

Management Strategies for Intensive Culture of Nile Tilapia (*Oreochromis niloticus* L.) in Tanks Using Drainage Water in Al Hassa Region of Saudi Arabia

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ABSTRACT. Three experiments during a growing season of 210 days (April-October) in Al Hassa region of Saudi Arabia demonstrated that Nile tilapia (*Oreochromis niloticus* L.) could be grown from an average weight of 20 g to over 300 g in concrete tanks giving a production of about 20 kg/m³ with a stocking density of 64 fish/m³. Drainage water was flowing through the tanks at the rate of 1 L/min/kg fish biomass, the tanks were uniformly aerated and a commercial fish feed with 34% dietary protein was fed to the fish. To provide 20 g fingerlings for early stocking, the fingerlings should be produced in September - October and overwintered for early stocking in April. The fingerlings produced and stocked in the same growing season will not reach a minimum marketable weight of 250 g.

The fingerlings (av. wt. 4 g) stocked at a density of 40/m³ in triplicate tanks attained an average weight of 544 g with a corresponding yield of 21.7 kg/m³ in 415 days. Average food conversion ratio was 2.16. In another experiment 64 fish/m³ with an average weight of 19 g were stocked in duplicate tanks and reared for one full growing season. An average weight of 361 g and average yield of 23.1 kg/m³ were obtained. The average food conversion ratio was 2.14. In the third study the fish had an average weight of 40 g and were stocked at a density of 42.6/m³ in duplicate tanks. They attained an average weight of 323 g in 164 days which gave an average yield of 13.4 kg/m³. The food conversion ratio was 1.96.

Tilapia culture is a very recent practice in Saudi Arabia. Since 1977 four species of tilapia - *Tilapia zilli*, *Oreochromis spilurus*, *O. niloticus* and *O. aureus* have been introduced. *O. niloticus* has become the most popular species for freshwater culture. The culture of *T. zilli*, *O. spilurus* and *O. aureus* was also tried in seawater cages near Jeddah (Osborne 1979). In view of the limited resources of freshwater in Saudi Arabia possibilities of utilizing drainage water from Al Hassa oasis for fish culture were investigated and *O. niloticus* and *O. aureus* were successfully raised to marketable size (Siddiqui 1983, Siddiqui and Adam 1985, 1987, Siddiqui and Howlader 1987). In these studies low density culture was practiced, but in view of the availability of cheap energy, long growing season and good market price for tilapia, it was realized that information for intensive culture of tilapia should be developed.

In Saudi Arabia the optimum temperature for tilapia growth is available for 210 days (April - October). The preferred marketable size for tilapia is about 300 g. No information is available on management strategies for raising tilapia fish to a marketable size in intensive tank culture. Therefore, the objectives of the present study were to grow Nile tilapia, *O. niloticus*, at high densities to marketable weight of about 300 g, giving a yield of 20 kg/m³ in one growing season. Culture strategies to be followed in regard to fingerling size and stocking density were investigated in three experiments.

Materials and Methods

Drainage water

Al Hassa oasis has an elaborate drainage system running parallel to the irrigation system. There are three main canals. Drainage canal 1 (D1), the source of water for the present fish culture, is the main drainage canal and drains the western side of the oasis. The water discharge in this canal ranges from 2 to 7 m³/second, and the salinity of the water ranges from 3.2. to 4.8 ppt (Siddiqui 1983) in different months of the year.

Experiment 1

The fish were reared for 415 days, from July 11, 1985 to September 1, 1986 in three tanks (8 × 5 × 1 m) with a water depth of 50 cm in each tank. 800 fingerlings with an average weight of 4 ± 0.1 g were stocked in each tank. Water was pumped directly from the drainage canal into each tank and a flow-through system was established in each tank maintaining a flow rate of about 1 L/min/kg fish biomass, except in winter months (November-March) when tank water was changed once in the morning and once in the evening. From April to September 1986 the tanks were continuously aerated.

A commercial fish feed with 34% crude protein was fed to the fish at the rate of 6% body weight daily, from July 11 to July 31, 1985, but as the fish grew in weight the feeding rates were adjusted to 5% (August to October, 1985), 3% (April 1 to June 9, 1986) and 2% from June 10 to September 1, 1986. The food was offered in the morning and evening, initially seven days a week, from July 11 to September 11, 1985, then six days a week afterwards. From April 1986 to August 1986 the fish were fed four times a day. The rate of feeding was adjusted every two weeks based on average weight of 20 fish from each tank. In winter months (November 1985 to March 1986) the rate of feeding depended upon water temperature. When temperature was 15.9°C and below there was no feeding; from 16.0 to 19.9°C, 1% of the body weight; 20.0 to 21.9°C, 1.5%; 22.0 to 25.9°C, 2%.

At the end of the experiment, 50 fish were randomly selected from each tank and were individually measured, weighed and sexed. From this data average and total weights of all fish, males and females in each tank were estimated.

Experiment 2

This study was conducted in two tanks, each measuring $2.5 \times 1.5 \times 1.2$ m and holding 3.75 m^3 . A continuous flow rate of about 1 L/min/kg fish biomass was maintained. In each tank 240 fingerlings with an average weight of 19 ± 0.5 g were stocked on March 31, 1986 and harvested on October 29, 1986 (210 days). Continuous aeration was provided in each tank.

The commercial fish feed offered was the same as that fed in Exp. 1. The fish were fed at the rate of 5% (April 1 to May 5, 1986), 3% (May 13 to October 1, 1986) and 2% (October 2 to October 29, 1986) of body weight daily. The food was offered in equal amounts four times a day and six days a week. The feeding rate was adjusted every two weeks as in Exp. 1. At the end of the experiment individual weight and sex of fish from each tank were determined.

Experiment 3

For this study two tanks (3.75 m^3) were stocked with fingerlings of *O. niloticus* averaging 40 ± 0.94 g at a density of 160/ tank ($42.6/ \text{m}^3$) on March 31, 1985 and reared for 164 days. Water flow and aeration were similar to Exp. 1 and 2. The fish were fed the same commercial fish feed as used in previous experiments at the rate of 3% of body weight daily. The ration size was adjusted every two weeks as in Exp. 1 and 2. The fish were fed daily except on sampling days, morning and evening for initial four weeks, then four times a day and six days a week. After 164 days all fish were harvested, counted and weighed.

Water analysis

Maximum-minimum water temperatures, dissolved oxygen (DO), pH and ammonia levels were measured daily, and biochemical oxygen demand (BOD), total alkalinity (as CaCO₃) and salinity were determined weekly in one tank in each experiment. All measurements except ammonia were made according to the American Public Health Association Standard Methods for Water Analysis (1975) using a HACH water analysis kit. Ammonia was determined according to the method of Boyd (1979) and salinity by a salinometer.

Results

Experiment 1

Data on stocking rate, survival rate, initial and final mean weights, average daily gain (g/fish/day) and food conversion ratio are given in Table 1. Growth curves are shown in Fig. 1. Survival rates were 99.7%, 100% and 99.5% in three tanks. The mean final weights per fish in three replicate tanks were 537 g, 562 g and 533 g with average daily gain of 1.28 g, 1.35 g and 1.27 g respectively. The food conversion ratios were 2.14, 2.15 and 2.14 and the yields were 21.4 kg/m³, 22.5 kg/m³ and 21.2 kg/m³.

Experiment 2

A summary of data is given in Table 1, and the growth curves are shown in Fig. 2. No mortality was recorded. The mean fish weights in 210 days were 372 g and 349 g. Average daily weight gains were 1.68 g and 1.58 g. The food conversion ratios were 2.11 and 2.16. The total yields were 22.8 kg/m³ and 22.3 kg/m³.

Experiment 3

The results are given in Table 1 and growth curves are shown in Fig. 3. In 164 days the average final weights in duplicate tanks were 322 g and 325 g with average daily gains of 1.71 g and 1.72 g and total yields of 13.2 kg/m³ and 13.3 kg/m³. The food conversion ratios were 1.93 and 1.99.

Discussion

In Al Hassa region of Saudi Arabia a survey was conducted to find the preferable market size for cultured tilapia (Siddiqui 1983). It was found that people of different ethnic origin preferred fishes of different sizes, but the most popular size was 300 g and above.

The growing season for tilapia in Al Hassa region is 7 months, from April to October. The present study showed that tilapia fingerlings with initial weight of 19 g (Exp. 2) and 40 g (Exp. 3) reached marketable weight of about 300 in 210 days and 164 days respectively. The experiment with small fishes (Exp. 1) started late (July, 1985) and therefore these fishes were reared for 111 days only in 1985 growing season. The average initial weight was 4 g and final weight after 111 days was 73 g. The large fishes (Exp. 3) were cultured for 164 days and at the end of the experiment the average weight was 323 g. The medium size fishes were grown for 210 days and their mean weight was 361 g (Table 1). If it was assumed that the growth for the small fish beyond 111 days proceeded in a generally linear fashion, as that of medium size fish, for 210 days then the small fishes would have attained an average weight of 250 g (Fig. 4). Thus, it becomes apparent that to reach a marketable size (about 300 g) in one growing season (210 days), the initial stocking average weight of Nile tilapia should be about 20 g. To achieve this objective the fingerlings produced in September and October should be overwintered and stocked in growing tanks in the last week of March when the water temperature rises above 20°C. Fingerlings produced in the same growing season can not reach the marginal marketable weight of 250 g in the remaining days of the season in high density culture.

Table 1. Data on stocking rate, growth and yield on Nile tilapia under different culture treatments

Duration of Experiment (days)	Number and weight of fish				Average daily gain (g/f/day)	FCR	Yield (kg/m ³)
	At start		At end				
	No. of fish	Mean weight (g)	No. of fish	Mean weight (g)			
Experiment 1							
415	800 (40/m ³)	4	798	537	1.285	2.14	21.4
415	800	4	800	562	1.346	2.15	22.5
415	800	4	796	533	1.247	2.18	21.2
Experiment 2							
210	240 (64/m ³)	19	240	372	1.681	2.11	23.8
210	240	19	240	349	1.579	2.16	22.3
Experiment 3							
164	160 (42.6/m ³)	40	154	322	1.708	1.93	13.2
164	160	40	153	325	1.725	1.99	13.3

The sex ratio of the fish in three experiments was 1 : 0.46 (♂ : ♀). At the end of Exp. 1 the average weight of males was 635 ± 120 g and females 344 ± 67 g. Similarly in Exp. 2 the males average weight was 399 ± 42 g and the females average weight was 248 ± 23 g. Better average weight and yield were possible if males were more in the population. From these experiments it also became evident that to obtain a yield of about 20 kg/m^3 in flow-through tanks in one growing season of 210 days a stocking rate of 60 fish/m^3 with an average initial weight of about 20 g is required. In case the initial weight of fingerlings is about 40 g, the same yield could be obtained by stocking 50 fish/m^3 .

The survival rates ranging from 95.6 to 100% were exceptionally high indicating that optimum environmental conditions were available to the fish. The growth rates recorded during the present study appear to be comparable to those reported for tilapias (Balarin and Haller 1982). A good growth performance appears to be because of the availability of optimum temperature of 26 to 31°C during the growing period (April - October).

Lauenstein (1978) and Balarin and Haller (1982) reported production of tilapia of 120 kg/m^3 in tank culture. However, at these densities growth inhibition was often noted. In such practices a large quantity of water is required, and in view of scarcity of water in Saudi Arabia such production levels are not possible.

The food conversion ratio ranged between 1.93 and 2.18 in different tanks and appears to be comparable to values reported for tilapias in other studies (Balarin and Haller 1982). Generally the smaller fishes were more efficient in feed utilization than larger ones.

The monthly average maximum water temperature ranged from 18.1 in January to 31.3°C in July (Figs. 5 and 6). During the growing period (April - October) the maximum water temperature ranged from 26.9 to 31.3°C. The temperature remained suitable for tilapia survival and growth and did not drop to lethal limits in winter. The monthly average maximum temperature remains above 18°C and feeding and growth have been reported at 16°C and above, though at reduced levels. Other environmental parameters like pH, total alkalinity and dissolved oxygen levels were within optimum limits of tilapia survival and growth (Figs. 5 and 6). Nile tilapia is euryhaline (Wohlfarth and Hulata 1983) and its culture in salinities of 8-10 ppt gives better growth than in freshwater because at this salinity no energy is spent for osmoregulation. The salinity of drainage water is about 4 ppt and this might have effected better growth than in freshwater. The ammonia levels never build up to critical levels. The exact lethal level of unionized ammonia for tilapia is not known, but it is generally believed that tilapia and channel catfish have relatively higher tolerance for ammonia. 24 h lethal limit for

channel catfish is 2.766 mg/L of unionized ammonia (Robinetter 1976), and its growth is affected at a level of 0.12 mg/L. Such ammonia concentrations were not built up in these experiments indicating that culture condition appears to be satisfactory.

Acknowledgement

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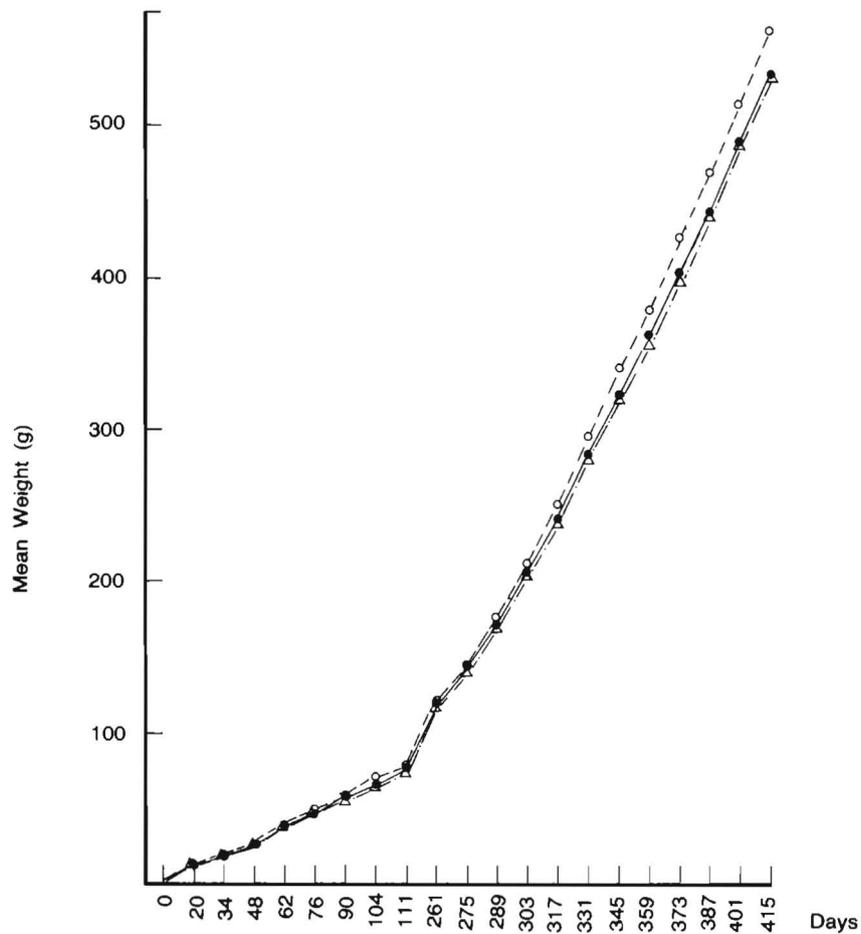


Fig. 1. Growth of *O. niloticus* in three replicate tanks at a stocking rate of 40/m³ with initial average weight of 4 g.

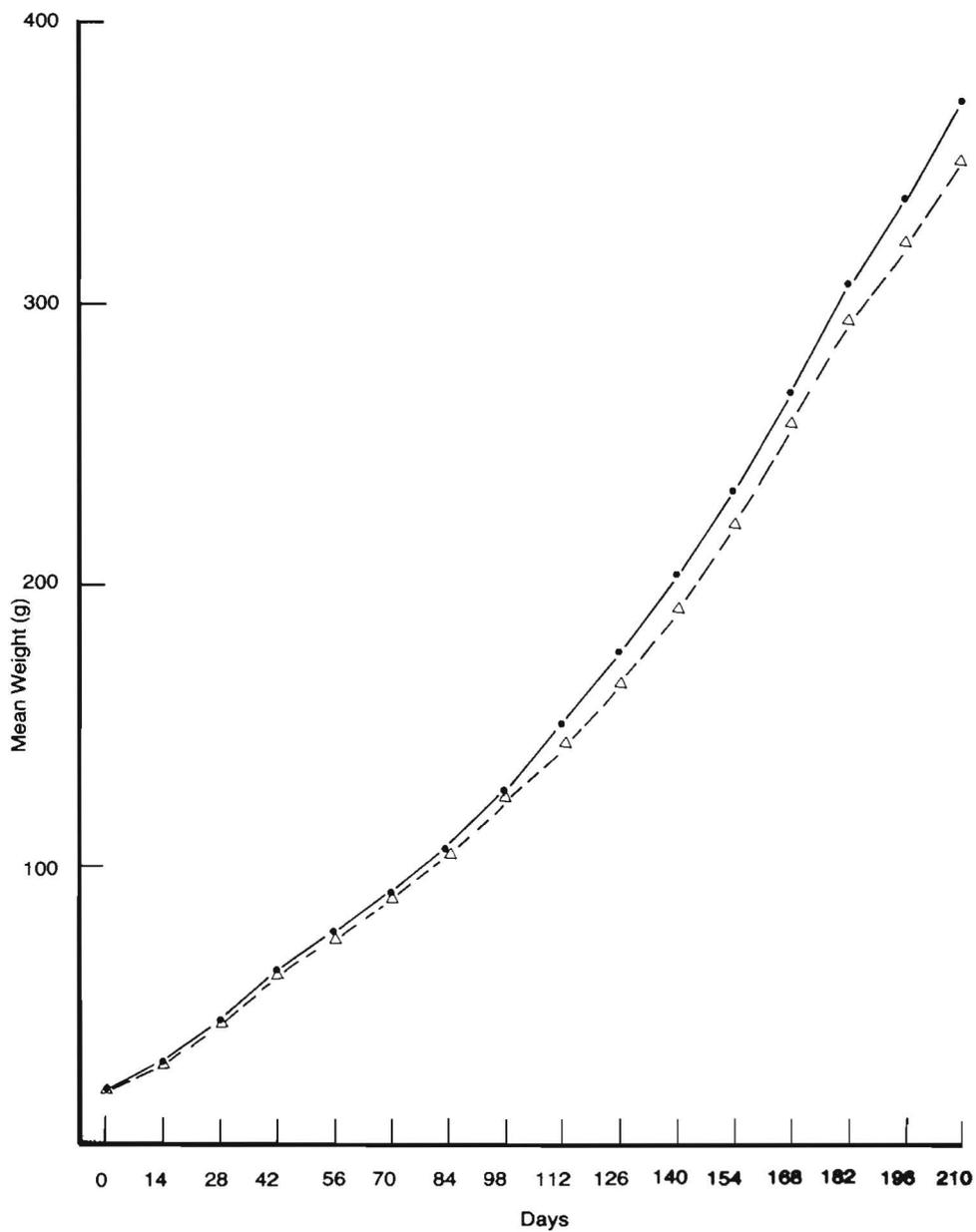


Fig. 2. Growth of *O. niloticus* in two replicate tanks at a stocking rate of $64/m^3$ with an initial average weight of 19 g.

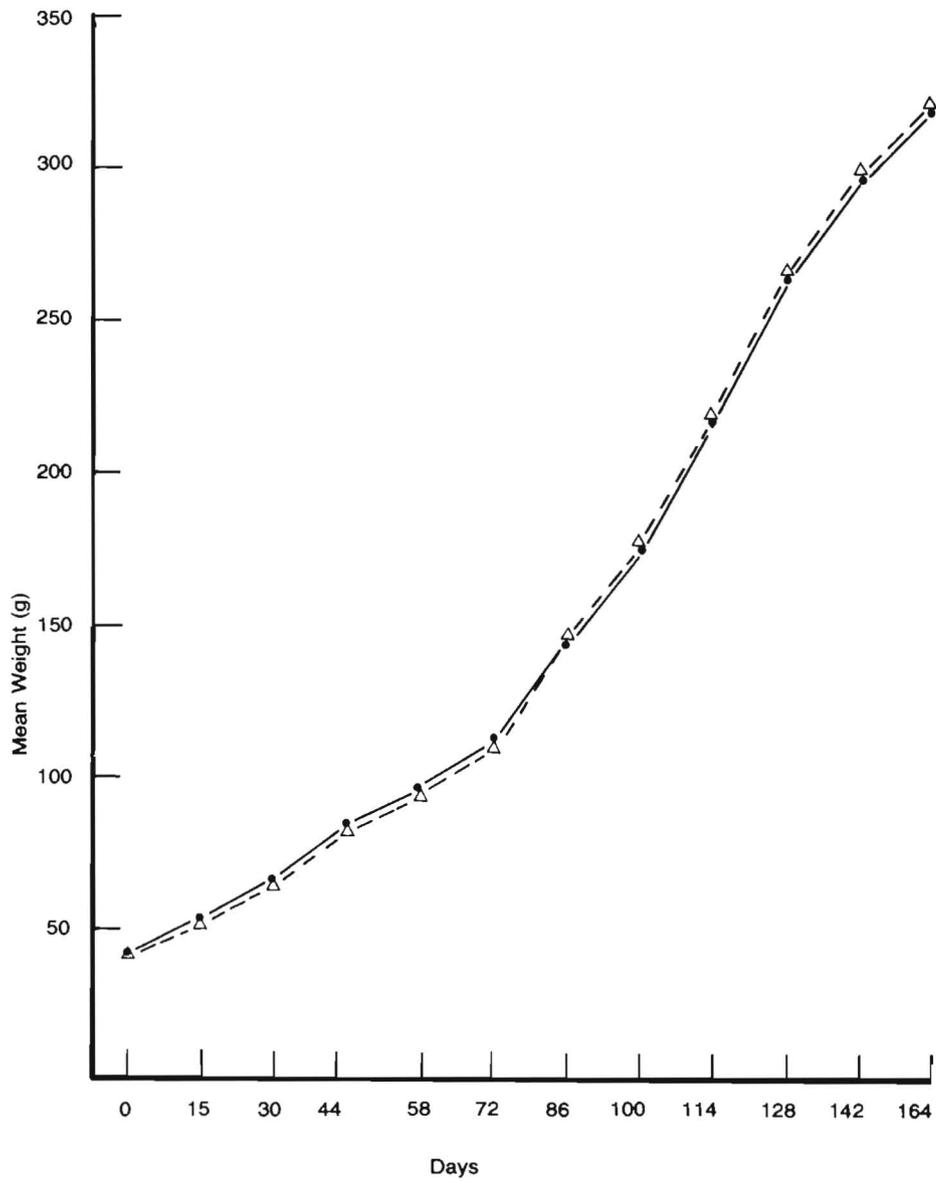


Fig. 3. Growth of *O. niloticus* in two replicate tanks at a stocking rate of $42.6/m^3$ with an average weight of 40 g.

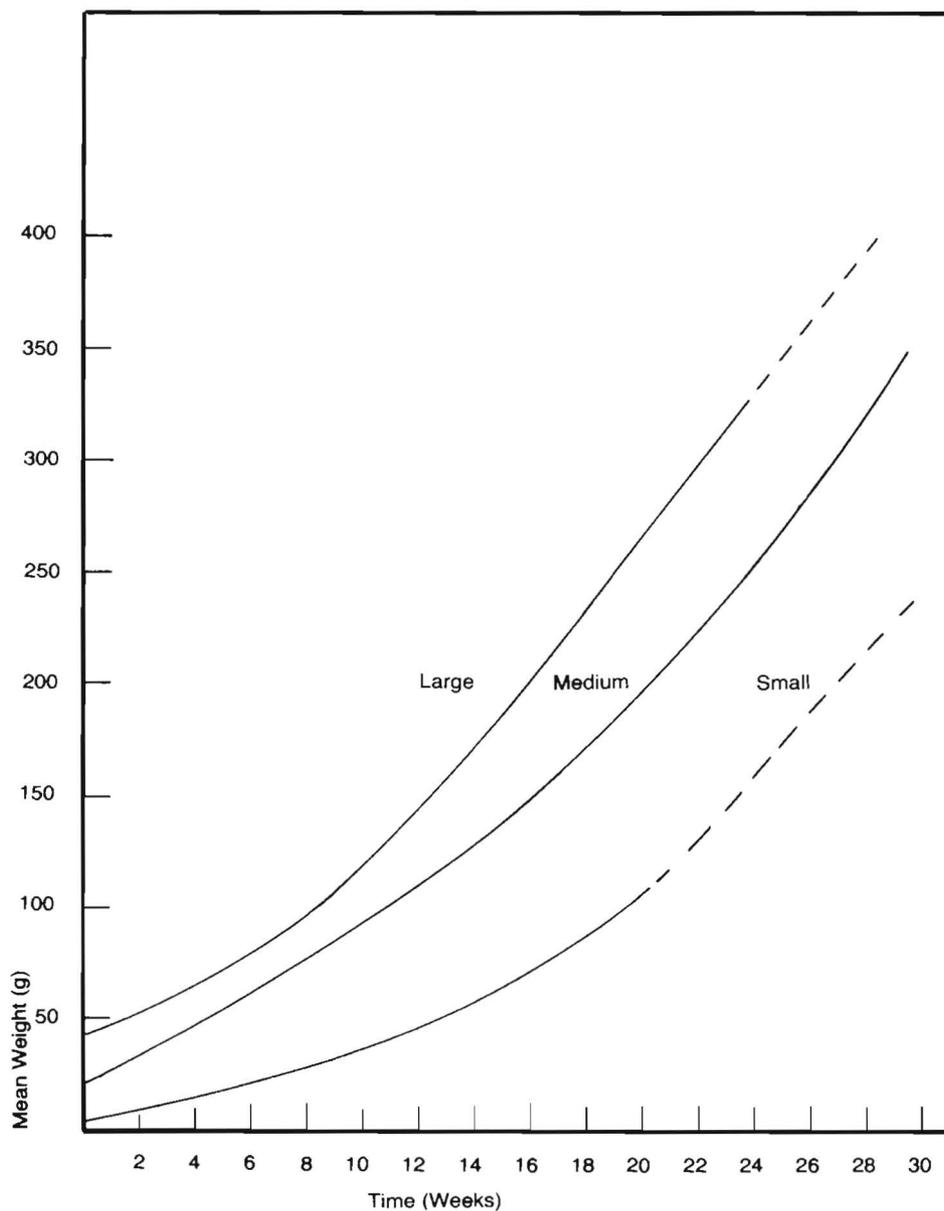


Fig. 4. Growth curves of *O. niloticus* reared in tanks with different starting sizes. The broken lines represent extrapolation of growth for 210 days.

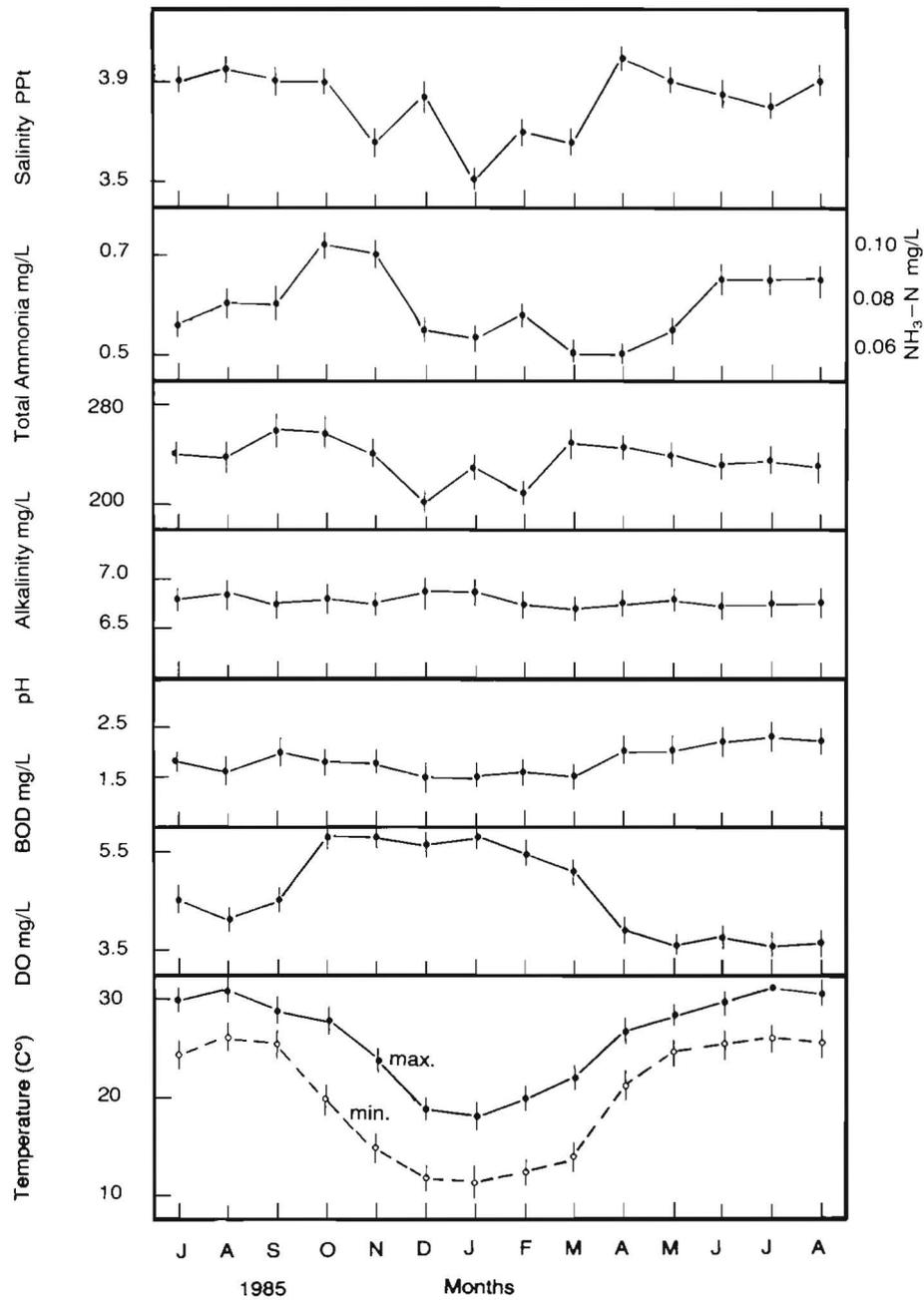


Fig. 5. Water quality parameters in a rearing tank with 40 fish/m³ (mean \pm SD).

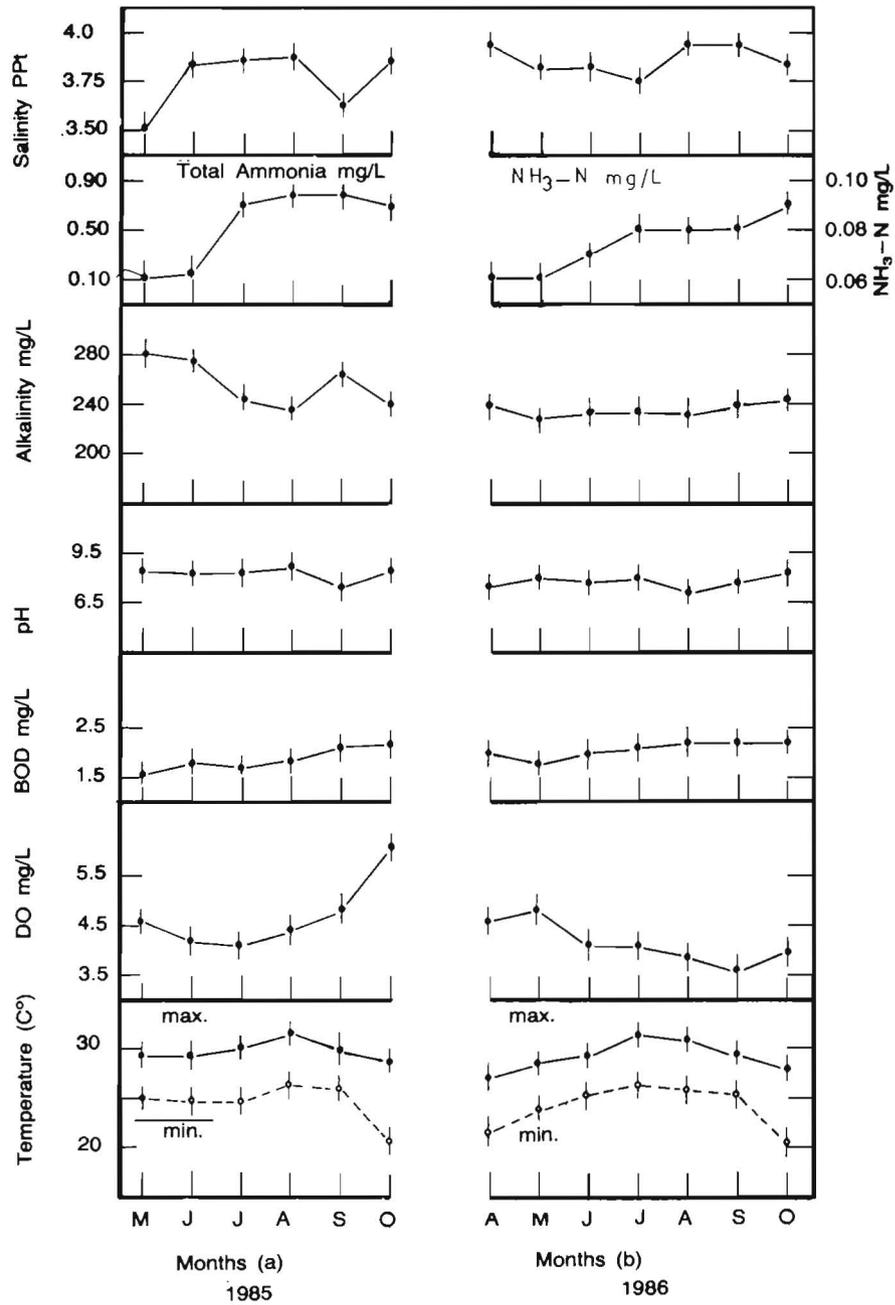


Fig. 6. Water quality parameters in a rearing tank with 42.6 fish/m³(a) and 64 fish/m³(b) (mean ± SD).

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الخطط الادارية للزراعة المكثفة لسماك البلطي النيلي

(*Oreochromis niloticus* L.)

أوريوكرومس نيولوتيكس في أحواض باستخدام
مياه الصرف في منطقة الأحساء من المملكة العربية السعودية

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أثبتت نتائج ثلاث تجارب خلال فترة نمو مدتها ٢١٠ يوماً من شهر أبريل إلى شهر أكتوبر، أجريت في منطقة الأحساء من المملكة العربية السعودية على إحدى أنواع أسماك البلطي النيلي المرباة في أحواض أسمنتية وهو (*Oreochromis niloticus* L.) وتبين أنه من الممكن الحصول على سمك في نهاية فترة التربية بوزن يصل إلى ٣٠٠ غرام وما فوق من وزن كان ٢٠ غراماً في بداية الفترة، كما أمكن الحصول على إنتاج بمعدل ٢٠ كغم/ متر مكعب عن كل ٦٤ سمكة وضعت في متر مكعب واحد. مياه الصرف كانت تتدفق خلال الأحواض بمعدل ١ لتر/ دقيقة كغم كتلة حية، كانت الأحواض منتظمة التهوية وكان غذاء الأسماك تجاري يحتوي على ٣٤٪ بروتين مغذي كانت تتغذى به الأسماك. فمن أجل الحصول على أصبغيات بوزن ٢٠ غراماً لكل منها تستخدم في التربية للمرحلة القادمة فإن علينا تربية مجاميع من ناتج شهر (سبتمبر- أكتوبر) على أن تحفظ للمرحلة القادمة في أبريل. الاصبغيات المنتجة والمخزنة خلال موسم النمو ذاته لن تصل حتى لمعدل التسويق

المقبول وهو وزن ٢٥٠ غرام .

الاصبغيات (والتي معدل وزنها ٤ غرام) المخزونة في كثافة ٤٠ ٪ متر مكعب في ثلاث أحواض قد تم الحصول منها على معدل وزن ٥٤٤ غرام مع انتاجيات متشابهة حوالي ٢١,٧ كغم / متر المكعب في ٤١٥ يوما . وكانت نسب التحويل الغذائي ٢, ١٦ . وفي دراسة أخرى فقد تم تخزين ٦٤ سمكة / متر مكعب بمعدل وزن ١٩ غرام خزنت في حوضين وتم تربيتها لموسم نمو كامل وتم الحصول على معدل وزن وهو ٣٦١ غرام ومعدل انتاج ١, ٢٣ كيلو غرام / متر مكعب . ونسبة متوسط التحويل الغذائي كانت ٢, ١٤ . وفي الدراسة الثالثة فإن الأسماك المخزونة (والتي معدل وزنها ٤٠ غرام) في كثافة ٤٢, ٦ غرام / متر مكعب في حوضين وأنتجت معدل وزن ٣٢٣ غرام في ١٦٤ يوم والتي أعطيت معدل انتاجي حوالي ١٣, ٤ غرام / متر مكعب .