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ENERGY CONTENT OF THE GONADS AND SOMATIC TISSUES OF NILE TILAPIA *OREOCHROMISNILOTICUS*(L.) DURING THE SPAWNING SEASON

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ABSTRACT

Nile tilapia *Oreochromis niloticus* were collected from a brackish pond near Lake Timsah (Suez Canal); the energy content of the somatic tissues (muscles) and gonads has been determined during the spawning-season (March-June 2003) using the wet dichromate oxidation method. The gonadal relative energy content (Jmg^{-1}) of the gonad of both males and females exhibited the same pattern of increasing throughout the maturity stages. There were no marked differences in the relative energy content of the fish muscles. The absolute energy content (J) of the somatic tissues of males and females increased gradually with the increase of length (cm).

INTRODUCTION

The reproductive effort is a measure of the energy expenditure by an individual on reproduction (William, 1966). Reproductive efficiency is the percentage of the total energy intake invested in gonad development (Calow, 1979). The deployment of energy during reproduction in teleosts has been partitioned into primary gonadal and secondary somatic sectors (Miller, 1979a). In addition, the magnitude of female reproductive investment will be primarily a function of batches of eggs that are laid during the season. Other less significant energetic considerations include the migration of female to and within the spawning grounds (Fonds, 1973). Closely associated with reproductive anabolism in both sexes are seasonal fluctuation in lipid storage and a variability in growth rate of somatic tissues (Fouda and Miller, 1981). While the gonads anabolism in the male is limited (Miller, 1984), it is possible that the catabolic functions of nest building, courtship and care of eggs might be equivalent to the high anabolic expenditure of the female (Rogers, 1986).

Bioenergetics provides a theoretical framework for relating growth and feeding rates of an organism to environmental conditions (Allen & Wootton. 1982). Estimation of the energy devoted to accumulation of body tissue and material lost as faeces can be obtained by oxidation techniques (Winberg. 1956, 1971: Craig *et al.*. 1978).

The technique most commonly applied to fish is measurement of oxygen uptake which is then given a suitable caloric equivalent depending on the mixture of fat. carbohydrate and protein that is metabolized. Oxycalorific equivalents of approximately 14.15 J (mg $O^2)^{-1}$ [1 J = 4.18 cal.] are commonly recommended (Winberg. 1971: Brett & Groves. 1979).

This study reports the energy invested in the reproductive organs and the somatic tissues during the spawning season of *O. niloticus*.

MATERIALS AND METHODS

Females and males (about 120 specimens) of *O. niloticus* were collected during the spawning season (March – June 2003) from a brackish water pond near Lake Timsah (Suez Canal). After transferring fishes alive to the laboratory. they were measured and weighed (with an average of 12.91 ± 0.37 cm and 42.11 ± 0.91 g respectively). The developmental stages of gonads were recorded. according to Miller (1963). These stages were immature (I). developing (II). early ripening (III). late ripening (IV). ripe (V) and spent (VI). In this study. stage I and II were gathered as they were too close in weight. and the spent stage was not recorded.

Somatic tissues (muscles). ovaries and testes were oven dried at 70°C for 24 hours. then the dried tissues were grounded to a fine powder. Representative samples (about ten) from each stage were used to estimate the energy content by wet oxidation method. using oxidizing solution of potassium dichromate following the method described by Winberg (1971). Rogers (1988) and Sharaf (1996). This method consists of treating the dried tissues with the oxidizing agent dichromate. This method is very simple as small quantities of the samples can be used. in addition no expensive equipment or instruments are required for the analysis. The procedures of this method is as follows:

Preparation of the reagents

Potassium dichromate (0.1N)

A weight of 29.419g of $K_2Cr_2O_7$ was dissolved into one liter distilled water.

Sodiumthiosulphate solution (0.1N)

24.18 g of $Na_2O_2O_3$ was dissolved in a liter of distilled water and stored in an amber coloured bottle.

Potassium iodide (10%)

A weight of 10g KI (Analar) was dissolved in distilled water and brought to a 100 ml volume in a standard flask, and stored in an amber coloured bottle.

Concentrated sulphuric acid (H_2SO_4)

Silver sulphate (AgSO4) was used as a catalyst

Starch indicator

A solution of 2 grams starch powder in 350ml distilled was made and added to a solution of 30 ml of 20% Sodium hydroxide with stirring until a clear solution was obtained. This solution was left for one hour then neutralized with hydrochloric acid using litmus paper. Finally it was acidified using 1ml glacial acetic acid. This solution can be stored for a long time.

Procedure:

About 10 mg of the dried sample were transferred to 250 ml round bottomed flask with 10 ml 0.1N potassium dichromate, 20 ml concentrated sulphuric acid and 100 mg silver sulphate as catalyst. The flask was connected to the reflux condenser, then heated at 140 °C on a heating mantle for 15 minutes. After that, the flask was cooled under a running tap water, then 15 ml distilled water were added, cooled again, and finally 10 ml 10% potassium iodide were added. After that pinkish orange colour solution resulted from the liberation of the free iodine, the flask was shaken and put in a dark place for 10 minutes.

The amount of iodine evolved at this stage was equivalent to the dichromate remaining in the flask after the oxidation of the tissues and can be determined by titration against 0.1N sodium thiosulphate. Adding the $Na_2S_2O_3$ to the flask changed the opaque orange color to pale yellow. Upon adding the starch (indicator), the solution turned to deep blue, further addition of the $Na_2S_2O_3$ resulted in the end point which was pale opaque green. The same procedure was followed with the blank, but without using the dried muscle sample.

Calculations:

The amount of oxygen used by the sample was determined from the difference between the amount of $Na_2S_2O_3$ consumed for the titration of the blank and that of the sample. These calculations were

1 ml $Na_2S_2O_3$ = 2.45 mg $K_2Cr_2O_7$
2 moles $K_2Cr_2O_7$ = 3 moles O_2
1g $K_2Cr_2O_7$ = 0.1633 O_2
Combining these equations:
1ml $Na_2S_2O_3$ = 2.45g $K_2Cr_2O_7$ = (0.1633 x 4.45) mg O_2
An oxy calorific equation of 14.15 Jmg^{-1} was used (Winberg, 1971).

The average relative energy content (J. mg^{-1}) of gonads and muscles were estimated for each stage of gonadal development. The absolute energy content (J) which is the amount of energy content of the total dry weight of muscles, was calculated and related to the standard length of both males and females.

RESULTS

Mean relative energy content (Jmg^{-1}) of the gonad and somatic tissues of females and males *O. niloticus* at different stages of maturity are presented in Figures 1 and 2. There was an increase in the relative energy content of ovary with maturity, varying from 12.76±3.05 Jmg^{-1} in stages I & II to 53.25±0.64 Jmg^{-1} in stage V. A marked increase in ovary energy content from only 19.20±2.42 Jmg^{-1} in stage III to 45.50±0.42 Jmg^{-1} in stage IV is shown. The relative energy content values of the testes exhibited the same pattern of increase from stage I & II to stage V. there was a significant increase from 22.54±0.31 Jmg^{-1} (stage III) of testes to 42.94±0.48 Jmg^{-1} in stage IV and reached the highest value of 49.45±0.25 Jmg^{-1} in stage V. On the other hand, there were no marked differences in the relative energy content of the somatic tissues with the different maturity stages and their values fluctuated in both sexes. However, values of male somatic tissues energy content were higher than those of the females.

The absolute energy content (J) of the somatic tissues (total dry weight) of females (Fig. 3) increased gradually with the increase of the standard length. The same pattern was observed in the relation of the absolute energy of testis and the standard length (Fig. 4). Comparing both female and male muscles means absolute energy content (4125 and 2836 J respectively) in specimens having a standard length of 16 cm showed that there was a difference of about 1289 J.

DISCUSSION

The Nile tilapia, *Oreochromis niloticus* is an important fish in Egypt. It lives in Nile delta and coastal rivers of Israel, the Chaid basin, in the middle Niger and Senegal river (Trewavas, 1983). This

species is found in Ismailia freshwater canal and the brackish ponds near Lake Timsah, Suez Canal. *O. niloticus* breeds more than once annually (Elester & Jensen, 1960; El-Zarka *et al.*, 1970a; Ahmed, 1978; Babiker & Ibrahim, 1979). In the current study, the increase of the energy content of the ovary throughout the different developmental stages is consistent with the findings of Roger (1988) in his study on *Pomatoschistus microps*. The same author mentioned that the greatest expenditure of energy during reproduction is on the development and maturation of oocytes.

The energy content of carcass, ovaries and liver of adult female plaice *Pleuronectes platessa* was related to the seasonal changes in their protein and lipids (Dawson and Grimm, 1980). In addition, variation in biochemical composition and energy content of liver and gonads was reported by Eliassen and Vahl (1982). Among the biochemical components of fish tissues, lipids are the most widely used as storage macromolecules. They are hydrophobic and have higher density than carbohydrates which give lipids immediate advantage for storage (Pond, 1981). In this work increase in gonad size was directly proportional to the increase in body size and the relative energy content of ovaries was higher than that of the testis in stages IV & V (Figs. 1 and 2). These results agree with those of Diana & Mackay (1979) in their work on pike *Esox lucius* prior to spawning. They recorded that energy content of testis was 22.60 kJg^{-1} dry wt. and that of ovaries was 24.69 KJg^{-1} dry wt. Furthermore, Sharaf (1996) reported that the relative energy content of the ovaries of female goby *Silhouettea aegyptia* was also higher than that of the testes. Wootten (1985) recorded that the mean value of energy content of newly spawned eggs or ripe ovaries for 50 teleost species was 23.48 kJg^{-1} dry wt. In the current study, a similar pattern of increased relative energy content was observed in ovaries and testes, but the former was greater in magnitude.

On the other hand, the somatic tissue values of both females and males fluctuated during the different maturity stages. Jonsson *et al.* (1991) mentioned that before spawning, the somatic energy content per unit weight did not differ between sexes. During spawning the energy loss of male soma was 35% higher than in females. These results align with those recorded in the present study. For a number of flat fish species, it is common that energy reserves, which are generally deposited in liver and carcass are considerably depleted during the spawning season (Haug and Gilliksen, 1988).

These authors pointed out that the carcass was affected by the energy expenditure. particularly in females where no significant sacrifices of body weight. In the present study, although, the female somatic tissue relative energy content was less than that recorded for male. the absolute energy content of female in relation to the standard length was higher than that of the male. Such results are consistent with what Sharaf (1996) recorded.

In summary. the present results confirm the fact that female *O. niloticus* expends high energy content during the spawning season. This energy is needed for egg production, batch formation and egg laying. This results are in line with previous studies.

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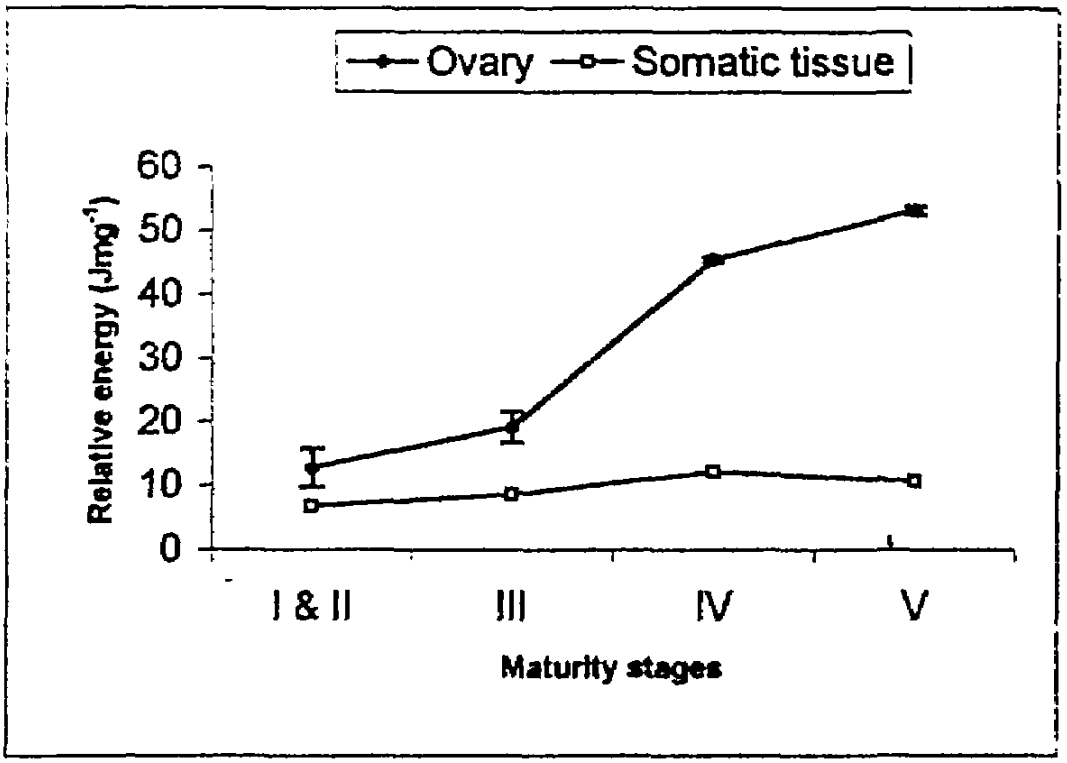

Fig.1 The mean relative energy content (Jmg-1) of the ovary and somatic tissue of female *O.niloticus*

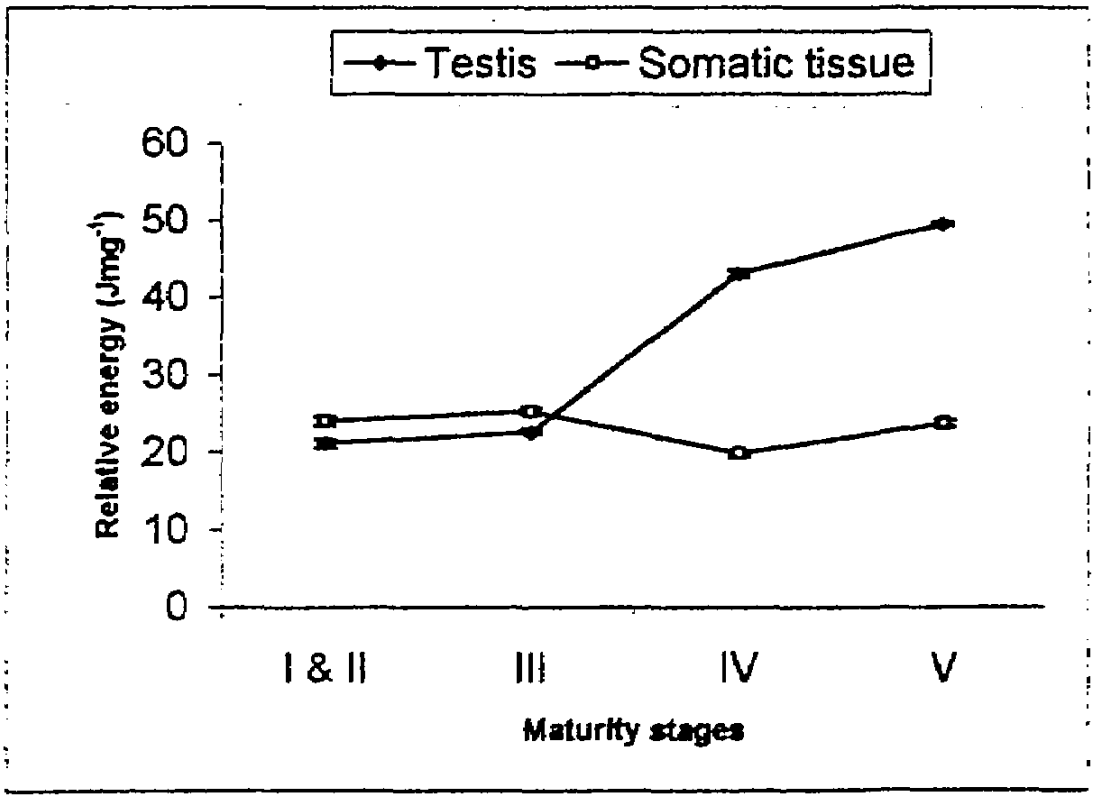

Fig.2 The mean relative energy content (Jmg-1) of the testis and somatic tissue of male *O.niloticus*

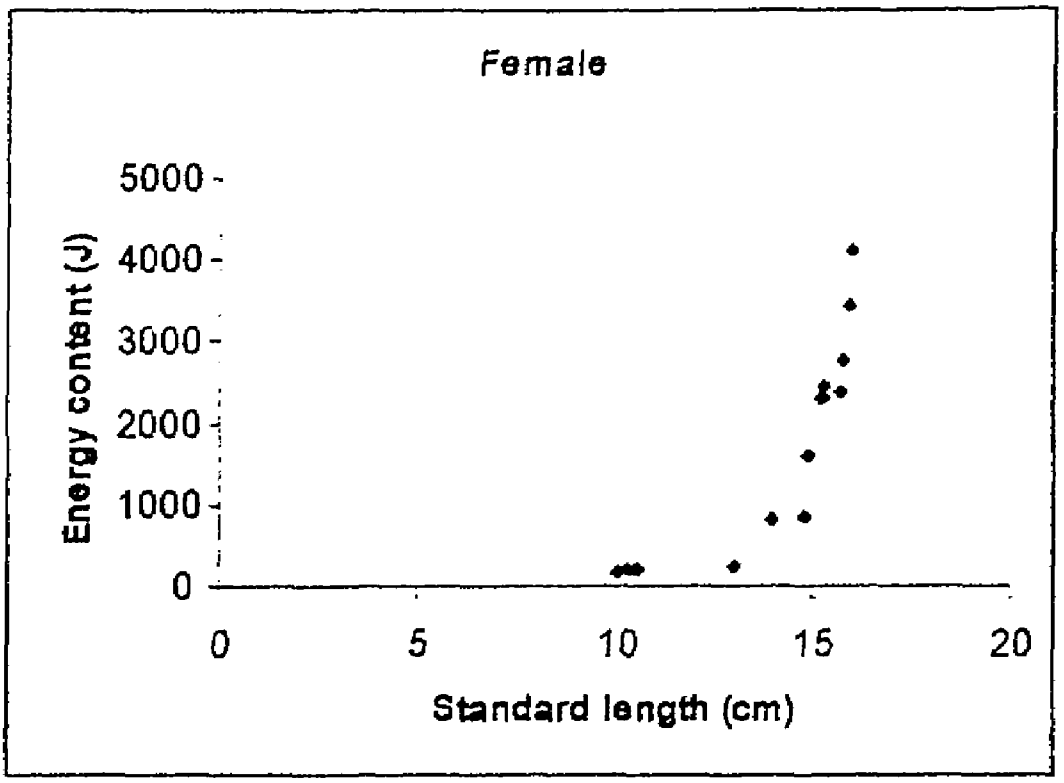

Fig.3 . The relationship between somatic tissue absolute energy content (J) and standard length of female *O.niloticus*

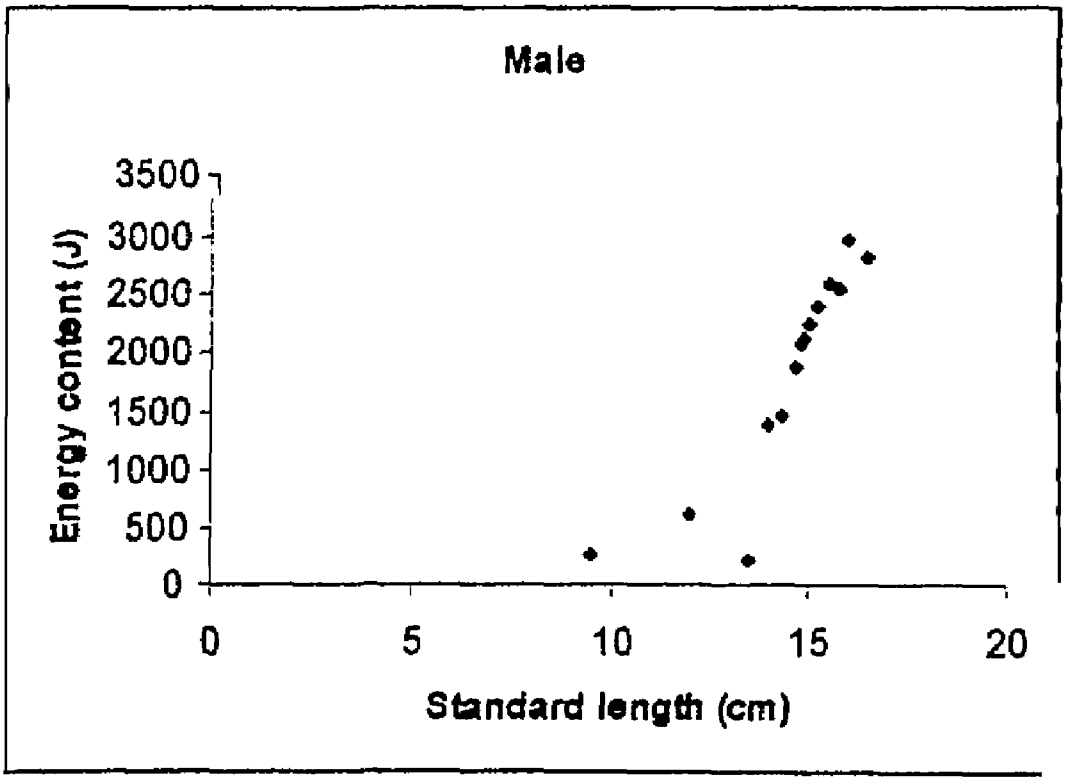

Fig.4 . The relationship between somatic tissue absolute energy content (J) and standard length of male *O.niloticus*