature deals with a few now ubiquitous *Tilapia* species without giving much attention to species with more limited distributions. Such species should be considered for aquacultural purposes and adequately investigated since they might easily be cultured in the biotope to which they are especially adapted.

The present work deals with the substrate feeder *Tilapia melanotheron*, a fish highly adapted to the extreme biotope of poikilohaline "closed" lagoons (Boughey 1957), occurring along the West African coast. Emphasis is given in the first part of this paper to its food and feeding habits — as compared with another well-investigated substrate feeder, *Mugil cephalus*. In the second part, the small but intensive artisanal lagoon fishery of *T. melanotheron* is described. The third part discusses the data with respect to the possibility of implementing an aquaculture scheme in Ghanaian or other West African closed lagoons.

Synonymy: *Sarotherodon melanotheron* (Rüppel 1852), *Tilapia heudelotii* Duméril 1859, *Chromis microcephalus* (Günther 1862), *Chromis macrocephalus* (Günther 1862), *Melanogenes microcephalus* (Bleeker 1863), *Melanogenes macrocephalus* (Bleeker 1863), *Chromis niloticus* (Steindachner 1869).

The present name, *Tilapia melanotheron* (Rüppel 1852) has been proposed by Van den Audenaerde (1968), in his revision of the genus *Tilapia*. The re-elevation of the sub-genus *Sarotherodon* to generic rank has been proposed by Trewavas (1973) but will not be followed here since repeated changes of name of widely known fishes is not considered helpful.

Within the sub-genus *Sarotherodon*, the species *T. melanotheron* (Fig. 1)

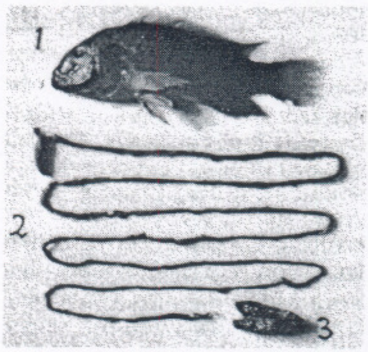

Fig. 1. (1) *Tilapia melanotheron*. (2) Outstretched gut of a 10.5-cm *T. melanotheron* (total length). (3) Ovaries of a 10.5-cm *T. melanotheron*. (Photograph J. Schwedes.)

is closely related to at least three other species: *T. heudelotii* Duméril 1859, *T. leonensis* Van den Audenaerde 1971, and *T. nigrippinis* Guichenot 1859.

Distribution: *T. heudelotii* — Brackish water and lagoons, Senegal to Sierra Leone.
T. leonensis — Brackish water and lagoons, Sierra Leone to Liberia.
T. melanotheron — Brackish water and lagoons, Ivory Coast to Cameroon.
T. nigrippinis — Brackish water and lagoons, Rio Muni to mouth of Congo.

In the genus *Tilapia*, only those species belonging to the sub-genus *Sarotherodon* are male mouth-breeders, the rest (70—100 spp.) is composed mostly of female mouthbreeders (e.g. *T. mossambica*). There is one sp. in which both sexes mouth-brood (*T. galilaea*), and four to ten spp. which are substrate-spawners (e.g. *T. tholloni*) (Lowe-McConnel, 1959; Peters, 1965; Van den Audenaerde, 1968, 1970, 1971, personal communication, 1974). Male mouth-brooding behaviour and the complex reproductive behaviour of

T. melanotheron have been thoroughly investigated (Aronson, 1949, 1951), but the first valuable information on the ecology, especially on the food, of *T. melanotheron* has been published only recently (Fagade, 1971).

T. melanotheron occurs both in lagoons which are open and closed to the sea. In open lagoons, it mainly occurs in association with *T. guineensis* (Van den Audenaerde, 1966; Fagade, 1971). In closed lagoons, however, it is the only *Tilapia* species present. There it acclimates itself to the frequently occuring hyperhaline conditions and to the reduced variety of food present there.
In this biotope it forms the major part of the fish biomass. The following aspects of its biology will be considered here: food and feeding habits of the adults; food of the larvae and juveniles; reproduction in the Sakumo Lagoon; parasitism.

The Sakumo Lagoon where this study was made is situated on the Ghanaian Coast, about 20 km east of Accra. It is fed during the rainy period by a few temporary rivers, has a surface area of $1 km^2$ an average depth of about 50 cm, and is connected to the sea at high tides through two pipes laid under the coastal sand bar. An account of the ecology of the lagoon in which the investigation was conducted has been published elsewhere (Pauly, 1975). The yearly salinity and temperature cycles are given in Fig. 2.

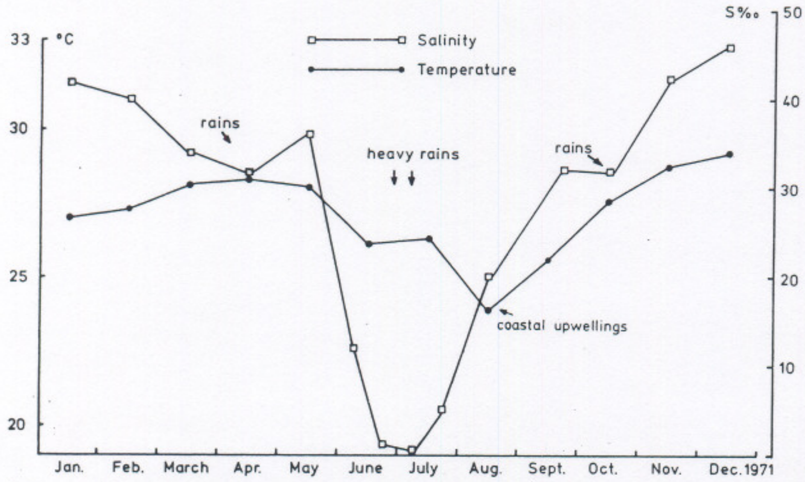

Fig. 2. Temperature and salinity cycle for 1971. Data: Fishery Research Unit, Tema, and D. Pauly.

Materials and Methods

A total of 1 605 *T. melanotheron* were examined. Samples were taken from the end of August to the beginning of December 1971, mainly by fisherman netting them for the author. The fishing gear and methods are described below. All fish were immediately killed, 1—2 ml of buffered 4% formaldehyde was injected into the visceral cavity for preservation of the stomach contents, and the fish were stored in plastic jars in 4% formaldehyde. Later, each fish was measured to the nearest g, and the individual condition factor (*Cf*) (Weatherley, 1972) was determined according to the formula:

$$Cf = \frac{W\,100}{L^3}$$

W being the eviscerated weight in g and *L* the total length in cm. The stomach content being a "bouillie indéfinissable" (indefinable pap) (Cadenat, 1957), strictly quantitative methods were used. Comparisons between stomach and hindgut contents (last 3 cm) are based on samples taken from the same fishes.

(a) *Gravimetric method.* — The method is an adaption of the "seston method" as described by Lenz (1971). The stomach contents are added to distilled water and filtered through pre-weighed glass fiber microfilter. The solid and filter are then oven-dried (60°C for 6 h) and weighed to the nearest 0.01 mg. The organic content of the stomach contents is defined as the weight loss of the dry stomach contents after being burned for 6 h at 520°C (see also Odum, 1970).

(b) *Size grading of particles by filtration.* — A battery of six filters with plankton netting of mesh size 20, 55, 100, 200, 300 and 500 μ was used for the analysis of the stomach contents and of sediment samples originating from the bottom of the lagoon which had been kept in 4% formaldehyde. The samples, generally ten stomach contents each , were added to 2—3 l distilled water and gently pumped through the filter battery. The weights of the six fractions were then determined by the seston method.

(c) *Calorimetry.* — The method described by Von Bröckel (1972) was adapted for fish food analysis. The various steps are: deposition of the sample (a few m dry weight) on a pre-weighed nitroacetate microfilter by means of filtration, drying and weighing (see seston method); then burning both the sample and the filter in a microbomb calorimeter. The burning filter releases enough heat to ignite the sample. The calorific content of the sample can then be calculated by recording the heat released and by calibrating with a substance of known calorific content, such as benzoic acid.

Since all the samples had been preserved in formaldehyde, there is a slight loss of calories from the samples to the preservative. For lack of reliable references, however, a correction factor can not be given. It is hoped that further work will close this gap.

To investigate the daily feeding rhythms, and the speed of food transport through the gut, 15 samples of about 15 fish each were removed from catches made during a night-time (September 15—16th) and a day-time (November

10th) 12-h fishing session (see below). The guts of 224 fishes were stretched out, measured, the dark and bright sections were defined respectively as "full" and "empty", and their position along the outstretched gut was measured to the nearest cm. Within one sample of 15 fish, the gut with the most "full" and "empty" sections was chosen for comparison (e.g. full, empty, full= 20 cm, 15 cm, 30 cm). Those guts not showing the same sequence (e.g. only: full, empty = 35cm, 28 cm) were made comparable by giving "missing" sections the value 0 cm (e.g. here: 0 cm, 35 cm, 28 cm). These values could then be averaged for the whole sample (Fig. 5). The last 2 cm were not considered because the fish defecated while being caught and handled. The intestinal ratio (gut length/standard length) was determined. The dry weight of the gut content was obtained by cutting the gut of ten fishes into small pieces, washing them over a 500 μ sieve, and drying and weighing the ingested mud. Forty stomach contents were checked microscopically. All the fish used for the food analysis measured 10.0—10.9 cm total length. Additionally, the gut content of 20 larvae and juveniles caught with a hand net in shallow parts of the lagoon in November were also analysed microscopically.

All fish were checked for metazoan parasites, especially in the buccal cavity.

Results

The food and feeding habits of the adults

T. melanotheron feeds on the fine fraction of the bottom mud, a fact best illustrated by comparing the particle sizes of the stomach contents and those of the mud samples (Fig. 3). Microscopic examination reveals a similarity of structure for both types of samples. Both contain mud grains of 50—100 μ in diameter, enriched with pennate diatoms and organic detritus. The sand fraction in the stomach is insignificant.

The organic and calorific content of the ingested mud over a period of 3 months is given in Fig. 4. The slight variations of both parameters throughout

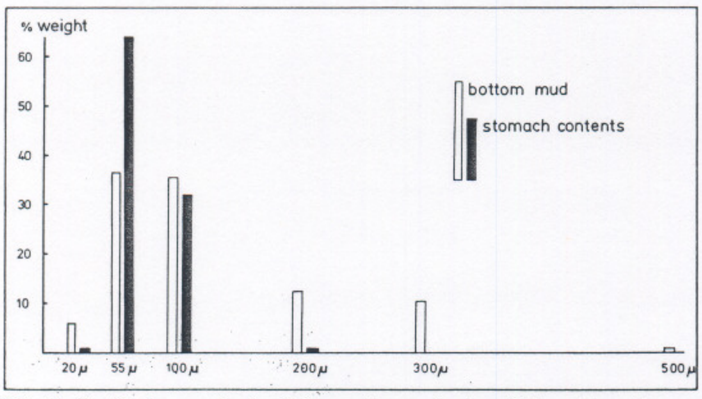

Fig. 3. Grain size analysis of stomach contents of *T. melanotheron* and of bottom mud samples from Sakumo Lagoon.

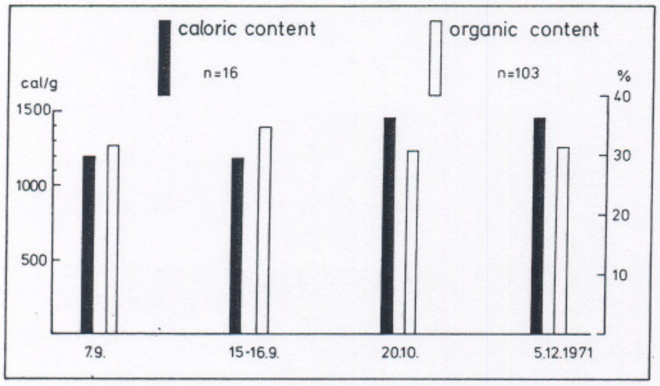

Fig. 4. Calorific and organic stomach contents over the period of investigation.

this period do not reflect any long-term trends, therefore, by extrapolation, the food available to *T. melanotheron* is assumed to be sufficient for the whole year (see also Odum, 1970). The daily cycle of food intake is given in Table I and Fig. 5; the feeding pause and its reappearance along the guts have been

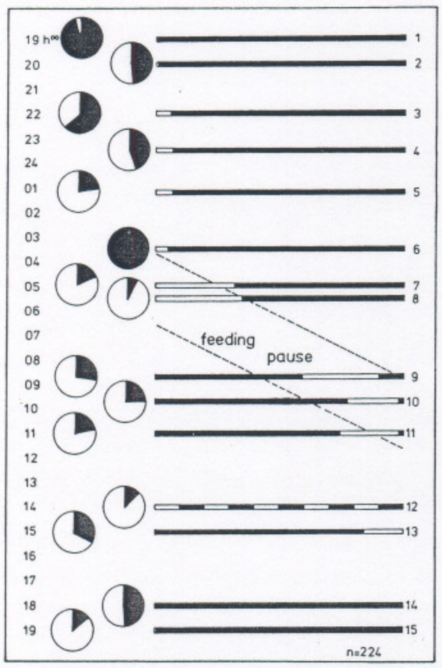

Fig. 5. Daily rhythm of food intake by *T. melanotheron* from left to right (cf also Table I): — time of fixation of the fishes - - circles: stomach contents as related to the sample with the highest mean stomach content (No. 6) — bars: outstretched guts, with sequence of full and empty sections — sample number. Sample 12 was fixed 1 h after the catch, no dominant sequence occurred.

TABLE I

Stomach contents of 224 *T. melanotheron*

Sample number	Time of fixation	Mean dry weight stomach contents (mg)	Stomachs containing food (%)	
1	19.00 h	32.8	100	heavy nocturnal feeding
2	20.00 h	15.8	85	
3	22.00 h	21.4	85	
4	23.30 h	15.0	75	
5	01.15 h	7.5	40	
6	03.30 h	34.6	90	
7	05.00 h	6.9	25	feeding pause
8	05.30 h	3.3	20	
9	08.40 h	10.0	100	intermittent day-time feeding
10	09.45 h	8.5	100	
11	11.00 h	6.9	85	
12	14.00 h	5.3	40	
13	15.15 h	11.9	100	
14	18.00 h	16.8	85	
15	19.00 h	5.8	75	

fitted graphically. The appearance of empty sections along the guts, their "transport" and later disappearance allow one to estimate that the passage of food through the guts occurs in about 7 h. The periodicity of feeding, then, is: nocturnal heavy feeding; feeding pause near sunrise; intermittent feeding during daylight. A fresh fish of 20 g contains an average of 0.5 g (dry weight) of ingested mud.

After having passed through the guts, which are extremely long (Fig. 1, Table II), the ingested mud has an average calorific content of 55% per unit of

TABLE II

A comparison of *T. melanotheron* with *M. cephalus.* Data for *Mugil cephalus,* Odum (1970)

	Tilapia melanotheron	*Mugil cephalus*
Adult food	Bottom mud	Bottom mud
Feeding behaviour	Picking up and swallowing "bites" (No gill-rakers)	Skimming surfaces, filtrating (gill-rakers present)
Concentration rate of selected food fraction	1—2 : 1	100 : 1
Intestinal ratio	7.1 (at 8 cm standard length)	3.0 (at 8 cm standard length)
Rate of food passage through the gut	3 × per day	5 × per day

dry weight lower than in the stomach. This does not exactly reflect the digestion rate, but combined with the total daily food intake and the mean calorific content of the ingested food, it gives the lowest value for estimating the calorific assimilation by each fish, namely $3 \cdot 0.5 \cdot 1\,200 \cdot 0.5 = 900$, 3 being the number of times gut contents pass through the gut per day (Fig. 5, Table I), 0.5 the weight of the food in the fish in g, 1 200 the calorific content of the food in cal/g, and 0.5 the "digestion rate"*. The resultant 900 cal/day represents a rough estimate of the lower limit of the daily food assimilation by *T. melanotheron* of 20 g, and 10.5 cm in total length. Table II summarizes the results, in comparison to the well-investigated *Mugil cephalus.*

Food of the larvae and juveniles

Table III summarizes the results of the food analysis of larvae and juveniles.

TABLE III

Food of *T. melanotheron* larvae and juveniles in the Sakumo Lagoon

Total length	2.5 cm	4.0 cm	4.0
Main food items	Harpactoid (copepods) (adults, copepodits, nauplii)	Phytoplankton, detritus	Adult food
Other food items	Phytoplankton, benthic diatoms, miscellaneous zooplankton	Benthic diatoms, copepods	

The food items have been roughly arranged according to their respective surface area on mounted microscopic slides. These results correspond well with the results obtained experimentally by Le Roux (1956) who worked with the young of four herbivorous *Tilapia* species, which preferred zooplankton when larvae, took any offered food when juvenile, and then passed gradually to the adult food.

Reproduction

Various workers report on the high salinity tolerance of *Tilapia* spp., stressing especially their ability to reproduce under euryhaline conditions (Bayoumi, 1969; Chervinsky and Hering, 1973). Field observations on this

* Although the calorific content of the faeces is known, the weight of faeces produced daily is not. The value of 900 cal/day implies that the weight of faeces equals that of the ingested food. This is not the case, more calories must be assimilated daily. Similarly, the upper limit for calorific assimilation equals the total calorific uptake assuming that no faeces are produced. Both limits are equally unattainable; the real value must, however, be nearer to the lower limit, because the inorganic, hence indigestible, content of the food is very high. (Fig. 4).

subject, however, are rather scarce. The present investigation also does not investigate this matter thoroughly; only a few observations are reported:

- The sex ratio in all samples was 50 : 50.
- All samples, from August to December contained at least a few ripe males and females.
- Small schools of *T. melanotheron* larvae and juveniles were seen in shallow areas of the lagoon throughout the whole period of investigation.
- Most samples contained a few males with eggs or larvae in their mouth or stomachs. Since eggs and larvae were often lost or swallowed when the brooding male was caught, the ratio of brooding males to non-brooders is not given.

The eggs or larvae found in the stomachs of males were always fresh, never semi-digested, and the digestive tracts were otherwise empty; females never had eggs or larvae in their stomach. It is therefore assumed that cannibalism, as observed by Aronson (1949) in aquaria is not the cause for the presence of eggs, and especially of larvae, in the stomach of male *T. melanotheron*. It seems that the fish spit out or swallow their eggs or larvae as they are caught. In a freshwater aquarium, *T. melanotheron* spawns the year round, with a strong peak in March—April and a weaker one in September—October (Aronson, 1951). This fits the rainfall in West Africa.

Parasites

(1) The copepod *Paenodes lagunaris* (Van Banning, 1974) which is found buried deeply in the soft tissues of the mouth of the host is the most common parasite of *T. melanotheron* in the Sakumo Lagoon. Infestation intensity and infestation rate were not constant over the period of investigation. There was a remarkable decrease of both infestation rate and intensity with increasing salinity which may be explained by a limnic origin of the parasite which infests the host during the rainy period. The males were infested at a rate and with an intensity significantly higher than the females (Pauly, 1974). This is probably related to the physiological condition of the mouth-brooding males, which spend up to 2 weeks (H.M. Peters, personal communication, 1974) without food and which grow visibly leaner than the non-brooding males and than females (Daget and Iltis, 1967). It was not possible, however, to detect by statistical analysis any effect caused by the infestation on the condition factors even in the most heavily infested fishes*.

(2) Six *T. melanotheron* out of 1 605 fishes were infested with the trematode *Clinostomum tilapiae* Ukoli 1966. Three fishes had two to five worms attached to the roof of their buccal cavities, the other three were more heavily infested, with up to 30 trematodes encysted behind the eye sockets and under the cranial case. The infestation rate of less than 0.4% contrasts sharply with the 37.5% recorded by Ukoli (1966) in the same host, at the (freshwater)

*Chauvin (1964) mentions that mouth-brooding cichlids tend to swim more slowly than when not brooding. This could well account for the higher infestation rate of *P. lagunaris* in male *T. melanotheron*.

Agricultural Research Farm in Ningua, Ghana (Ukoli, 1966). The final hosts of the trematode are piscivorous birds.

(3) Seven *T. melanotheron* had white spots on the inside surface of their lower jaws; the spots were identified as sporozoon (H. Möller, personal communication, 1974).

Discussion

The "selection" by *T. melanotheron* and by related spp. of closed lagoon biotopes can be explained best by their substrate-feeding habit. Bottom mud, enriched with detritus, has been reported to be the sole source of food of fish (Odum, 1970), crustaceans (Quasim, 1970) and gastropods (Newell, 1965). In West Africa, because of the structure of the coast, temporary and permanent rivers generally flow into lagoons before they reach the sea. It is in the lagoons that most of the fine mud is deposited. Any fish making use of this lagoon substrate must tolerate rapid changes of salinity, caused by tides in open lagoons (Hill and Webb, 1958) or by dilution and evaporation to hypersalinity in closed lagoons (Pople, 1962). The genus *Tilapia* which occurs mainly in fresh water seems to have marine ancestors (Myers, 1938; Steinitz, 1953) and still is undergoing speciation (Lowe-McConnell, 1959). So it does not seem surprising to find a few species "returning" to the sea and able to tolerate salinities up to 72‰, as in the Ghanaian Kpeshie Lagoon (Pople, 1962). The decreasing infestation rates and intensities of the parasites *Paeonodes lagunaris* and *Clinostomum tilapiae* during periods or at places of increased salinity reflects the adaptive lag between parasite and host that often accompanies parasitism.

Even in the Lagos Lagoon, which has a highly diversified fauna, *T. melanotheron* feeds mainly on bottom mud (Fagade, 1971). In an almost closed lagoon, such as the Sakumo Lagoon, this fish has no relevant vertebrate food competitor and has a food supply that is renewed during each rainy season and constantly enriched by seston deposition as well as by the microphytobenthos. Young *T. melanotheron* are not often preyed upon because they live in very shallow water areas. Fagade and Olaniyan (1973) did not find any predator of *T. melanotheron* fry in the Lagos Lagoon, which has a diversified fauna. The production of *T. melanotheron* in the Sakumo Lagoon is, however, quite low and, it is therefore suggested that it is larval food which represents the limiting factor. The shallowness of the lagoon and its rapidly changing salinities argues against the development of dense zooplankton populations outside the rainy season.

FISHERY IN THE SAKUMO LAGOON

Fishery in the Sakumo Lagoon is purely artisanal. The main gear is cast nets and 70 to 100-m long nets that are used either as beach seines or gill nets. No boats are used in the lagoon. There is a 6 day-week, which is strictly respected and a close season for 4 months, beginning at the end of December.

Methods

During the period of investigation, samples were taken about every second day. There were many opportunities to observe the fishermen at work, across the whole lagoon. The catches made by the fishermen could be checked at any time and they were often weighed. Two quantitative fishing sessions were organized; one in September with five young fishermen, the other in November with four fishermen. They were to fish in their usual way and at their usual places. They used a gill net of about 100 m length and 1 m depth (mesh size knot to knot 3.4 cm), which was shot in an arc in several central parts of the lagoon area. Eight hauls were made from 18.00 h on the 15th to 06.00 h on the 16th of September, and seven hauls on the 10th of November from 08.00 h to 19.00 h.

Results

Fishing effort. — Fig. 6 shows the mean number of fishermen working each

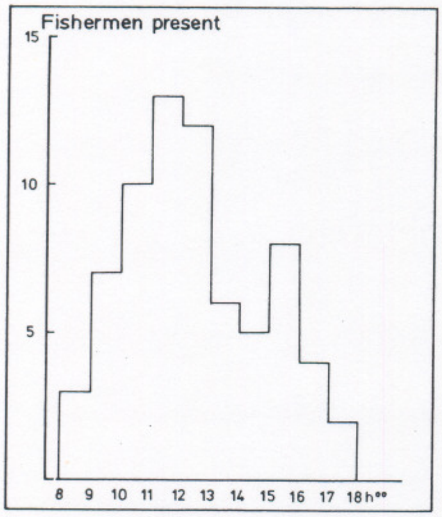

Fig. 6. Mean daily fishing effort in Sakumo Lagoon (August to December 1971).

day, counted over the period of the investigation. Each fisherman fished for about 3--4 hours. The catch per unit effort (see below) with the different gear was similar, therefore all fishing effort can be given in "man-h/day". The fishing effort was 70 man-h/day and the fishing intensity was 70 man-h/day/km^2.

Catch, catch per unit effort and gear selectivity. — For the two "quantitative fishing sessions", the average catch per unit effort was 0.9 kg/man/h in September, and 0.6 kg in November. This, combined with the mean fishing intensity, gives 63 kg and 42 kg, respectively, taken out of the lagoon every day. A mean of about 50 kg/day for the whole lagoon corresponds well to estimates based on weighing one fisherman's individual catch and multiplying it by the number of fishermen present. These estimates also oscillated around 50 kg/day, with a decreasing trend from August to December.

Considering the 4-month investigation time of mid-August to mid-December, and fish being caught 6 days per week, we obtain a catch of about 50 kg/ha in 4 months (100 days at 50 kg = 5 000 kg). It is possible that the fishery can compensate for its closure during 4 months with doubled catches during the rainy period (April—May to August). If so, the *T. melanotheron* fishery in the Sakumo Lagoon would produce a maximum of 150 kg/ha/year (fish other than *T. melanotheron* are not considered separately, since they contributed to less than 7% of the total catch).

The catch per unit effort of one fisherman using a cast net could reach 1 kg/man/h, but it was mostly small fish that were caught. The other fishermen set up teams of two to five people and used their nets as described above, as gill nets, or less often as beach seines. The analysis of the condition factor of *T. melanotheron* caught by gill-netting reveals the selectivity of this gear (Fig. 7). In cases of gear selectivity, condition factors cannot be used as an indicator of the average physiological situation of the fish in a certain stock. (Nikolskii, 1972).

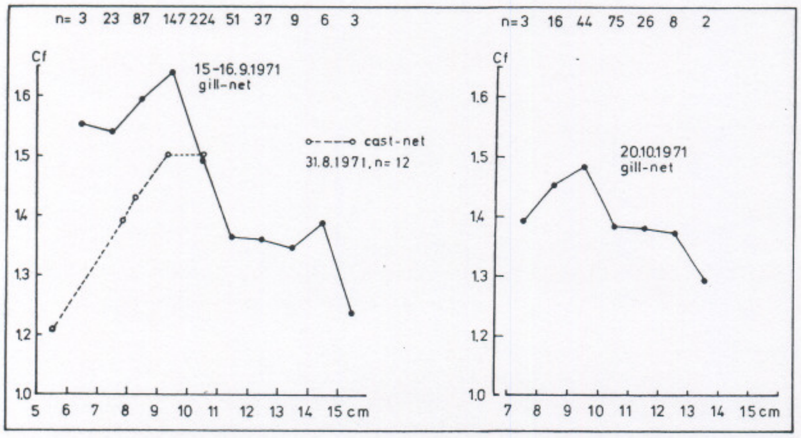

Fig. 7. Selectivity of a gill net, as reflected by the condition factor (*Cf*) of *T. melanotheron* of different size (total length).

Size composition of the catch. — Fig. 8 gives the size composition of the combined catches of the two 12-h fishing sessions. Of a total of 1 605 measured *T. melanotheron*, only one, caught in September, was above 19 cm (total length); the rest were smaller than 15 cm. *T. melanotheron* is never over "6 inches" in the Niger Delta (Pillay, 1965). Daget and Iltis (1965) report a maximum length of 25 cm (total length) for the Ivory Coast. Fagade (1973) who developed a method to age this fish, reports a length of 21.1—24.5 cm for fish 5 years old in the Lagos Lagoon. An attempt was made to age the

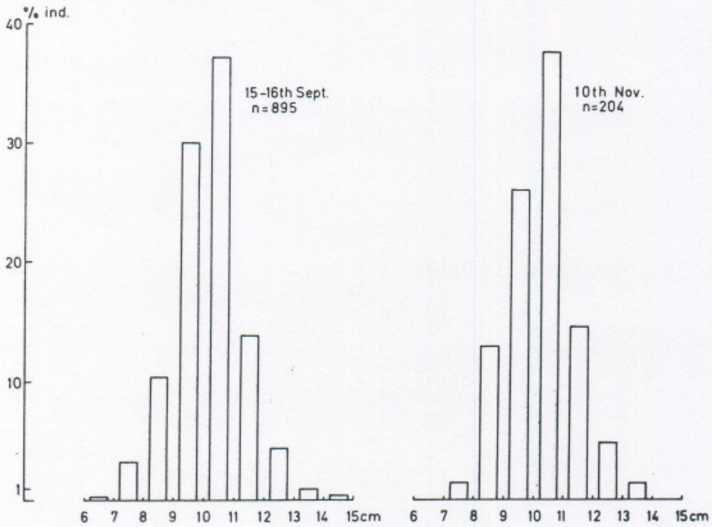

Fig. 8. Size composition of the *T. melanotheron* catches.

fish using this method. The results are not conclusive; neither "complete" nor "incomplete" rings were found on the opercular bones of the fish. It can therefore not definitely be said whether the *T. melanotheron* population in the Sakumo Lagoon is a "stunted" one, as occurs commonly in the genus *Tilapia*, or whether the stock was so heavily exploited that it consisted only of relatively young fishes. The latter seems more likely.

Economics of the fishery. — The main part of the day's catch — made during the morning (Fig. 6) — was immediatly sold on the Accra–Tema road. 4 kg of *T. melanotheron* were sold during August–December 1971 for about US$ 1. This was more than the minimum legal daily wage in 1971 (Jensen, 1972). The afternoon catch (second peak on Fig. 6) was mainly for subsistence.

THE POTENTIAL OF *T. MELANOTHERON* FOR AQUACULTURE

There have been at least two attempts to cultivate *T. melanotheron* in brackishwater ponds (McLaren, 1949; Smith, in Pillay 1965). The reports on these experiments could not be obtained. The experiments seem to have been abandoned for lack of a market for this relatively small fish and the availability of better-suited species in the investigated area (Pillay, 1965).

Three alternative possibilities of increasing the overall fish yield of a lagoon similar to the one investigated can be proposed here, as deduced from the present study and from published data.

(a) *Setting up an "acadja" fishery.* — This type of fishery, as described by Welcomme (1972), actually represents a form of aquaculture. It consists of "dense masses of branches planted at the bottom" (of the lagoon) which attract the fish from the surrounding area, and in which they breed. The fish in these "fish parks" are then caught at intervals of up to several months. These installations can contribute to increase the yield of a lagoon by up to 1 800 kg/ha (Lemasson, 1961), over 70% of which would be *T. melanotheron*. The main problem with this type of aquaculture seems to be the regular supply of an enormous number of branches to be planted into the lagoon bottom for setting up and maintaining the installations (Welcomme, 1972).

(b) *Stocking with juvenile T. melanotheron.* — Any use of this method implies that a prior investigation be conducted which would confirm that it is indeed the recruitment of *T. melanotheron* which limits the overall production in the investigated and in similar lagoons. This solution, as well as the one mentioned above, seems to be too costly and sophisticated to be implemented in more than a few lagoons.

(c) *Tilapia/Mugil polyculture.* — It was observed that large quantities of juvenile *Mugil* spp. were washed into the Sakumo Lagoon between September and November 1971, at a time when the sand bars sealing off the nearby lagoons were already built up. These sand bars prevented the fishes from colonizing relatively sheltered habitats, after the rainy season, in which they would have found adequate food. Similar conditions elsewhere have led to large-scale stocking measures, as reported by Bardach et al. (1972) e.g. for various North African countries. It has already been suggested that *Mugil* spp. fry be caught by beach-seining and used for stocking tidal ponds in Ghana

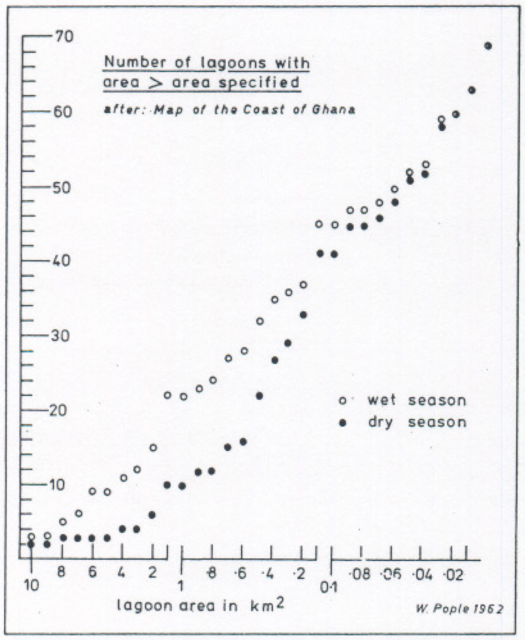

Fig. 9. Distribution of lagoons along the Ghanaian Coast. From Pople (1962).

(Pillay, 1962). In the light of the present investigation, it also seems that an extensive scheme of stocking closed lagoons would be most adequate. Fig. 9 gives an impression of the number and size of Ghanaian lagoons, most of which could be stocked. As mentioned above, the *Mugil* fry occurring along the coast seem most suitable for this purpose. Its occurrence, abundance and taxonomic composition would, however, have to be monitored first. Then, given positive results, an extensive scheme of stocking could be implemented in Ghana or in other West African countries with similar closed lagoons. Such a scheme would be a relatively cheap and simple way to increase the catches of the fishermen as well as to familiarize many people with basic aquaculture.

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RÉSUMÉ

Pauly, D., 1976. La biologie, la pêche et le potentiel de l'aquaculture de *Tilapia melanotheron* dans une petite lagune de l'Afrique Occidentale. *Aquaculture,* 7: 33—49.

(1) La biologie, et plus spécialement la nourriture du poisson cichlidé *Tilapia melanotheron* Rüppel 1852 a été sujet d'une étude. La nourriture est la vase des fonds, laquelle a un contenu organique pondéral de 30% et un contenu calorique de 1,2 Kcal/g. La consommation quotidienne d'un poisson de 20 g (poids frais) a été estimée à 1,5 g (p.s.) et un minimum de 900 cal par jour est assimilé. La reproduction semble avoir lieu sur toute l'année, le parasitisme est faible, à cause de la salinité variable de la lagune.

(2) La pêche lagunaire a une production estimée à 150 kg/ha/ année, la prise moyenne par unité d'effort atteint au maximum 1 kg/h de pêche et pêcheur, l'intensité de pêche est de 70 h de pêche par jour et km^2. Les filets utilisés sont des éperviers et des filets maillants. Les prises sont representées pour plus de 90% par *T. melanotheron.*

(3) Trois méthodes alternatives, capables d'augmenter les prises de poissons dans la lagune, et dans d'autres lagunes similaires, sont brievement presentées. Il s'agit: (a) de l'installation d'une pêcherie du type "Acadja"; (b) du stockage avec des alevins de *T. melanotheron*; (c) du stockage avec des alevins de *Mugil* spp. (polyculture *Tilapia/Mugil*). C'est cette dernière méthode qui semble être la plus prometteuse, les alevins de *Mugil* spp. étant facile à capturer le long de la côte. Il semble aussi que cette méthode soit la moins onéreuse et la plus facile à implémenter sur une grande échelle.