Effect of ambient seasonal changes in physical and chemical properties of the three types of ground water on the reproductive potential of *Oreochromis niloticus* reared in concrete ponds

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ABSTRACT

This study was conducted at the intensive fish farm of Arab Fisheries Company (AFC) to investigate the effect ambient seasonal variations of three types of ground water quality (pure aquifer, recycled aquifer water and 50% mixture of both) on the reproduction of *Oreochromis niloticus*, Highly significant increase in seed production per pond and newly hatched fry per kilogram of females per season were obtained in spring within the pure aquifer water (8013.33±5.89 seed/pond, 5520.00±3.62 seed/ kg female/season respectively). Highly significant ($p<0.05$) differences were observed during the four seasons under ambient condition for the three types of water.

The total fry production and/or relative fecundity of brooders were highly significant ($p<0.05$) 280041.25±40.3, 951.72±19.33 respectively under ambient condition of spring in pure aquifer water. In addition, highly significant differences ($p<0.05$) were found in water temperature among the studied four seasons.

Although a wide variation in the ambient seasonal changes, the quality of water in reproduction pond were within the optimal range that required for reproduction of O. *niloticus*.

Key words: ground water, water quality, reproduction, *Oreochromis niloticus*.

INTRODUCTION

Groundwater provides about twenty percent of the world fresh water supply, which represents about 0.61% of the entire world water (Columbia Water Center, 2009). Groundwater discharges often have an effect on quality of fish spawning and rearing habitat, and in biological productivity of streams (Alexander and Caissio, 2003; Gibert *et al*., 2008,).

In general, recirculation systems recycle about 90-99% of the daily cultured water, utilize water efficiently, allow for more intensive year-round fry propagation and fish production, and also maintain water quality and temperature within safe and acceptable ranges necessary for fish survival, growth, and reproduction (Van Gorder, 1994).

Tilapia is a well known fish of warm-water aquaculture because it has better tolerance than most commonly farmed freshwater fish regarding salinity, water temperature, dissolved oxygen content, and ammonia concentration. Moreover, its easily spawning, wide variety use of natural and artificial feed, rapid growth in warm temperatures and relatively low input costs, as well as, tilapia markets worldwide have expanded rapidly as a consequence of consumers' acceptability to both its good flesh and tasty flavor (Biswas *et al*., 2005; FAO, 2005).

Tilapia has the capability of breeding continuously throughout the year as long as the environmental conditions are suitable for spawning (Lowe-McConnel, 1958). However, in places that are characterized by marked fluctuations in temperature between summer and winter months, the distinguished characteristic of continuous spawning behavior of tilapia is often interrupted by cold temperatures in winter and high temperatures in summer (Fishelson, 1966).

The reproductive potential of tilapia has been reported to be influenced by many factors, including each of temperature (Hyder, 1970), salinity (Chervinski, 1982; Jalabert and Zohar, 1982), food (Bagenal, 1969; Miranova, 1977) population density and social factors (Fryer and Iles, 1972; Allison *et al*., 1979). The optimum levels of water quality for *Oreochromis niloticus* reproduction have been determined as 5 mg/l of dissolved oxygen, total ammonia and pH concentration ranged from 0.5-2.0 mg/l and 6.5-7.5 respectively (Ridha and Cruz 1998).

Tilapia male and female broodstock replacement brings about 16% increase in seed production, when compared with female replacement only with no broodstock exchange (Lovshin and Ibrahim, 1988). Therefore, it is recommended that broodstock be replaced after each period by a fresh batch (Little *et al*., 1993).

This study was conducted to evaluate water quality effects of ambient seasonal changes on three sources of ground water (pure, recycled aquifer water and the 50 % mixture of both) on the reproductive potential of Nile tilapia (*Oreochromis niloticus*) in concrete ponds.

MATERIALS AND METHODS

The present study was implemented in three groups of rectangular concrete ponds with water volume capacity of about 20 cubic meters. Three types of ground water were used (pure aquifer, recycled aquifer water and 50% mixture of both). The used ground water was considered the main source of irrigation and was pumped through pipeline net that innervated for the concrete ponds group that irrigated with pure aquifer water.

Mechanical recirculation system was used. The system was built on a simple technical design which ensures safe and effective function of the mechanical purification of water arriving from the reproduction ponds. In all ponds, water level was maintained at 60-80 cm according to ambient temperature. Water outlets were built at the bottom of ponds with standby tube as a way to control each of water flow, draining, and cleaning the study ponds. Air was supplied to the study ponds for improving oxygen capacity of fish reproduction ponds. In the design, air-blower machines (5hp each) were used.

Broodstock of *Oreochromis niloticus* were selected and stocked (30♀and 10♂) in each pond (20 m^3), was set so as to keep the bio-mass of the three pond groups constant while maintaining the sex ratio at 3:1 females to males, had average body weight of 284 grams. Males and females were replaced alternatively after each period according to ambient temperature.

The seeds (eggs, yolk –sac fry and swim-up fry) were collected from each pond by removing them from the mouth of the brooding females periodically in accordance with water temperatures that were different between seasons. Seed and sac-fry enumerated volumetrically.

Mean number of seed per pond was calculated by dividing the accrued total number of seed on the total number of brooding females per pond.

Seed production was quantified as number of seeds Kg^{-1} female and was analyzed for the entire duration. In this sense, the relative or quantum fecundity may be expressed as the number of seed produced per kg of brooding females (De Graaf *et al*., 1999).

Ponds were cleaned and water was changed at the time of seed collection. Brooding fish were fed twice daily, 6 days a week (at a range of 1-2% of their body weight with 40% protein pelleted fish feed).

Water samples were drawn periodically (weekly) from each pond and were analyzed to determine their chemical and physical characteristics. The work was carried out as follow:

1. Temperature and dissolved oxygen (DO) was measured, twice daily at 6 a.m. and 6 p.m. by using Oxygen-meter (model YSI 58).
2. pH was measured by using a glass electrode PH-meter (Digital Mini-pH-meter model 55), at 8 am. Transparency was measured by using Secchi disc (SD) according to Boyd (1990).
3. Salinity was measured by using an electrode-conductivity meter, Hach Comparison Apparatus (model Dril 2100) following the method reported by APHA (1985).

4. Total hardness was measured by titration method according to APHA (1985).
5. Total ammonia concentration was measured by using Hach Spectrophotometer Apparatus (model, DR 2010). The NH3-N was calculated from total ammonia according to Boyd (1990).

Statistical analysis

Data were analyzed using one and two-way ANOVA for fertilization levels and growth parameters of different fish species as factors. Statistical significance was set at the $P<0.05$ probability level and means were separated using Duncan's new multiple range test. The software SPSS, version 12 (SPSS, Richmond, USA) was used as described by Dytham (1999).

RESULTS

- Temperature (°C)

The highest mean values of water temperature were recorded during summer (34.10±0.69 to 34.50±1.73°C) all treatments, while the lowest mean values of water temperature were recorded during winter (23.80±0.51 to 24.30±0.52°C) for different investigated types of water. Highly significant differences ($P<0.05$) were recorded in water temperature during the different seasons (Fig 1).

Dissolved Oxygen (DO)

Dissolved oxygen content of water in reproductive ponds ranged between 4.48±0.42 and 4.80±0.61 mg/l in aquifer water during autumn and spring; and between 4.87±0.80 and 5.35±0.53 mg/l in mixture water during summer and winter; and between 5.73±0.35 and 5.99±1.0 mg/l in recycled water during summer and winter respectively (Fig. 2). The results showed that there were no significant differences ($p <0.05$) among different seasons for the dissolved oxygen content in the experimental ponds, except aquifer water.

- Hydrogen ion Concentration (pH)

Mean values of pH were ranged between 7.13±0.09 and 7.25±0.06 in aquifer water during summer and winter respectively; and between 7.66±0.05 and 8.12±0.04 in recycled water during winter and summer respectively; 7.38 ±0.05 and 7.49±0.08 in mixture water during spring and summer respectively. It could be observed that there were significant differences ($P<0.05$) in hydrogen ion concentration among different seasons for the three investigated types of waters (Fig 3).

- Salinity

Salinity of aquifers waters (Fig 4) ranged between 2.41±0.00 and 2.57±0.03 g/l in winter and summer; and 3.37±0.02 and 3.66±0.12 g/l in mixture water during winter and autumn and 2.47±0.29 and 3.95±0.25 g/l in recycled water during winter and summer.

- Total ammonia (ionized +unionized)

Total ammonia concentrations in irrigation waters (Fig 5) showed slightly significant differences ($P<0.05$) among different seasons for recycled and mixture water (0.04±0.00 to 0.160±0.00 and 0.01±0.00 to 0.07±0.02 mg/l) during spring and summer respectively. In aquifers water, there were no significant differences among different seasons (0.00±0.00 to 0.01±0.02 mg/l).

- Total hardness

Total hardness ranged from 1371.33±35.69 to 1470.67±12.72 mg/l in aquifers water; 1702.67±20.80 to 1841.00±17.10 mg/l in recycled water; 1571.67±15.49 and 1701.67±67mg/l in mixture water during winter and summer respectively. Analysis showed a significant differences ($P<0.05$) among seasons for the three types of water (Fig 6).

- Secchi disk (SD)

It was observed that there were seasonal variations in Secchi disk reading (Fig 7) for irrigation waters ranged from 45.66±0.33 to 53.83±1.16 cm in aquifers water; 16.33±0.33 to 22.50±0.50 cm in recycled water during summer and winter respectively and 20.50±0.28 and 32.50±1.10 cm in mixture water during summer and spring respectively. In general, all values represented high significant differences ($P<0.05$) among the different investigated types of water, during different seasons.

- Seed production and Fecundity

Total number of seed that produced per pond during the ambient condition (Fig 8) indicated that the peak of seed production was during spring especially at aquifers water treatment (8013.33±5.89 seed/pond), followed by mixture and recycled water that were 5106.03±3.25 and 2995.83±1.16 seed/pond respectively. High significant difference ($p<0.05$) in seed production among the three treatments were observed. The lowest number of seeds that produced during winter for aquifer and mixture treatments were 1971.42±8.20 and 1316.66±4.85 seed/pond respectively meanwhile, the recycled water provides the lowest production within autumn (1045.68±6.05 seed/pond).

Highest newly hatched fry per kilogram of females per season (Fig 9) with the ambient condition were obtained during spring in pure aquifer water followed by summer, autumn and winter (5520.00±3.62, 3718.48±4.15, 1942.96±2.14 and 926.66±4.40 seed / kg female/season) respectively. Meanwhile, the lowest numbers of newly hatched fry per each kilogram of females per season were in the pure recycled water during spring followed by summer, autumn and winter (2083.43±3.30, 1820.3±2.873, 563.54±2.38 and 526.50±2.88 seed/ kg female/season) respectively. The difference were highly significant ($P<0.05$).

Peaks of natural reproductive curve during ambient conditions of different seasons throughout the experimental period were 280041.25±12.88, 201233.06±15.88, 89585.73±9.88 and 53145.29±6.88 during spring, summer, autumn, and winter respectively. Highly significant (p<0.05) differences were found among the total fry produced during the four season under ambient condition of study for the three investigated types of water (Fig 10).

DISCUSSION

Fresh and low salinity waters were also conserved through the use of brackish water (quite hard) and / or treated recycled water. In the present study, there were no significant differences among different treatments in concerning of various dissolved constituents (i.e. dissolved oxygen, pH, total ammonia and salinity), which were maintained within the acceptable limits these agree with (Balarin and Haller, 1982; Chervinski, 1982 and Ridha and Cruz 1998). The roles of environmental factors in the regulation of reproductive activity in tilapias are not aquifers-understood (Jalabert and Zohar, 1982). Increasing seed production during spring (27.76^{o}C) may have been stimulated by maintaining temperature within the optimum range for spawning (28.4±1.0^{o}C) these in accordance of Rothbard and Pruginin (1975); Beehrends and Smitherman (1983) and Al Ahmad *et al*. (1988).

In the present study the increased water temperature in summer and autumn (35.34 and 31.5^{o}C respectively) also depressed reproduction and resulted in low seed production rates. A similar observation was reported by Ridha *et al*. (1985) and Al Ahmad *et al*. (1988) for *Oreochromis spilurus* breeders in first and second years of spawning where seed production decreased during August and September. As well as Brummett (1995) reviewed that the environmental factors, which regulate maturation and reproduction in tilapia, and stated that photoperiod, temperature and population density are predictive cues, which effect the onset sexual maturation and reproduction.

Under ambient condition of these Study, increasing of seed production with increasing water temperature during spring to be around 27.76^{o}C indicated the important role of water temperature in optimizing seed production in tilapia in accordance with Behrends and Smitherman (1983) and Bautista *et al*. (1988) who reported a similar effect of water temperature on the spawning of *O. niloticus*.

Seed production under different types of water (aquifers, recycled and 50% mixture of both) during four seasons were significantly (p<0.05) correlated with the fluctuation of water temperature around the year. In addition, the temperature of aquifers water showed the best ratios of seed production all over the year. Those accrued findings may be due to the increasing of penetration of light which is very important for ovulation and seed production. The obtained finding was in agreement with that of Brummett (1995).

The very low seed production of females under ambient spawning condition of winter was due to the low temperature 24.03^{o}C. These finding showed the adverse effect of low temperature on spawning activities of tilapia. The finding was in agreement with that of Rothbard & Pruginin (1975), and Ridha and Cruz (1998) who stated that tilapia has the capability to start spawning at 22^{o}C with the optimum range at 25-29^{o}C.

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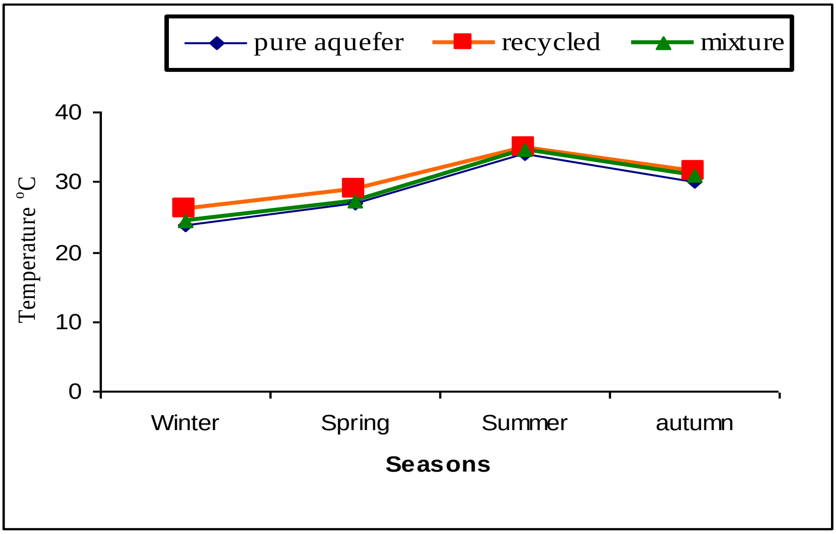

Figure (1): Seasonal variation (mean ± SD) of temperature of pure aquifer, Recycled and 50%mixture of both inside reproductive ponds of *O.niloticus*.

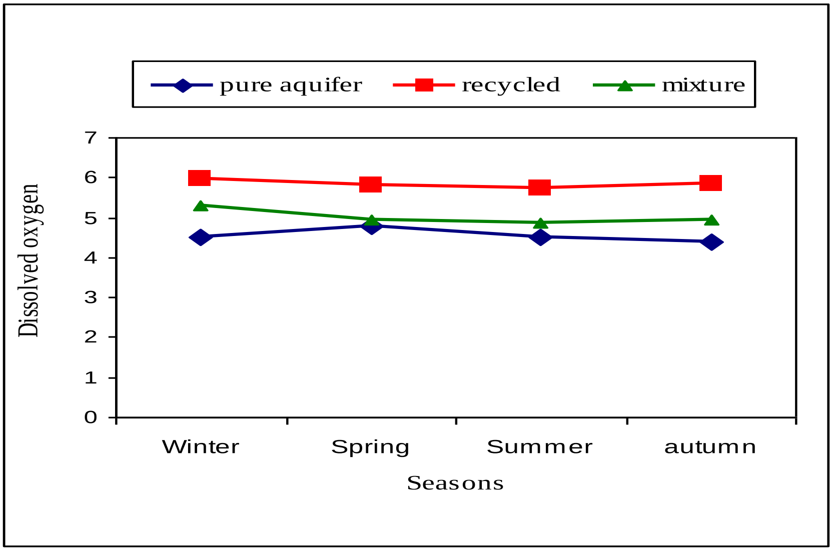

Figure (2: Seasonal variation (mean ± SD) of Dissolved oxygen of pure aquifer, Recycled and 50%mixture of both inside reproductive ponds of *O.niloticus*.

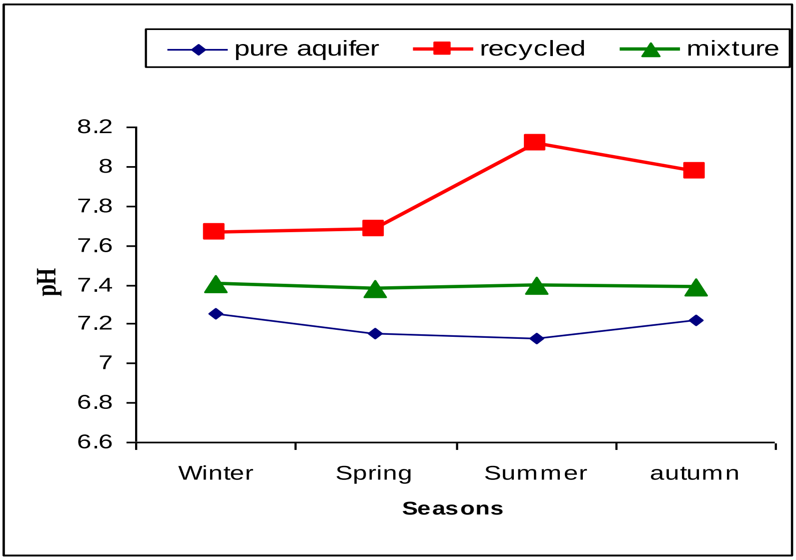

Figure (3): Seasonal variation (mean ± SD) of Hydrogen ion conc. of pure aquifer,Recycled and 50%mixture of both inside reproductive ponds of *O.niloticus*.

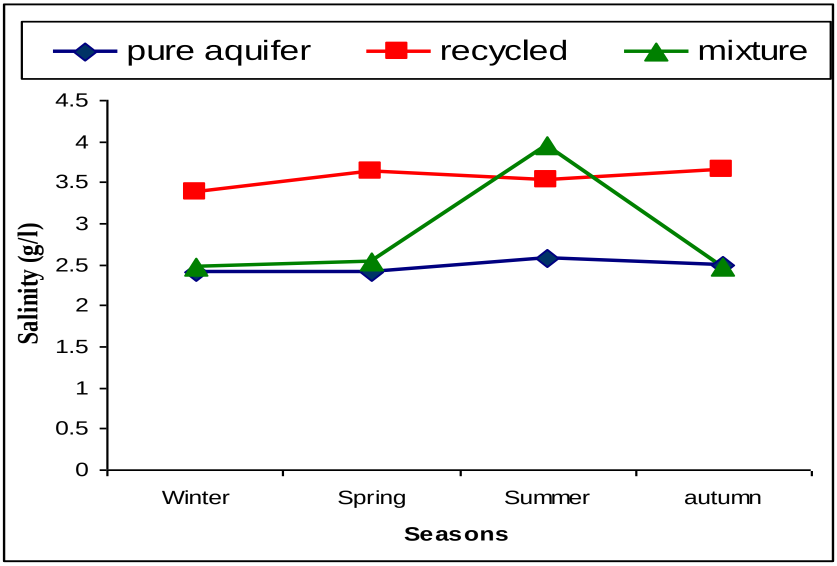

Figure (4): Seasonal variation (mean ± SD) of Salinity of pure aquifer, Recycled and 50%mixture of both inside reproductive ponds of *O.niloticus*.

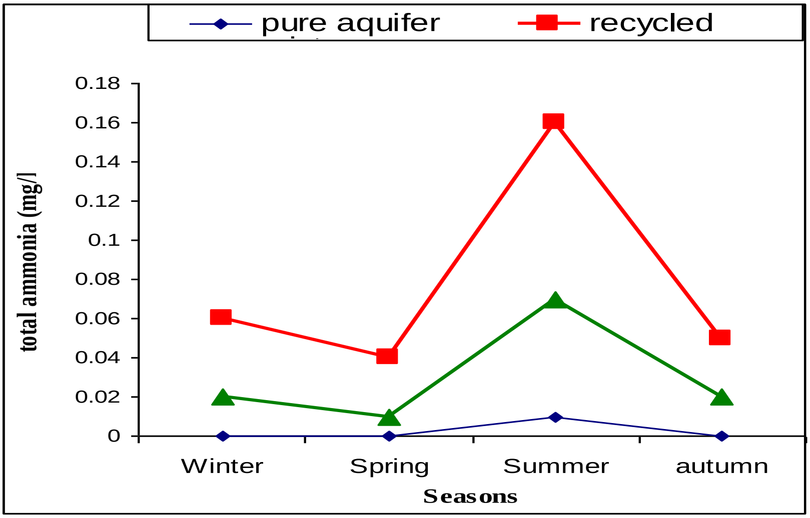

Figure (5): Seasonal variation (mean ± SD) of total ammonia of pure aquifer, Recycled and 50%mixture of both inside reproductive ponds of *O.niloticus*.

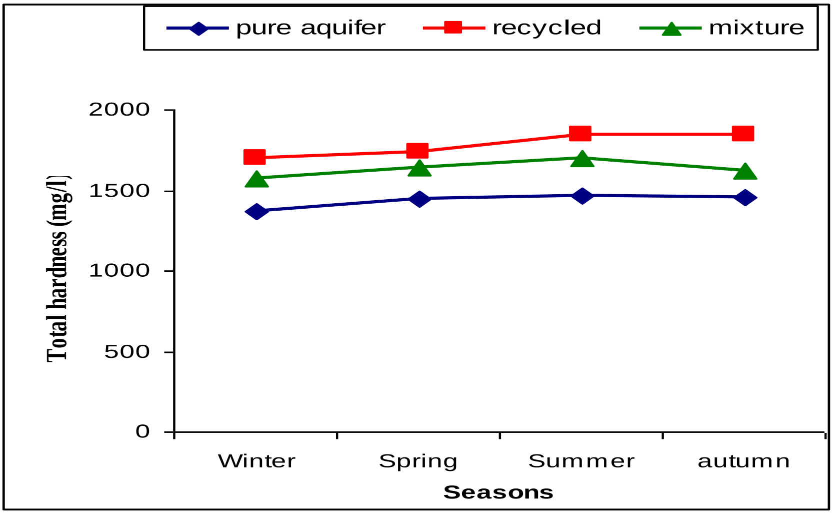

Figure (6): Seasonal variation (mean ± SD) of Total hardness of pure aquifer, Recycled and 50%mixture of both inside reproductive ponds of *O.niloticus*.

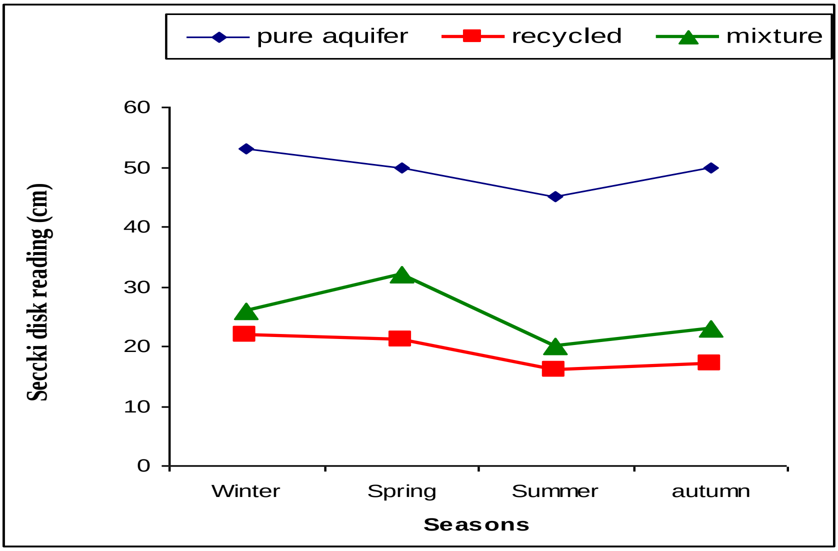

Figure (7): Seasonal variation (mean ± SD) of Seccki disk reading of pure aquifer, Recycled and 50%mixture of both inside reproductive ponds of *O.niloticus*

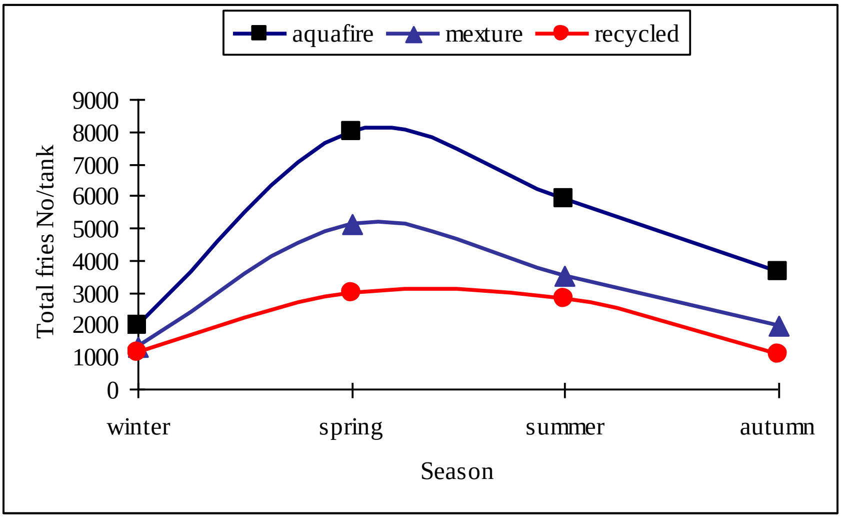

Figure (8): mean (SE) of total fries number collected from each ***O. nilotcus*** reproduction concrete ponds filled with pure aquifer, recycled aquifer water and the mixture (50%) of both .

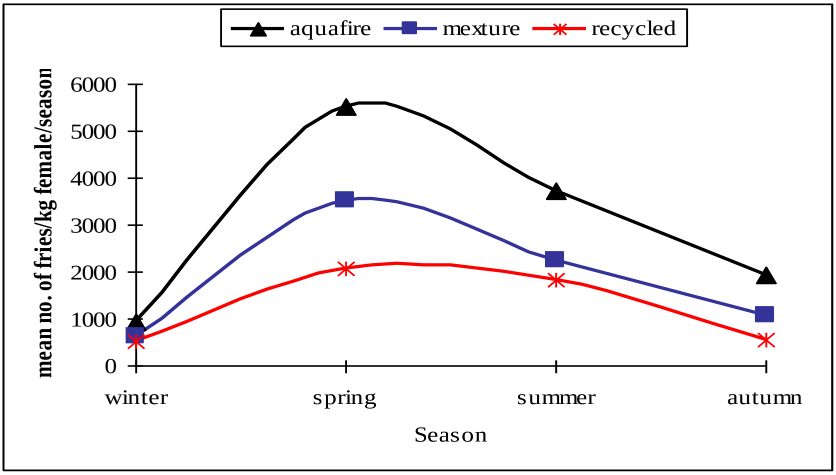

Figure (9): Mean (SE) of total fries number/Kg of brooders collected from ***O. niloticus*** reproduction concrete ponds filled with pure aquifer, recycled aquifer water and the mixture (50%) of both.

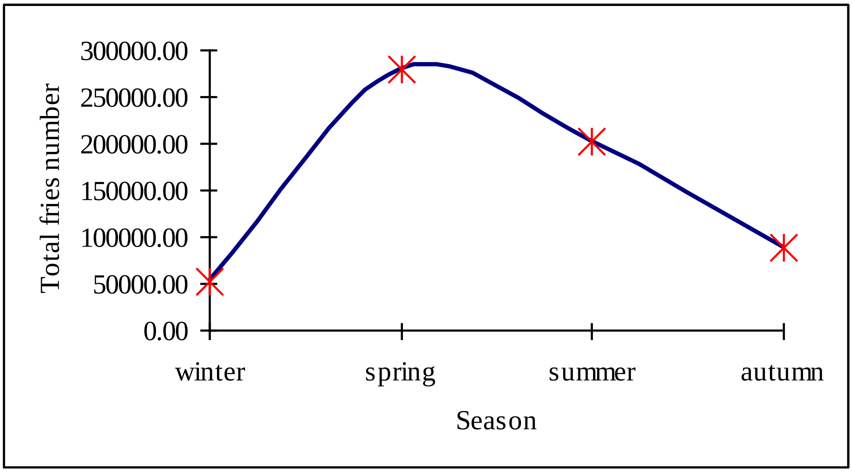

Fig (10): Natural reproductive curve of ***O. niloticus*** reproduced within concrete ponds filled with pure aquifer, reused aquifer water and mixture (50%) of both during four seasons.

تأثير التغيرات الموسمية فى الخواص الفيزيقية والكميائية لثلاثة انواع من ماء البئر على الكفاءة التفريخية لأسماك البلطى النيلى المرباة فى أحواض خرسانية

أشرف محمد محمد على سليمان

المعمل المركزى لبحوث الثروة السمكية العباسة – قسم الليمنولوجى

مركز البحوث الزراعية

الملخص العربى

أُجريت هذه التجربه فى المزرعه السمكيه المكثفه والتابعه للشركه العربيه لمصائد الأسماك لتوضح مدى تأثير التغيرات الموسميه فى جودة ثلاث أنواع من مياه الآبار وهى مياة آبار نقيه ومياة آبار مُنقاة وخليط بنسبة 50% لكل منهما على كفاءة التفريخ لأسماك البلطى النيلى على مدار الفصول الأربعه.

ولقد أظهرت النتائج فروقا ذات دلاله معنويه عاليه ($p<0.05$) فى زيادة المنتج من الزريعه لكل حوض من احواض التفريخ وايضا متوسط اعداد الزريعه حديثه الفقس لكل كيلوا جرام من وزن الإناث فى كل فصل من فصول السنه فقد لوحظ فى فصل الربيع للأحواض المرويه بمياة الآبار النقيه حيث بلغت 8013,33 ± 5,89 وحدة زريعه للحوض كما أعطت 5520 ± 3,62 وحدة زريعه لكل كيلوا جرام إناث فى الفصل الواحد على التوالى. ولقد كانت الفروق ذات دلاله معنويه ($p<0.05$) عاليه ملحوظه خلال الفصول الأربعه تحت الظروف المناخيه الطبيعيه لأنواع المياة الثلاثه.

اوضحت النتائج ان مجموع الزريعه وكذلك الخصوبه النسبيه للإناث المستخدمه فى التفريخ فد اعطت معنويه ($p<0.05$) عاليه فقد كانت 280041,25±40,3، 951,52±19,33على التوالى تحت الظروف الطبيعيه لفصل الربيع فى مياة الآبار النقيه.

وعلى الرغم من التباين الواضح فى التغيرات الموسميه الطبيعيه اثناء فترة التجربه إلا ان جودة المياة فى أحواض التفريخ كانت فى الحدود الطبيعيه المناسبه واللازمه لتفريخ أسماك البلطى النيلى ولقد اعطت درجات الحرارة فروقا معنويه قويه ($p < 0.05$) بين الفصول الأربعة.