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Some Remarks on the Fecundity of Tilapia (T. mossambica Peters) and its Introduction into Middle Central America (Nicaragua) together with a first Contribution towards the Limnology of Nicaragua

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Some Remarks on the Fecundity of Tilapia (T. mossambica Peters) and its Introduction into Middle Central America (Nicaragua) together with a first Contribution towards the Limnology of Nicaragua[1)]

by

DIETMAR RIEDEL

(with 4 figs.)

FOREWORD

In his brief review of ichthyological life of Middle Central America, MYERS (1955) concluded that any introduction of *T. mossambica* PETERS[2)] would most likely have a disastrous effect upon the native fish fauna. Furthermore, "the introduction may be (a) of comparatively little benefit or (b) less useful than that of some native species". Reasons which had led him to this assumption derived from biological peculiarities of the species under discussion, which are summarized as follows:

a. *T. mossambica* is extremely prolific and breeds several times per year. Thus, waters stocked with it might easily become overpopulated (stunted) within a relatively short period.

b. *T. mossambica*, considered ecologically, is broadly tolerant of

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1) The data were collected while the author was on an FAO (UN) assignment as TA Fisheries Officer in Nicaragua C. A. from November 1961 to October 1962. However, the views expressed in this article are not necessarily those of FAO.

2) Synonym: *T. natalensis* (M. WEBER)

salinity (euryhaline) and thus can thrive in environments of limnetic to euhaline characteristics. In consequence, the fish can easily establish itself in almost any water so long as there is any means of communication with the original place of introduction.

A successful eradication programme, if so desired, appears extremely difficult, if applicable at all, when the financial requirements for such an action are taken into account.

c. The presence of rather numerous family members of Cichlidae in Middle Central American waters makes it appear more logical to select one or more of these instead of bringing in an exotic family member. Neither would it be easy to predict the latter's effect upon the already-existing populations, nor is there any likelihood at present that the relevant basic studies could be carried out by the countries concerned simply due to the lack of trained personnel.

The present writer agrees in principle with this general account, to which some further aspects have been added. His observations in Nicaragua, however, have disclosed facts which are evidently in contradiction to MYERS' paragraphs and which thus seem to require some clarification. Moreover, this is all the more necessary since, in the meantime, *T. mossambica* has been introduced. (Actually, one would be rather optimistic to believe that the "world-wide-travel" of this very cichlid could easily be detained after it had already been given so much publicity all over the world). It is not the place here to discuss how and through whom this wide distribution of a particular species has been achieved. But it is certainly justified to present the findings of investigations in Nicaraguan waters and to learn to what extent they differ from MYERS' conclusions. And in so doing, the present writer does not wish to add new optimism to the "myth fish" but only desires to review opinions which appear not to have resulted from on-the-spot studies but rather from literature or probably second hand information only.

There is no doubt that one, and probably the most frequent, way of predetermining the value of a certain species, especially with regard to its potential introduction, derives from literature studies. However, it should also be realized that those data ought to be reviewed and interpreted free of resentiments and with a certain degree of flexibility. Hence, it follows that the emergence of one particular point or problem, which might have occurred under certain circumstances, might lose its significance somewhere else. It is mainly with this in mind that the present author has prepared this report. At the same time there is little doubt that much of what will be presented requires expansion and further studies under the particular conditions existing in Middle Central American countries.

It should be repeated that the present writer, by no means, is in favor of hasty transplantations of exotic species without having first obtained reliable basic information. If these necessary data are at hand, then it might well be preferable to introduce an exotic species instead of selecting a native one, which, despite its presence, may be faced with many biological, ecological and economical difficulties. It is only too well known that a native fish does not necessarily attract consumers around its habitat. And it is just this very fact which occurs in Nicaragua. There are, naturally, many other points, too. (The reader is referred to various authors and especially to CHIMITS (1960) for further details.)

Prior to describing the establishment of a *T. mossambica* stock in Lake Moyua/Nicaragua, situated about 80 km north of the capital, Managua, some biological facts of the "newcomer" might be presented. In addition, it ought to be included that the fish's introduction in 1959 and its possible impacts on the native fish fauna had not been studied beforehand nor had the lake ever been investigated. The introduction, therefore, might be called an incident rather than an experiment.

1. SOME SELECTED DATA ON THE LIFE HISTORY OF T. MOSSAMBICA

1.1 **Feeding**

1.1.1 Fry

T. mossambica fry feeds exclusively on diatoms and other unicellular planktonic and epiphytic algae. (Handbook on Fish Culture in the Indo-Pacific Region (1962)).

1.1.2 Adults

If available, vegetable food seems to be preferred (herbivorous). If the latter becomes scarce or is not attainable in sufficient quantities, *T. mossambica* develops omnivorous characteristics by taking planktonic crustaceans, bottom-dwelling animals, insect larvae mingled with vegetable decays, and sometimes even small fish as well. It follows then that the composition of food entirely depends upon the availability of the different groups. (This particular feeding habit strongly supports again the necessity that the three major taxonomic food groups under which fish can be classified should not only be enlarged but that ecological conditions ought to be taken into thorough consideration as well in order to arrive at reliable application of food and feeding habits.)

1.2 **Spawning habits**

Sexual maturity of *T. mossambica* is reached at a size of about 9 cm only. No mention, however, was made of the conditions of the stock from which this figure was derived. Propagation takes place every two months or at even shorter intervals, under favorable conditions, throughout the reproductive life. (VAAS & HOFSTEDE (1952)). The male digs a hole into the bottom which is about 40 cm in diameter and about one-fifth of that in depth, into which the female is driven. Immediately after the eggs have been discharged they are taken up by the female's mouth where fertilization takes place. (The female "sucks" the milt dispersed in the water). Incubation, which is performed in the female's bucca takes from three to five days. The number of eggs produced by one female is said to range from 75 to 250, according to the Handbook on Fish Culture in the Indo-Pacific Region (1962). The eggs are yellowish in fresh water and whitish in brackish waters. Their diameter is said to be about 0.7 mm.

After hatching, the larvae and small fry stages are protected in the brooder's mouth, for a period of from 10 to 15 days. After that time the very close contact ceases and the fry begin to swim about independently.

1.3 **Growth**

Growth of *T. mossambica* largely depends on the density of the population. Thus, recorded data as to the growth vary considerably and can hardly be compared. Under favorable conditions, it is said that a gain of up to 800 g per year has been observed in freshwater ponds. Half of that weight was reached under similar favorable conditions in brackish water ponds. If by reproduction, which as was said is performed several times during a year's period, the number of members of a stock rises, then the stunting effect is to make responsible that single specimen may not gain more than 100 g per year or even less. Naturally, by application of food and fertilizer the holding capacity of tilapia ponds can be increased considerably, which will result in a better growth.

2. Origin and history of transplantation of *T. mossambica*

Like all other family members of the Cichlidae family, *T. mossambica* has most likely originated in South America. But the genus *Tilapia*, of which no fossils were found outside of Africa and Asia Minor, may therefore be considered as being indigenous to both the latter regions. (For more details see Chimits (1957)).

Due to its rather speedy and somewhat adventurous world-wide spread, this species can nowadays be found in many countries. It is extremly interesting to follow-up its "travel through the world", which is still going on.

Its place of origin is the East African Coastal river system extending from the Algoa Bay in the south to the Webi Shebeli River (Somaliland) in the north. In 1939, very surprisingly, five or six specimen of *T. mossambica* were discovered in East Java. (Serang River, south of Blitar). During the Second World War, offspring of these were

TABLE I
Time-table of the travels of T. mossambica

Introduced in	Coming from	Year	Manner of Introduction into open waters
Java*	East Africa(?)	1939(?)	
Sumatra	Java	1939	
Bali, Indonesia	,,	1941	
Lombok,	,,	1941	
Malaya*	,,	1943	Escape
The Celebes	,,	1944	
Taiwan (Formosa)*	,,	1944	Escape
The Moluccas	,,	1949	
St. Lucia*	Malaya	1949	Direct release
Thailand*	,,	1949	Direct release
Trinidad	St. Lucia	1949	
Grenada	,,	1949	Direct release
West Borneo	Java	1950	
East Borneo	,,	1950	
Amboina, Moluccas	,,	1950	
Banka, Indonesia	,,	1950	
The Philippines*	Thailand	1950	Direct release
Jamaica*	St. Lucia	1950	Escape
Barbados	,,	1950	
Dominica	,,	1950	
Martinique	,,	1950	
Sabang, Pakistan	Java	1951	Direct release
Ceylon*	Malaya	1951	Direct release
Haiti*	Jamaica	1951	
North Borneo	Malaya	1951	
Hawaii	,,	1952	
Dominican Republic	Haiti	1953	
Travancore-Cochin, India	Malaya	1953	
Guinea, Br.	Haiti	1954	
Egypt	Thailand	1954	
Fiji	Singapore	1954	
Japan	Thailand	1954	
Cook Islands	Fiji	1955	
Guam	Philippines	1955	
Laos	Thailand	1955	
New Caledonia	Fiji	1955	
Saipan (Micronesia)	Philippines	1955	
South Korea	Thailand	1955	Direct release
Guatemala	Haiti	1958	
El Salvador	Guatemala	1958	
Nicaragua	El Salvador	1959	Direct release

Notes: Data presented in accordance with ATZ (1954) and CHIMITS (1957) enlarged by the present writer for Central America.
* = *T. mossambica* has established itself in open waters.

transported to Indonesia, Malaya and Taiwan. During the following post-war period introduction took place in Borneo, the Philippines and other countries (See Table I). Finally, the "myth fish" arrived in Honduras and El Salvador from where it was taken to Nicaragua in 1959. Table I presents a more accurate and detailed time-table of the species under discussion.

It ought to be mentioned that most of the introductions were done with a view to cultivating the newcomer in confined waters, such as fresh or brackish water ponds. In some cases, as could be expected, the fish escaped into open waters and thus more or less men's control. Finally, Thailand, Ceylon, and Haiti are examples of countries where a direct release into open waters was made.

3. Studies into and observations on the *T. mossambica* stock in Nigaragua

As already briefly stressed, *T. mossambica* was introduced into Nicaragua from El Salvador in 1959. One hundred fry from two to three cm in total length were planted into Lake Moyua on December 22 of that year. Up to the time of investigation of the present writer, no commercial fishing had been done but only some sporadic nettings. A lake survey had never been undertaken before, nor did any data as to the lake's limnological features exist. The results obtained by the writer as to the limnology of Lake Moyua and the development of its tilapia stock are presented in the following.

3.1 **Lake Moyua**

3.1.1 Location and Description

Lake Moyua, the largest water body of a group of three lakes situated East and West of the Pan-American Highway, about 80 km north of Managua, is definitely of perennial character. The other lakes, Lake Tecomapa, and Las Playitas Lake, are either closely approaching the characteristics of a swamp (Lake Tocomapa) or temporarily disappearing completely (Las Playitas Lake). Thethree lakes are separated from each other by ridges of hills rising to about 600 m (See Fig. 1). Quite in contrast to those lakes of the country which are situated in the chain of volcanoes (quaternary or recent origin) along the west side of the Nicaraguan depression and which thus are very deep (up to 96 m), Lake Moyua and its neighbours are pan-like shaped depressions filled with the flow of seasonal rivers and rain water, respectively. The basic rocks and soils are eocenic. They are covered by soils which originated from more recent volcanic activities. A few kilometres north of the lakes, rhyolit and dacittuff are scatterly protruding.

The elevation of Lake Moyua is 420 m. A little higher lies Lake Tecomapa (428 m). Las Playitas Lake, finally, is 442 m above sea

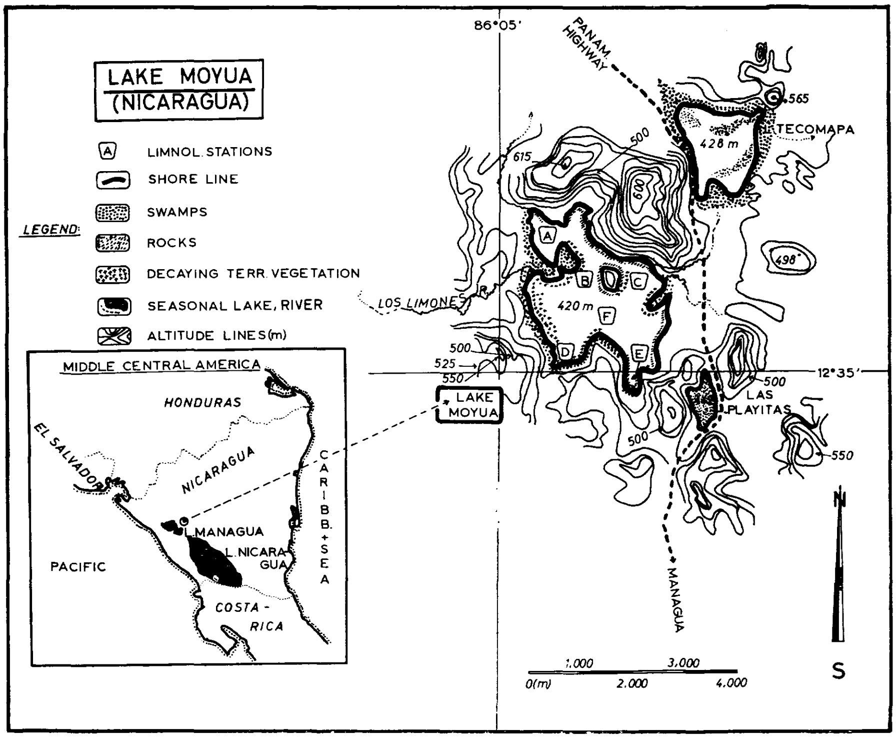

Fig. 1: Sketch Map of Lake Moyua and its surroundings.

level. These elevation data, naturally, fluctuate in response to the periodical changes from dry to wet season. The accessibility is good during the dry season only. When the annual rains start (April/May)- duration of the rainy season is about 6 months – most of the shoreline becomes overflooded which prevents any motor driven car from approaching the lake proper. Existing maps indicate trails leading around the lake. For all practical purposes, however, none are motorable after the wet season had begun. In addition, protruding basalt rocks on the slope seriously impede access.

The drainage bassin covers approximately 200 to 250 sq.km. Its topography might be summarized in the following:

Northern area: Highland character, sloping abruptly to the depression filled by the lake;

Western area: Highland character, declining slowly towards the lake's shore line;

Eastern area: Extension of the depression (beyond the Pan-American Highway) which reaches the swamps of Lake Tecomapa in the north;

Southern area: The same depression area is bordered to the south by a ridge of hills beyond which the Las Playitas Lake's depression is situated.

The vegetational cover is mainly composed of scattered members of the Mimosaceae and Ulmaceae families, exhibiting the thornbush-savannah character.

Climatological data are not on record as yet. The wet tropical characteristics of the western part of Nicaragua are somewhat tempered by altitude. Daily temperature fluctuations are small only. Those of the relative humidity are more pronounced, and depending upon the season.

There are only three small tributary streams of any consequence, the largest of which is the so-called Los Limones River which extends about 5 km. None of them, however, is perennial and thus during the dry season (November/December – April/May) there is practically no discharge.

The maximum length of Lake Moyua is about 4 km, its width little more than 2.5 km. These figures, naturally, undergo considerable changes exercised by the seasons. This is indicated, for example, by the hundreds of stumps and shrubs occupying parts of the shore areas (see Figs. 1 and 2). These trees, it was said, had grown during the extremely dry years 1950/51 when the surface of the lake had become shrunken considerably. Actually, the aerial photographs taken in 1954 indicated the presence of two islands, only one of which

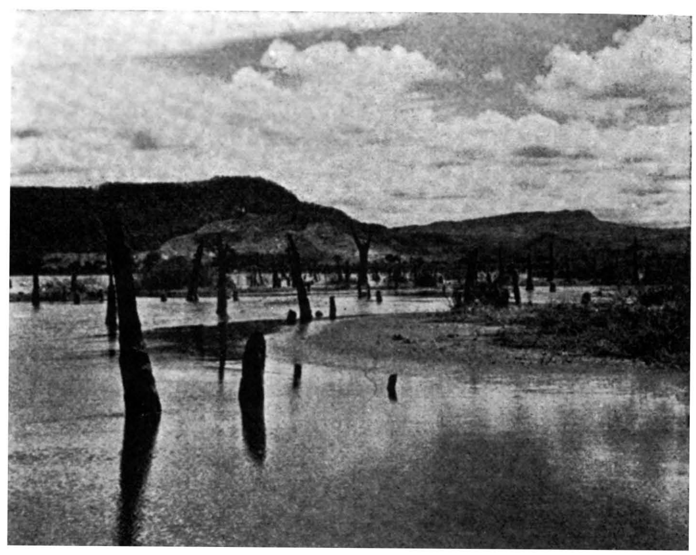

Fig. 2: Southern shore of Lake Moyua during the dry season (Photo: RIEDEL)

was there in 1962. The shape of the lake, its depth, extension, insulosity will thus be closely linked with the amount of annual rainfall. The surface, which was measured to cover approximately 6 sq.km, is, therefore, of only restricted value as is the perimeter of 15 km. Bottom materials vary to some extent. Aside from a rather limited rocky area which extends parallel to the east and part of the northeast shoreline, bottom materials in all other parts are either composed of muddy and/or muddy-sandy substrates (clay). The rocky zone was estimated at less than 15% of the total bottom area in the middle of the wet season. When the lake's level becomes lower, the extension of the rocky area under water decreases drastically. Table II and Fig. I contain more detailed indications. No snails or clam shells have been found.

3.1.2 Physico-chemical Aspects

Organoleptic tests reveal that the lake water is sweet and good tasting. Its color is greenish-brown with an overcasted sky; in sunlight, a change occurred and it appeared more a reddish green during the observation time. Transparency (Secchi disk reading) is small and remained below 15 cm (See Table II). pH varied from 7.2 to 7.9 (electrical pH-meter). Alkalinity (obtained as to SBV) was relatively low and, surprisingly, differed in one out of six places (1.5 – 3.7 mval/1). Dissolved oxygen (mg/1) was high and ranged from 10.5 – 12.5. Table II contains all determinations obtained from locations marked in Fig. 1.

TABLE II

Some physico-chemical aspects of Lake Moyua (see also Fig. 1)

Station	Depth (m)	Type of bottom	Tw TA (C°)	Visibility (cm)	SBV	O_2	pH	Date
A	0.85	clay	27.5 32.5	12	3.6	12.0	7.2	18.V.62
B	1.25	clay	26.5 32.5	15	3.1	10.4	7.3	„
C	1.65	clay-sand	27.5 32.0	12	3.2	11.6	7.0	„
D	0.65	clay	27.0 32.0	14	1.5	12.1	7.3	„
L	1.05	rocky	26.0 29.5	15	3.0	12.0	7.1	12.VII.62
F	1.90	clay	26.0 29.5	12	3.1	11.8	7.4	„

Notes: All data relating to O_2, SBV, and visibility, were derived from two measurements which were averaged.
Tw = water temperature; TA = air temperature.
Measurements obtained on 12.VII.62 as to depth are wet-season data.
SBV determination in Station D was made 4 times, the above 1.5 figure is the mean.

3.1.3 Biology

The lake during the time the survey was carried out was lacking any higher aquatic plant. „Flor de Mondongo" (*Nymphaea rotundifolia*) was reported to have mass-appeared in the southern marginal area of the lake during the past until 1959. In 1962, however, not a single specimen was found. Reasons for this disappearance may be attributed to the extreme fluctuations of the water level, especially exercised in this part of the shore line[1]). Terrestrial plants, as was already mentioned, invade the marginal areas whenever the water level becomes lower. (See Fig. 2).

Decaying brushes and tree stumps are abundant along the southern and south-eastern shore, east of the small island and along the small spit of land opposite (east of) it. (See Fig. 1). It is very likely that if the lake were to remain at a very low level long enough, terrestrial vegetation would establish itself right in the middle of the lake.

During the second period of observations (wet season), the lake flooded the surrounding shallow areas, which are densely covered by graminaceous plants, mainly along the south and south-east shore. The decay process of those partly inundated grasses takes about four to five months, during which excellent conditions for the development of tilapia fry prevail. Wherever these areas have been examined by wading, they were found to hold an abundance of midge larvae. Dragon fly nymphs were present on decaying stumps and bush remains. Midge larvae, in the rocky areas, have been much less abundant. Besides, some diptera larvae have been found, but were not identified.

(A comprehensive study of bottom organisms was beyond the scope of the present contribution, as was the exact determination of the plankton components, both of which require further taxonomic studies. Information presented above and in the following on plankton, thus, is by no means complete. Results of exact determination work will be published elsewhere later on).

Meanwhile, limited information as to the essential members forming the bulk of the coarse plankton may be restricted to: *Cyclops*, *Bosmina*, and copepodits. The bulk of the fine plankton was made up of: Rotatoria (*Brachionus*), a tremendous number of blue-green algae and green algae (*Pediastrum*, *Scenedesmus*) and numerous diatoms (*Navicula*). The plankton production of Lake Moyua is definitely very high as indicated by the greenish color component of the water, during the entire time the lake was visited. It is self-explanatory that

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1) A second reason for the disappearance of *Nymphaea* may be attributed to the establishment of the tilapia population which might have drawn on it and thus weeded out that population gradually.

the lake's productivity is mainly based on (a) its morphology, (b) excellent climatological conditions, and (c) the annual provision of essential minerals washed into the lake by its tributary rivers and rains.

Prior to receiving the stock of tilapia, the only fish species inhabiting Lake Moyua was that of *Paragambusia nicaraguensis* (GÜNTHER), of the Poeciliidae family, members of which are found in almost all the waters of the country. This light brownish-colored fish with black-spotted dorsal and caudal fins has no economical value whatsoever. Its observed maximum length did not exceed 29 mm (females); males remain much smaller. Their habitat is restricted to the marginal belt where they appear to be in food competition with tilapia offspring. The latter occasionally may even be taken as food, though in not too great a number because of size relationships.

Water birds (*Podiceps dominicus* and *Podilymbus podiceps*) in rather dense flocks were observed during the entire time of investigation. Their numerical abundance has been estimated to be from 300 to 500. Their movements are likely to be restricted to the lake area although some migration to and from neighbouring Lake Tecomapa has been observed. Both populations mainly feed on tilapia fingerlings of a size range from 30 to 40 mm individual length. In two cases out of nine *Paragambusia* was found to make up about 50% of the food. The number of tilapia per bird varied with the length of the rainy season. At the beginning (about three weeks after the rain had started), the number of tilapia found in the stomach of *P. podiceps* varied from 6 to 8 per bird. In the middle of the rainy season, the latter number increased to 8 to 12. The average weight per tilapia fingerling preferred as food was about 3 to 5 g; *i.e.*, the food intake per bird ranged from 24 to 32 g at the beginning of the rainy season, and rose later to approximately 32 to 48 g.

The numerical daily loss of tilapia fingerlings may thus be assessed to be in the neighbourhood of 4,000 to 6,000 specimen of the above mentioned sizes. It appears very likely that this biocoenotic relationship, or, in other words, predation pressure partly governs the individual growth of tilapia. (Any further management of Lake Moyua, consequently, will have to fully recognise this relationship

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[1]) It may be of interest to insert here that *Podiceps cristatus*, under European conditions, takes about 200 g of fish daily. Thus, the observed quantity mentioned above for Lake Moyua *Podiceps*, appears to be rather small (approximately 20% only). It has been observed that feeding starts at sunrise and ends with sunset. In order to arrive at the total daily food intake, stomach contents have been investigated at sunset time only. Birds were either shot or collected from the nets in which they trapped themselves during their attemps to extricate fish which became netted near the float lines.

between ichthyological and ornithological life: Should the bird populations be eradicated, then netting activities will have to be intensified in order to provide space for those recruits at present consumed by birds. Should it be desired to have the present what might be called biological equilibrium remain, then fishing activities should be restricted to removing the uppersize classes only. – See 3.2.2 –).

The presence of piscivorous turtels would not seem to decisively influence the tilapia population of Lake Moyua. However, turtels may have a future impact on netting activities insofar as they have been repeatedly observed to feed on meshed fish when the nets have been placed close beyond the inundated marginal grasses.

3.1.4. Discussion of the limnological features of Lake Moyua together with an attempt to arrange it within the Classification of Lakes

Lake Moyua, although its extension is most closely linked with the annual rate of precipitation and evaporation, can be limnologically considered as (still) a permanent water body. Its morphology (depth less than 2 m, size about 6 sq.km) and geographical position (equatorial region) makes it resemble a tropical pond. It seems quite possible that should a change in the relationship between evaporation and precipitation ever occur, *i.e.* should the former exceed the latter, the permanent character of the lake would become of a temporary nature, which within the process of ecological aging, may finally turn the lake into a swamp (see Lake Tecomapa). This process, doubtless, will be supported by the lake's speedy metabolism which accounts for the formation of a thick layer of decomposed bottom substrates, and which already occupy considerable parts of the southern and south-western parts of the lake. Since a swamp in many cases has been proceeded by an aging fertile (in limnological terms eutrophic) water body, there is much evidence to preclude that Lake Moyua in its present form exhibits the characteristics of eutrophy. This assumption is not only supported by the presence of heavy phytoplankton development, but from the alkalinity data as well, listed in Table II (Station D excluded). The average alkalinity in terms of SBV was slightly above 3 mval/1. Such figure indicates the presence of 165 mg $CaCO_3$/l or 92.4 mg CaO/l or, finally, 65.8 mg Ca^{++}. According to SCHAPERCLAUS (1933), two-thirds of the determined CaO already indicates that the upper margin of fertility (in terms of fish production) is being reached (in pond culture). The resemblance of the lake to a pond has already been stressed above. In addition. BUSCHKIEL (1938) points out that under tropical conditions, an SBV above 3 mval/1 is one of the governing factors that leads to fish yields of 1,000 to

2,000 kg/ha. The present writer is aware of the fact that generally fish form the last chain within the lake's metabolism, and do not necessarily indicate whether a water is productive (eutroph) or not simply because all other components linked with metabolism, are being excluded (see ELSTER (1958)). However, the morphology of Lake Moyua will certainly exclude the danger that with an increasing primary production, a declination of fish production might go hand in hand. This is simply because there is no hypolimnion, whose volume can be enlarged, as there is, likewise no tropholytic layer.

Oxygen supersaturation in percent was generally above 140, whereever, whenever and at whatever depth determination was carried out. This fact, in combination with a high and constant water temperature throughout the year (the latter judged from the constant temperatures prevailing in the country), whether measured at surface or at bottom during the time of observations, indicate no thermal resistance and, thus, the absence of any stratification. Again, both are in relation to transparency which definitely (although not measurable by Secchi disk application) enables light penetration through the entire water layer. Assimilation, therefore, will take place extensively not only immediately below the surface layer but down to the bottom area as well. Near the latter, naturally, the process of photosynthesis will be of a smaller degree because the light quantities in the surface layer are being reduced by the presence of planktonic life and turbidity caused by complex compounds typical of volcanic areas (colloidal ferri-compounds). The latter are usually responsible for a brownish-red coloration of the water. Furthermore, colloidal $CaCO_3$ established by the presence of excess CO_2 (pH-alkalinity relation) reduces intensity of light penetration.

As was expected, any sign of sulphate reduction (liberation of free H_2S) was lacking.

The materials in the stage of reduction ("mineralization") rapidly sink (due to the lowered viscosity of warm water) to the bottom; however, it does not remain there but is transported to the surface again by vertical circulation which takes place regularly daily when the superficial strata cool down during the night and finally attain a lower temperature than that of the bottom. Sporadic measurements with a simple thermometer indicated a lowering of surface temperature by about 2°C in the early morning hours. A slight decrease in the oxygen content did occur at the same time which is, doubtless, due to the assimilation activities of the abundant phytoplankton. (In addition, due to the lack of higher aquatic plants, there is no "storage" of oxygen which could temporarely compensate for that loss).

In summarizing the above mentioned observations and measurements, Lake Moyua appears to possess a definitely eutrophic character. Owing to its morphology, which together with the favorable climatological conditions, is responsible for a continuous vertical circulation, decomposition is not restricted to the bottom layers where the minerals would be stored ("mineral traps" as in deep tropical lakes) but takes place continuously from up to down and *vice versa*. Thus, a high fertility of the entire water body is assured *the year around*. This very maintenance of an extremely favorable ,,momentary balance" (HARVEY 1945) or, in consequence, "food balance", is the basic reason for the establishment of such an excellent tilapia resource, as will be described later on.

It may thus be quite possible (and may certainly have some technical advantage) to solely and directly determine the stage of trophy of a similar tropical water by its fish production ("economic production") rather than just by applying recently developed methods (Carbon C^{14} method and others), requiring expensive modes of determination.

In accordance with its thermal properties, Lake Moyua will have to be arranged within the system of Classification of Lakes – established by FOREL and later on modified by WHIPPLE (cit. WELCH (1952)) – as belonging to Type III-Order 3: "Surface temperature always above 4°C; temperatures of bottom water very similar to that of surface water; circulation practically continuous throughout year". By application of the classification system of HUTCHINSON &

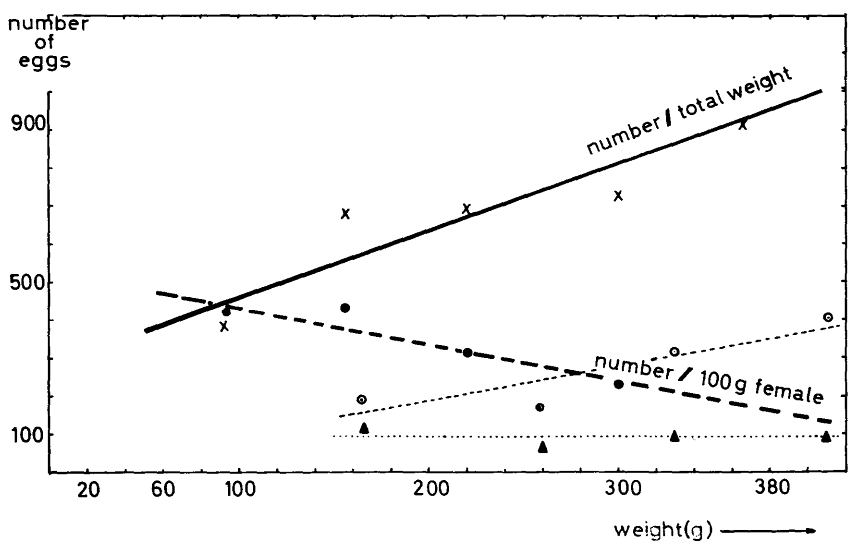

Fig. 3: Diagram explicating the relationship between (a) number of eggs produced per female and (b) number of eggs carried in the bucca. (Fine shaded line: number of eggs carried as per total weight per female; fine dotted line number of eggs carried as per 100 g brooder weight).

LÖFFLER (1956), Lake Moyua indicates the polymictic type, although it is by no means a highland lake (see ELSTER (1958, p. 101)).

Anticipating eventual further contributions towards the limnology of Nicaragua all the other main inland waters of the country may be grouped as follows:

Group A	
Polymictic type	Lakes Nicaragua, Managua, and Lagunas Plazuelas (West of Lake Nicaragua)
Group B	
Oligomictic type	Lakes Apoyo, Masaya, Tiscapa, Jiloa

3.2 **Some remarks on the bionomics and structure of the *T. mossambica* population of Lake Moyua**

3.2.1 Fecundity of *T. mossambica* in comparison with other native or exotic species from Middle Central America

According to the number of eggs per spawning period[1]) (counted prior ovulation) within the spawning season (annual ovarian cycle) obtained from female *T. mossambica* from Lake Moyua, a numerical relationship between the sizes (age?) of fish and eggs developed became apparent as shown in Table III (See also Fig. 3).

TABLE III

Relationship between the number of eggs and size of female[2]

No.	Weight of single female (g)	Number of eggs counted	Calculated number of eggs per 100 g female weight
1	92	390	424
2	157	670	427
3	220	695	316
4	303	725	239
5	365	910	249
Average number of ripe eggs/100 g female weight = 331			

[1]) In accordance with the terminology suggested by BERTIN (1958) *T. mossambica* belongs to the type "plurimodal" i.e. the ovaries contain more than only one portion (batch) of ovarian eggs which are distinguished from each other by sizes, stage of development and appearance.

[2]) Compare LOWE (MCCONNEL) (1955), whose findings are thus confirmed to some extent. It appears that fecundity of the species is equal at any place where identical onditions are provided.

As can be seen in the above Table, the number of eggs produced during one spawning period is considerably larger than that mentioned in Handbook on Fish Culture in the Indo-Pacific Region (1962, Chapter 1.2). VAAS & HOFSTEDE (*l.c.*) obtained from a 15 cm long female 800 eggs, and from a 8 cm long one some 80 eggs. BAERENDS & BAERENDS VAN ROON (1950) published that they had found a 15 cm long female which had developed some 200 to 300 ripe eggs. VAAS & HOFSTEDE (*l.c.*), in addition, observed that females exceeding 20 cm in length appear to cease to produce eggs. The latter observation into the limitation of reproductive life of *T. mossambica* could not be acknowledged, here for Nicaragua, however, it is quite likely that with increasing size (age), the number of eggs produced decreases as can be seen from the above Table which includes a 92 g female with 420 eggs/100 g, while the 365 g specimen only developed 249 eggs/100 g, *i.e.* about 43% less.

It, therefore, seems justified to deduce that fecundity of *T. mossambica* (in terms of egg production) is a function of the size (age) although the relationship is apparently not proportional. (See also CRIDLAND (1962)). Beyond a certain size of the female, egg production (*i.e.* reproductive life) may even totally cease.

Table IV serves to explicate the number of eggs carried in the mouth of the female.

TABLE IV

Number of eggs found in the bucca during the incubation period

No.	Weight of single female (g)	Number of eggs counted in the bucca	Calculated number of incubated eggs per 100 g female weigh
1	165	185	112*
2	260	170	65
3	330	315	95
4	410	405	99**

Average number of incubated eggs/100 g female weight = 93

Note: * = including 1 larva
** = including 2 larvae

As is evident from the above data, no relationship is revealed between the size of the brooder and the number of eggs being incubated, but only that the latter numerically decreases, per unit female weight by about 70% in comparison with the number of ripe eggs counted in the ovaries.

BAERENDS & BAERENDS VAN ROON (*l.c.*) observed in aquaria that a certain loss of eggs was due to the fact that the male, during the spawning process, had picked up eggs the moment they had been laid[1]). The present writer, in addition, supposes that in general a certain percentage of the eggs might get lost before being taken up by the female's mouth and that, furthermore, the latter might even dismiss eggs in cases where a disparity between the total volume of all eggs and that of the bucca exists. (See also ARONSON (1949)). After that what might be called „mechanical reduction" it will be the more interesting to check on the number of larvae and/or fry carried by one female. By presenting relevant figures in Table V, it is to be realized that the obtained numbers might not necessarily represent the entire number of larvae and/or small fry, for the figures have been obtained from gill-netted females. It is, thus, likely that in the moment of capture and during the liberation attempt of the motherfish a certain shock might have been induced which resulted in a partial loss of larvae which the brooder was unable to suck back. The latter becomes the more possible when larvae begin to leave temporaly the mother's mouth. The very young larval stages, however, do not appear to get lost easily which was proved by observing a female which had been disturbed for about 5 minutes but did not „spit out" its youngs. (These moments ought to be tested carefully in aquaria). That similar effects, naturally, might accidentally develop at any time, should unexpected dangers or obstacles suddenly disturb the brooder, goes without saying. Furthermore, the entire number of eggs carried in the bucca may not necessarily hatch at only one time but in succession. (Indefinite brooding period – see Table IV, females Nos. 1 and 4, respectively).

In this connection it is noteworthy to refer to laboratory studies on the survival rates of tilapia eggs undertaken by CRIDLAND (*l.c.*). According to his findings the survival rate of *T. nigra* eggs during buccal incubation varied from 13.5—100%. The average was 60.7%. Such a mortality would seem to additionally account for the numerical discrepancy between the number of eggs per bucca and that of larvae and/or fry.

TABLE V

Number of larvae and/or fry carried by female T. mossambica

No.	Weight of single female (g)	Number of larvae and/or fry carried
1	145	71
2	210	67
3	290	81
4	340	94

[1]) According to PETERS (1963) out of 16 *T. mossambica* females, 3 had one to ten, 1 ten to twenty and 1 seventyfour eggs swallowed.

The following data were obtained from gill-netted specimen of Lake Moyua.

Due to the many reasons to which the loss of fry can be attributed as illustrated above, any calculation as to the correlation between the size of the female and number of hatchlings presents some problems. It is most evident, however, that the above figures as well as relevant results obtained elsewhere, suggest the necessity for some reconsideration as to whether or not it is justified to determine *T. mossambica* as prolific. In accordance with the number of eggs produced per entire spawning season (*i.e.* per year), *T. mossambica* is certainly n o t prolific when compared with the number of eggs produced by other fish.

Before entering into a more detailed discussion it is also necessary to assess the sexual composition of the *T. mossambica* stocks. Male and female *T. mossambica* can easily be distinguished by their body coloration. Males are much darker than females. In the test fishings carried out, it was found that males numerically exceed by far the females. The relationship was 70 to 30% disregarding the location where the nets were placed.

Most apparently, spawning does not start prior to the onset of the rainy season. This was indicated by the absence of fry at the end of the dry season. The nursing area, at this time, was considerably reduced in size. End of May 1962, after the rain had started and overflooding of the nursing grounds began, an almost explosive appearance of tilapia fry was observed. The inundated graminaceous vegetation provides excellent possibilities for rapid food development and sheltered places. These areas shrank again during the second half of the wet season when precipitation started to decline. The length of what might be called the spawning and nursing period may thus be confined to about 5 to 6 months. (Since with the onset of the rain, tilapia fry occurred, rain appears to stimulate spawning. This observation corresponds with those of LOWE (MCCONNEL) (1946) who reported from Lake Victoria that its *T. esculenta* population starts spawning when the rains appear. Reasons why both events coincide cannot be given as yet, since rain involves too many factors (change in light intensity and temperature, as well as chemical composition of water) from which, to select the most stimulating one is extremely problematic.

Sporadic sampling of small tilapia with simple baskets carried out in the typical nursing grounds during the wet season indicated the presence of five distinct length-groups. From these observations a maximum of five spawnings per wet season might thus be concluded with reasonable certainty.

Apart from the above-described method of arriving at the number of spawnings per entire spawning season, a second one had been applied which was based upon the number of batches of egg-groups per ovary, differing from each other in diameter and appearance and, thus, providing a hint to the calculation of the number of spawnings per entire spawning season. The average number of egg-groups was found to be 4 to 5. Unfortunately, it has not become known yet how long a particular egg-group may need to ripen. In comparison with relevant species observed elsewhere, support is given to the theory that ripening will take about 30 days, upon which the maximal five batches of offspring per spawning season are suggested[1]).

The total fecundity of *T. mossambica* per year in terms of the number of eggs produced per 100 g female weight may thus be concluded to be approximately from 200 to 450 $\times$ 5 = 1,000 to 2,250. The number per female varies from approximately 400 to 1,000 $\times$ 5 = 2,000 to 5,000. The so-called "fertility coefficient" N ($N = E/Lt^3$; E = number of eggs produced per spawning season, Lt = total length of female in cm) of *T. mossambica* from Lake Moyua varies, therefore, from 0.6 to 0.3.

In concluding data presented in this chapter as to (a) number of eggs produced per female per spawning season; (b) number of larvae carried by a single female; and (c) sexual composition of the tilapia stock, the following might be summarized:

a. The total number of eggs per female varies from 2,000 to 5,000;
b. The survival rate of incubated eggs as is the number of hatchlings per female are considerably smaller than the number of eggs found in the gonads.
   The number of recruits per female per entire spawning season amounted to about 70 to 100 $\times$ 5 = 350 to 500. (The number of recruits which might result from the first spawning of the first batch of larvae excluded).
c. The sexual composition of the stock of *T. mossambica* of Lake Moyua was 70% males to 30% females.

Compared with that of other *Tilapia* spp., fecundity of *T. mossambica* in terms of the number of eggs produced is only slightly higher as can be compared with the data given by LOWE (MCCONNEL) (1955, Table I).

If one assumes that maturation of *T. mossambica* is reached when the females are from 5 to 6 months old (see Chapter 3.2.2) it becomes

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[1]) This assumption leaves out the possibility that a group of ripe eggs (just prior to ovulation) may not necessarily be discharged but retained in the ovary where resorbtion takes place. In addition, the batch of ripe eggs may include partly or fully degenerated menbers which either will not respond to fertilization at all or, later on, cause mortality to developing embryos (see also PETERS, l.c.).

possible to calculate the number of offspring per female per year as follows:

Out of the number of offspring/spawning season an average of about 400 recruits is produced. Only those from the first batch of youngs may become able to reproduce at the end of the spawning season, just prior to the onset of the dry season when they have reached an age of about 5 months. Their number may be figured at around 80 specimen, out of which (in accordance with the sexual stock composition) only 24 are females. These may produce $24 \times 80 = 1920$ recruits which are to be added to the above 400 plus 56 (the number of males) in order to arrive at the total number of offspring = 2,400 year; anticipating no other modes of mortality

The general statement that *T. mossambica* is extremly prolific thus appears to be exaggerated and all the more when compared to fecundity figures of native *Cichlasoma* which MYERS suggested to select instead of *T. mossambica*[1].

Referring back to the latter suggestion, attention is invited to the following findings. *C. managuenses* (GÜNTHER), locally called "guapote", an excellent and extremely palatable species, which tentatively was considered as a suitable candidate for pond raising, was found to develop about 50,000 to 60,000 eggs per one kilogram female weight, which was measured in accordance with the volumetric method. The smallest specimen found carrying ripe eggs weighed 180 g only and had between 15,000 to 16,000 eggs. The fertility coefficient was thus approximately 2.5. The age of that specimen was not more than one year as could be judged from the appearance of one "annulli" which apparently had just been formed by crowding of circuli during the change from the dry to the wet season (ending of

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1) At this point it appears necessary to draw attention to the common carp introduced to Middle Central America in 1952. It is a well known fact that carp females produce approximately 100,000 eggs per kg female weight which, most likely, are laid down in batches in succession which theory is suggested by the almost uncontrollable appearance of carp fry in the ponds of the Experimental Fish Culture Station at Porillo (about 70 km east of San Salvador/El Salvador), observed by the present author in late autumn 1961. An attempt to control them by adding piscivorous fish, such as *Cichlasoma managuense* (endemic to Nicaraguan waters) is cited here. MYERS did not mention anything all about the introduction of carp which is all the more surprising because of the above-mentioned and well-known high egg production and, in addition, soon reaching maturity (from 6 months on). Overpopulation will thus occur easily in ponds if not managed properly. It is well-known as well that carp, under crowded conditions, do gain less weight per unit of time than tilapia does. While it appears much more likely that small-sized tilapia can be marketed, carp of about 100 g would find hardly any acceptance. Finally, but not least, carp can spread out as easily as tilapia, although its tolerance of salinity is smaller than that of *T. mossambica*.

May 1962) and which was considered as sufficiently reliable for age determination. The smallest guapote male found with "running" milt weighed 145 g and was of the same age and captured on the same day as the small female. It, thus, emerged that guapote if kept in ponds, consequently, will soon lead to overpopulation doubtless much more rapidly than *T. mossambica*. In addition, and this fact appears to be of even more importance, Guapote is definitely a predator and would thus, if kept in ponds, require either meat or forage fish which under tropical conditions would not seem to be easily providable, whereas *T. mossambica* readily accepts any kind of food for carp which easily can be transported and stored. Finally, random checks made into the growth rate of guapote indicated a slow growth which would account again for its not appearing suitable for fish culture, so long as other species like *T. mossambica* (and probably carp as well) are available, which were found to gain per year more than 250 g. It would, of course, not matter much if guapote escaped from places of cultivation since it is already a member of the ichthyological fauna of both the Big Lakes of the country, as well as in some of their tributaries and in neighboured pools.

3.2.2 Growth of *T. mossambica* in comparison with that of native species of Nicaragua

Unfortunately, scale readings of tilapia did not become possible for the Lake Moyua population. Actually, some extremely vague formations of crowded circuli were observed but were definitely much too faint for providing reliable indications[1]. However, a number of conclusions may be drawn which contribute to the gain of weight within a certain time limit. As mentioned on page 362, 100 *T. mossambica* fry from 2 to 3 cm in length (calculated weight from 0.2 to 0.4 g each) had been stocked into Lake Moyua on December 22, 1959. The first offspring from this original population had certainly not hatched prior to June 1960 when the parental stock had reached an age of about 5 to 6 months and during which period they had gained about 200 g at least, due to most favorable conditions of the new habitat. The gill-net catch of tilapia in 1961 (see RIEDEL (1963)) comprised part of those recruits, presumably a good share of the biggest sizes above 450 g which correspond to a standard length above 22 cm (see Table VI below). Whatever the number of the 1960 recruits within the length groups above 22 cm and the corresponding

[1]) HOLDEN (1955), *cit.* LOWE (MCCONNEL) (1956) reported from *T. esculenta* the formation of scale rings which seem to be in correlation with the breeding periods during which no food is taken.
Since there is nothing definitely known yet about the frequency of spawnings per entire spawning season (year), scale reading, consequently, will encounter a series of difficulties when it comes to interpretation.

age might have been, the decrease in the coefficient of condition (k) – see Table VI and Fig. 4 – obviously suggests that under present circumstances, a further economic growth could hardly be expected. When analysing the individual length-weight relationship it became clear that probably two groups of correlation should be regarded within the 20—24 cm length groups: One which has a much more favorable factor k, probably indicating younger specimen (below 2 years of age) and another one which by its low k suggests that its members have already reached the vertex of the growth incline[1]). The former group points to the presence of sufficient food and thus, demonstrates that tilapia is in positive ecological response to the habitat.

TABLE VI

Mean lengths and weights including relevant standard deviations and coefficients of condition (condition factor) of T. mossambica (both sexes combined)

Mean lengths (mLs) in mm within established length groups (LG.) LG.	mLs	SDm(Ls)	Mean Weights (g)	SDm(Weight)	k	n
240—230	232	±0.7	447.5	±64.1	3.38	4
230—220	222	±0.14	467.4	±46.0	4.27	21
220—210	214	±5.1	456.5	±12.9	4.66	54
210—200	204	±1.45	410.8	±47.9	4.84	42
200—190	192	±0.17	345.2	±39.2	4.88	32
190—180	184	±1.8	303.2	±60.7	4.87	31
180—170	174	±0.4	267.3	±26.0	5.07	15
170—160	164	±0.9	213.0	±66.9	4.83	15
160—150	155	±0.6	180.9	±52.7	5.13	23
150—140	143	±1.08	156.7	±44.1	5.36	29
140—130	135	±1.07	107.5	±35.3	4.37	20
130—120	124	±0.32	91.9	±55.5	4.82	32
120—110	116	±0.28	80.4	±22.8	5.14	14
110—100	105	±1.08	64.2	±17.4	5.54	13
100— 90	95	±0.9	50.8	±15.0	5.93	6
90— 80	84	±0.84	38.5	±17.1	6.49	10

Notes: All Figures are slightly rounded;

SDm = Standart deviation (SDm = $\sqrt{\frac{\Sigma x^2 - (\Sigma x)^2/n}{n-1}}$

$K = \frac{100{,}000\ W}{L_S^3}$ (Ls = standart length (mm); W = weight of fish (g)

[1]) It was at first believed that the different stages of the development of ovaries might be responsible for this decline of the factor k. However, since most of the bigger specimens were males, confirmation was presented that the vertex of growth is a response ot size (age).

It is fully realized by the present writer that probably more specimens ought to have been measured in order to provide more data for evaluation and inclusion in the above Table. Since the presented figures bear a good degree of persuasive power in relation to the observations, and, furthermore, appear to be in analogy with observations obtained elsewhere, they were thought to be of sufficient certainty for the purpose of this paper.

As was already stressed, the lack of reliable annulli prevents determination of the age of tilapia. In consequence, one is not in a position, as yet, to conclude that in Lake Moyua its *T. mossambica* population ceases to gain weight at the age of two years; one can only assume that the well-being of those specimens weighing more than 400 g becomes quickly reduced. This is not likely to be a response to overpopulation as has been described above. Thus, it only leaves that beyond a weight of 400 g cessation of growth is a function of age, and not one of the density of the population in relation to the habitat. CHIMITS (*l.c.*) reported that the maximum size of *T. mossambica* was 700 g in fresh water, which seems to refer to a very rare case since no other similar weights became known so far, but only smaller ones around 400 to 500 g as maximum.

From experiments and observations made by the present author in experimental ponds in Syria, *T. zilli* and *galilea* – under favorable pond conditions – grow rapidly within the first 4 to 5 months, during which time 300 to 350 g were gained. Selected specimens from these crops were later on given sufficient space in spawning ponds for reproduction purposes. During the following three years, these breeders did not gain more than 100 to 150 g each. Cessation of growth, thus, is suggested and only adds confirmation to the above-mentioned observations as well as many others made into tilapia elsewhere[1]).

For all practical purposes with regard to the aim of achieving an economical yield from tilapia management, it is most important to know the optimum economical size of single specimen to be removed from the population. In other words, the knowledge of the particular size beyond which no economic gain can be expected, is the crucial factor upon which the tilapia management will have to be planned.

Another important factor as well, is the onset of maturation. From observations elsewhere, it became known that tilapia slows down in the gaining of weight at an age of about 6 months which is interpreted as response to the process of maturation. A confirming observation was

[1]) A further example as to the growth of *T. mossambica* is presented by HICKLING (1962). He reports that 6 tagged females gained, within the first 7 to 8 months, 250 to 280 g each. From then on, growth retarded considerably and, finally, practically ceased after the age of 10 months.

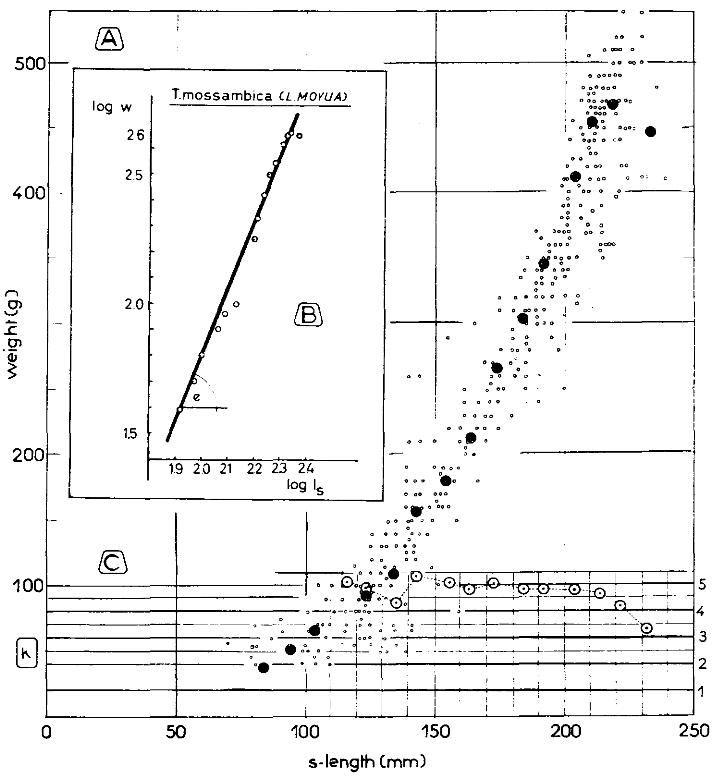

Fig. 4: Graphical presentation of: A= Length-weight relationship of T. *mossambica* (both sexes combined) from Lake Moyua/Nicaragua, and B= Allometric line (see BANK, O. (1954): Das Längen-Gewichtsverhältnis des Karpfens. *Fischw.* 4 : 134—138 –further references are presented herein). In accordance with the allometric equation: y= bx^a (y= weight (g), a= tangents of angle e, b= value of log, weight at log. Ls= 1) a and b have been computed: a= 2.540; b= 0.00259. From the above mentioned value for b it follows that *T. mossambica* fry weighed at a length of 10 mm= 0.00259 g each. This computed figure corresponds well with the weight obtained for single specimen being 10 mm in length: 0.0027 g.

Since it appears that L. Moyua's tilapia population is positively linked with the biocoenetic relationship the value for a (2.540) is suggested as a model-figure for population studies into the well-being of *T. mossambica* stocks in Central America elsewhere. Length and weight data can easily be obtained and either plotted on logarithmic graph paper or turned into the log form to be plotted on ordinary graph paper. The angle e can then easily be measured. As long as it exceeds about 65° the relationship is good.

C = graphical presentation of factor k.

made from the Lake Moyua population. Table VI and Figure 4 depict a break in growth – or better well-being – of specimens which belong to size groups from 120 to 130 mm (80 to 100 g) demonstrated by the factor k, which is lowest for the 107.5 g fish. This interference, doubtless, occurred in connection with the first spawning and thus suggests that the latter takes place the first time when the individual weight approaches the 80 to 100 g weight margin or, the fish attains a length of 12 to 13 cm. However, maturation by no means prevents fish from further growth if habitat conditions (biogenic capacity) are favorable. Figure 4, however, shows that growth is only speedy during the first months of life; later on it gradually slows down until a standstill demonstrates that cessation of growth is a function of size.

Since continuation of growth, after maturation of fish, has taken place in Lake Moyua its favorable conditions are indicated for all following economical size groups up to 400 g. The population as a whole, therefore, seems to be in positive ecological relationship to the habitat – probably with the exception of sizes exceeding 400 g which should be removed.

Summing up the conclusions drawn as to the rate of growth and the well-being of the *T. mossambica* population of Lake Moyua in Nicaragua, the following might be said:

a. *T. mossambica* reaches maturity at a length between approximately 12 and 14 cm, which corresponds to a weight of 90 to 110 g, which fish have gained after about 5 to 6 months;
b. Onset of maturation is indicated by a decrease of the coefficient of condition;
c. Gain in weight of a single specimen slows down after maturation is reached;
d. Growth appears to cease after the single specimen has reached the 400 g weight margin.

Remark: Unfortunately, there was no possibility for the present writer to compare the relationship between length and weight of *T. mossambica* populations from elsewhere. The graph made available by LOWE (MCCONNEL) (*l.c.*) refers to the length-weight correlation of *T. esculenta* and *T. variabilis* in Lake Victoria.

Just how important it is to follow-up the growth (length-weight correlation) of *T. mossambica* wherever they might have been planted or escaped in wild waters, will be demonstrated by the following reflection: If, for example, the Lake Moyua population had been closely observed from the very beginning, the break in well-being of its members just during the onset of maturation might have induced the idea that this indicates the optimum growth margin, and, thus, such fish should not be allowed to remain any longer in the lake. Onset of maturation, therefore, might have been easily explained as a pronounced ecological effect on growth. This explanation had been the more likely since a good deal of information on tilapia in general and *T. mossambica* in particular, emphasizes the rapid approach of the stunting momentum. The single fish weight of about 100 g (*i.e.* the weight at onset of maturation), in addition, might have even created the idea that this is a fairly good weight, simply because from places where this species is Asia-type cultured, 100 g is a good weight, which makes a market fish.

With regard to MYERS' proposal to select one or more of the native *Cichlasoma* members for cultivation in ponds, it appears essential to have the species populating Nicaragua's waters reviewed with regard to their natural growth.

The following *Cichlasoma* regularly appeared during experimental fishing in Lake Managua during 1962. Their market acceptance greatly depends upon sizes. Normally, specimen below 20 cm in total length are not marketable at all. Native *Cichlasoma*, therefore will only be of economic importance if their average size meets the market limits.

TABLE VII

Cichlasoma species of Lake Managua (and other waters) and their market value

Species	Local name	Average size in catch (mm)	Market value
dovii	guapote	200—400 (700)	very good
managuense	lagunero	200—400 (700)	very good
citrinellum	mojarra	100—250 (250)	good for bigger sizes
Cichlasoma spp	mojarra	100—200	nil

Note: Figures in parantheses refer to maximum sizes observed; size figures refer to total length.

Out of altogether 11 native *Cichlasoma* known to inhabit both the Great Lakes and other waters, only the species *dovii* and *managuense* find a ready market where they obtain a (relatively) good price, provided they exceed more than 30 cm in length. (Actually, fishermen do not land smaller ones because of the non-acceptance risk). The mean corresponding weight of fish above 30 cm in length was found to be from 500 to 700 g. Specimen exceeding 700 g are extremely sparse and for all practical purposes, are luxury fish. Both species are undoubtly piscivorous – not only specimens of the larger sizes – which became apparent from analyses of the stomach contents (about 70% of food consists of fish). If one considers the crowdings of circuli, which might have been formed by the onset of the dry season, as reliable, then specimens of 30 cm of length are from three to four years old. All other *Cichlasoma* which are grouped under the local name "mojarra", although palatable, are not readily accepted because of their small sizes which rarely exceed 250 g. All of them are mainly omnivorous but *citrinellum* tends to be piscivorous and was found to feed occasionally on *Melaniris* and any fry available. Since larger specimen have not been caught or observed in fishermen's catch, 250 g suggest to be the maximum weight margin.

In accordance with the above "economical" classification of *Cichlasoma* that number, appearing to have fish culture potentials is, for all practical purposes, reduced to only two species. However, both are carnivorous. The disadvantage of carnivorous species has already been mentioned above.

3.2.3 *T. mossambica* in the light of its broad tolerance of salinity.

As already mentioned on page 1 *T. mossambica* can tolerate fresh to saline water. Consequently, the fish not only can spread out to all inland waters but migrate into and live in any brackish to marine environment as well.

It is of importance, therefore, to view the possible effects which might have to be faced in case *T. mossambica* did invade the coastal waters of Nicaragua. That the newcomer will most likely introduce new elements to the given ecosystems of estuaries, their stability and continuity, is of no doubt. Furthermore, it is unlikely that those brackish water ecosystems, which have evolved over long periods without substantial human interference, have not filled all habitat niches. In other words, *T. mossambica* in case it did reach the described area either by itself (which is extremely unlikely) or by any other mode of "travel" (accidentally, or by introduction by unqualified persons etc. which is likely) will have to establish its place by suppressing other members of the invasion area. There are some rather substantial barriers, however, which certainly will considerably reduce what is generally called the "biological power" of that exote.

a. The entire brackish water area along the west coast of Nicaragua is subject to tidal fluctuations. It was estimated that during low tide about 80 to 90% of the so-called "lagunas" fall completely dry and that happens for about 3 to 4 hours twice a day. Only during the wet season does river water in alternating quantities flow along the dry-fallen estuaries. It is, therefore, impossible for *T. mossambica* to dig spawning nests for reproduction in the lagoon areas proper. In addition, the fish do not reproduce in an environment whose salinity exceeds 30‰ (VAAS & HOFSTEDE (*l.c.*)). A higher figure, as such, is quite common in Nicaragua's estuaries. Consequently, the only suitable places for spawning would then be in the tributary rivers. This again is hardly possible because, when the rivers carry sufficient water this is brought down with remarkable velocity. During the dry season only scattered rest-waters (pools) occur in the lowest courses of rivers near the mingling areas between fresh and salt water. Although these sites have almost nothing in common with the usual spawning places, known to be selected by tilapia, nevertheless spawning might be conducted to some degree there. The number of recruits, however, will be greatly diminished by all other "rest-water" inhabitants, especially catfish and mojarras. In addition, survivors would have almost no chance to secure sufficient food because of its scarcity and the presence of considerable numbers of other small fish which take shelter between the big boulders. The recruitment process, as follows from the above, is faced by a number of serious obstacles which doubtless will result in an extremely strong reduction of the number of offspring of *T. mossambica*, should the latter ever happen to invade these regions.

b. The possible effect of any *T. mossambica* survivors which might succeed in invading the brackish water area will be discussed in the following. It is a well-known fact, although no explanations as to the why can be given, that most of the native species inhabiting the estuaries are faced with prejudices from local consumers. For all practical purposes, catadromous mullets, mass-aggregating at the beginning of the rainy season, are nowadays considered as an appreciated market species. All others, mainly rays and sharks, and a tremendous number of catfish, cannot be marketed economically.The same applies to jacks, which beside bluefish, sometimes occur in the catch and whose numbers increase towards the ocean sides of the lagoons. *Cichlasoma* (mojarras) appear only during high floods, their number, however, is small as is the individual size. Therefore, it is only too obvious, that *T. mossambica* cannot be expected to develop a commercial harm in the estuarian ecosystems whatsoever. The only friction which might occur is that with migrating mullets, but this will have a seasonal character only. Finally, heavy predators (sharks and rays) populating the estuaries will suppress strongly on any establishment of a tilapia stock. Following from the above there is almost no likelihood that the newcomer will ever be able to establish permanent dominance or even a brutal dominance, although they are doubtless able to acclimatize individually in saline waters.

In concluding what has been illustrated under (a) and (b) above it is very unlikely that *T. mossambica* will ever have (or develop) sufficient biological (ecological) power to press on the ecosystems, although it would appear to be of great economical advantage if it did.

3.2.4 *T. mossambica* in relation to the fresh water fish fauna.

It may be assumed that *T. mossambica* does escape from Lake Moyua and establishes stocks in other inland waters of the country. With all possible certainty it can be already precluded that no harm whatsoever will be affected in all the countrys' crater lakes, simply because they are known only to possess a very restricted economical value mainly because of limnological characteristics and extremely restricted accessibility.

The two Big Lakes (Lakes Managua and Nicaragua), certainly do have a commercial value although their fish fauna is composed mainly of species which are not regarded as marketable as yet. (Here again, no reasons for this situation can be given). (See also FAO (RIEDEL) (1964)). Present fishing activities, are restricted to lagunero and guapote and sometimes bigger-sized mojarra only. All of those are known to inhabit the edges of the lakes. As could be seen their growth is slow and all are piscivorous. If *T. mossambica* were to succeed in spreading out to these waters, its reproduction would therefore be confronted with a strong predator pressure exercised by the above *Cichlasoma* which certainly will lead to a considerable numerical reduction of tilapia recruits, which will be preyed upon. Thus, there develops a fair chance for a greater development of appreciated *Cichlasoma*, although some feeding competion between the youngs of the latter genus and those of tilapia may occur. Adult tilapia, however, do not appear to come into direct food competition with other species' adults since they prefer open water areas and only approach marginal stripes for spawning when food intake decreases. The consequence of *T. mossambica* introduction, thus, should be assessed mainly with regard to the ecology of the open water areas of both lakes. These do not have any valuable market fish whatsoever. The establishment of *T. mossambica* in this very area which makes up about 80 to 90% of the lakes' total surface, would thus be of great an advantage from the economic point of view. The presence of predators (*Brycon*, *Rhamdia*, *Lepistosteus* and *Gobiomorus*) populating the open waters of the lakes, and above-mentioned marginal conditions will certainly act as a substantial controlling factor which will prevent any stunting tendency of the tilapia population.

The presence of numerous small water bodies, either permanent or seasonal, natural or semi-natural (irrigation canals, water storage tanks etc), spread all over the west of Nicaragua has attracted some of the rural people to stock them with fish from the native fauna. Quite a good number of these waters have been visited and investigated by the present writer in the light of making best uses of them. It was clearly revealed that, whenever and wherever *Cichlasoma* appeared, they proved to be extremely small in size and in excessive abundance. These observations clearly indicate again that native *Cichlasoma* do not appear to have favorable growth characteristic making them potential species for cultivation. Other waters visited had no fish stock at all, although they are waterfilled the whole year round. Most of them had a good growth of higher aquatic vegetation (*Typha*, *Phragmites* beside *Scirpus*), as well as planktonic life. That all those waters would not only sustain but well support a *T. mossambica* population, is doubtless. They, thus, could easily contribute to the daily diet of people around. Any introduction of native *Cichlasoma* would hardly result in as good a yield as can be expected from tilapia. Finally, these waters of a seasonal character only (like Las Playitas near Lake Moyua) ought to be mentioned which occur with the rains and keep water until half of the forthcoming dry period. That those waters, which have an optimum fertility, should be stocked with the quickly growing *T. mossambica*, goes without saying. The fish can easily be removed when the water starts shrinking which would not require any skill but only bare hands. The present author estimates the "annual" yield from those small pools and "ponds" to be in the neighborhood of from 400 to 500 kg/ha. About 35 separate bodies of water of the above-described type have been counted around Managua. Their total surface was from 15 to 20 ha which could easily produce from 6 to 10 tons of tilapia annually. The danger of overcrowding is completely eliminated.

Here again, it can be justifiably concluded that, if *T. mossambica* were to be stocked the only effect would be an improvement of these waters, which, for the time being, have no economical value whatsoever. In analogy with observations mentioned above, this value is not likely to be achieved by native *Cichlasoma*.

Summary

a. This paper presents an account of (i) fecundity studies into *T. mossambica* under Middle Central American conditions and (ii) limnological investigations into Lake Moyua/Nicaragua which have been performed during 1961/62.

b. Data obtained as to fecundity of *T. mossambica* are discussed in the light of the term prolificy and with regard to ecological and biological characteristics of Nicaraguan waters and native fish fauna.

c. A more detailed contemplation about the possible effects of a spread out or transplantation of *T. mossambica* into other Nicaraguan waters concludes the paper.

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