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Research Article

The Reproductive Biology of Grass Carp (*Ctenopharyngodon Idella*) Collected From Floating Cages in River Nile, Egypt

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Abstract: Grass carp (*Ctenopharyngodon idella*) is one of the most important fish species cultured in Egypt to overcome and for controlling aquatic vegetation. Biological parameters such as stage of sexual maturity, gonadosomatic index (GSI), hepatosomatic index (HSI), length at the first sexual maturity, monthly distribution of ovary stages and fecundity studies were also used to define exactly the period of spawning. The results showed that, the spawning season extended from the middle of April to late of June, since GSI of female peaked in May with (17.645±0.381), however the HSI exhibited the minimum value with (1.389±0.098). The male became ripe and peaked value of GSI attained in April (2.797±0.333). The females became matured in length 62 cm, while the first indication of the first sexual maturity of male was expressed at 53cm length, Also the result of monthly distribution of ovary stage showed all females were in ripe stage during May. The studies on the fecundity showed a strong relationship between total body weight and length. However correlation between gonad weight with absolute and relative fecundity and the absolute fecundity ranged from 268372±10772 to 810990±21510.
Keywords: Gonadosomatic index (GSI), hepatosomatic index (HSI), fecundity, grass carp, *Ctenopharyngodon idella* (Teleostei).

INTRODUCTION

The grass carp is one of the largest members of the family Cyprinidae, and related to the genus *Ctenopharyngodon* (Shireman and Smith, 1983; Chilton and Muoneke, 1992). Grass carp, *Ctenopharyngodon idella* are native to large river systems of eastern Asia, from the Amur River on the Russian-Chinese border south ward Michael and Masser, 2002 and this species introduce to Egypt for aquaculture fish farming and used for controlling aquatic vegetation.

Grass carp is economically important for Egyptian community because of its nutritional value; tasty food, economic value and the over advantage its ability for controlling aquatic vegetation.

Grass carp, *Ctenopharyngodon idella* failed to spawn out their native waters during maturity as in Egypt, so reproduction achieved artificially either by injection with extraction of mature pituitary gland or with exogenous hormones injection.

Biological parameters are carried out to clarify maturation of fishes. These parameters include HSI, GSI, condition factor (CF), length at the first sexual maturity, sex ratio and fecundity. GSI is important for gonad maturity and spawning. It is increased during maturation of the fish and reaches to its high peak at maturity. Also, HSI gives us information about the condition of liver and body state as well as the energy reserve in fish. (King, 1996; Nandikeswari and Anandan, 2013; Agbugui, 2013).

Fecundity represents the scale for the total number of ripe egg developed during the spawning season (Bagenal and Brian, 1978; Nandikeswari and Anandan, 2013). The assessments of fecundity facilitated the assessments of the productivity and reproductive biology of fish species (Agbugui, 2013; Lowerre-Barbieri, 2009).

It is important for estimating the reproductive potential, the stock of the population, and widespread of

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fish species (Lambert *et al*., 2003, Armstrong &Witthames, 2012 and Costa *et al*., 2016).

Although, the importance of grass carp is comes from its nutritional source and economic value for farming culture in Egypt. A little biological studies were reported in it. The present study was carried out to assess the biological indexes, spawning, fecundity and their relation to the teleost growth.

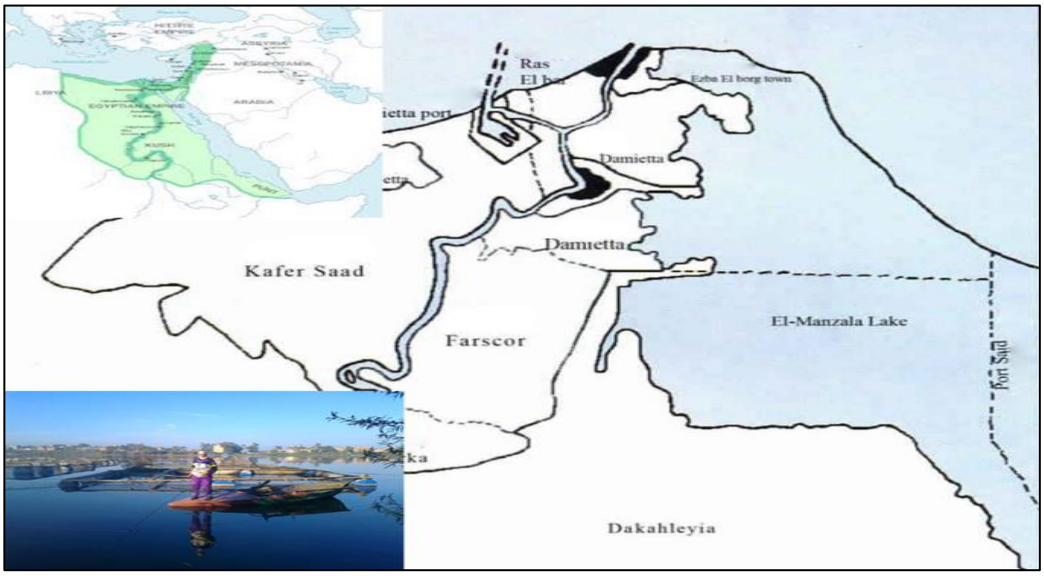

Fig. (1): Map of Egypt (inset) showing the north of Egypt and downstream of Damietta branch of the River Nile and the relative location of the sampling from floating cage sites at Farscor City.

MATERIAL AND METHODS

Specimens of grass carp, *Ctenopharyngodon idella* that selected for the present investigation were collected from floating cage in Damietta branch of the River Nile near to Faraskor city shown in Fig. (1). during the period extended from January 2015 to December 2015

After specimen were collected and transported to the laboratory, the length between the tip of the snout till the end of the fish tail was measured to the nearest 0.1 cm. Also the total weight of each specimen was measured to the nearest 0.01gm. The sex of each fish was determined with the difference in smoothness of pectoral fin, where in the female the pectoral fin was smooth and soft, while male characterized by a rough pectoral fin.

The specimens were killed by decapitation and the fish were dissected to obtain the gonads, (testis from male and ovary from female) and liver. These organs were weighed to the nearest 0.1gm by using Sartorius electronic balance.

I- GONADOSOMATIC INDEX (GSI)

According to Yoneda *et al*., 2001; El-Gamal, 2001 Gonadosomatic Index (GSI) Was Calculated Using The Following Equation:

$$GSI = \frac{\text{Gonad weight (g)}}{\text{Gutted weight (g)}} \times 100$$

Π - HEPATOSOMATIC INDEX (HSI)

Hepatosomatic index (HSI) was calculated using the following equation according to (Htun-Hun, 1978, Andrade *et al*., 2003)

$$HSI = \frac{\text{Liver weight (g)}}{\text{Gutted weight (g)}} X\ 100$$

Ш-Fecundity:

Fecundity defined as the potential number of the mature eggs (yolked ova) that could be spawned during one of the reproductive seasons (Nikolsky, 1963). Twenty-six females were collected between the ends of May to the middle of June (spawning season). The gonads were weighed to the nearest 0.1gm, and the lengths were measured to the nearest 0.1cm. The samples from the outer, middle and posterior parts of each ovary were taken away for egg counting, and weighed by a Sartorius balance. The samples were preserved in 4% neutral buffered formalin, placed in a petri-dish and the eggs were counted under a sterio-binuclar microscope. The gravimetric method is used to determine the fecundity by using the following equation:

$$\text{Fecundity} = \frac{\text{Average of ripe eggs in sample}}{\text{Weight of sample (g)}} \text{ x Weight of ovary (g)}$$

The relation between fecundity and total length, body weight, gonad weight were plotted using linear regression technique and equations for fecundity was computed in general equation formula as reported by Bagenal and Brian (1978):

$$F = aXb$$
$$\text{Log } F = \text{Log } a + b \text{ Log } X$$

a = constant, b = exponent, X = weight, length

RESULT

The present result on GSI of grass carp female showed that there was a gradually increase from January (0.3664±0.025) till March (0.4785±0.101). While the apparent increased of GSI was recorded during April (8.874±5.466) and the peaking value (17.645±0.381) in May. The sharp decreased in GSI value attained in June 8.289±0. 253. In case of male, the peaked value of GSI attained in April 2.797±0.333, while sharply decreased was recorded in May 1.255±0.385 Fig.(2).

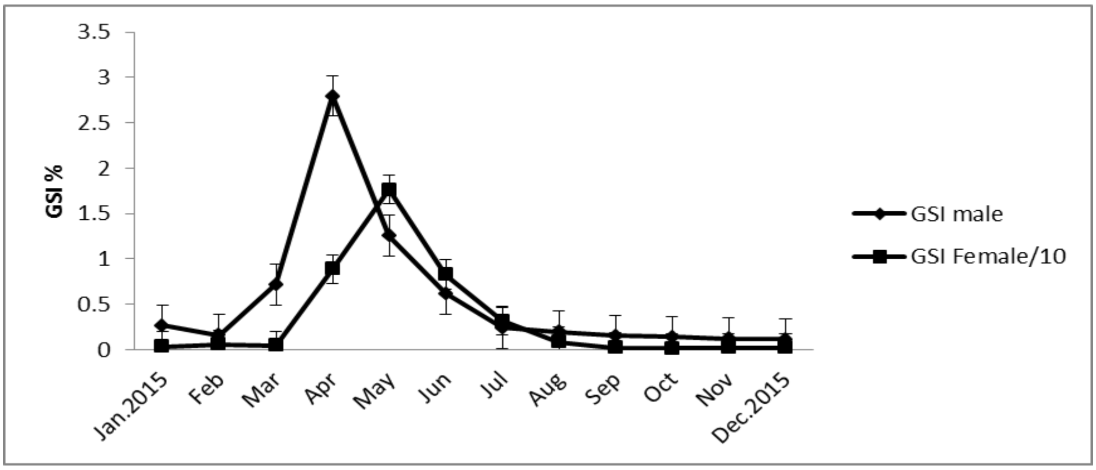

Figure (2): Monthly variation of the gonadosomatic index (GSI) of females and males grass carp during the period from January to December, 2015

Heptosomatic Index (HSI):

HSI values for male and female are illustrated in Fig. (3) In females HSI was gradually decreased from January to May. This value returned to increase gradually started from June (1.695±0.144) reached to value in 2.855±0.06 and 3.685±0.168 in September and December respectively. The lowest value was recorded in May in coincided with the peaking of female GSI. In case of males HSI were showed irregular fluctuations during the annual cycle.

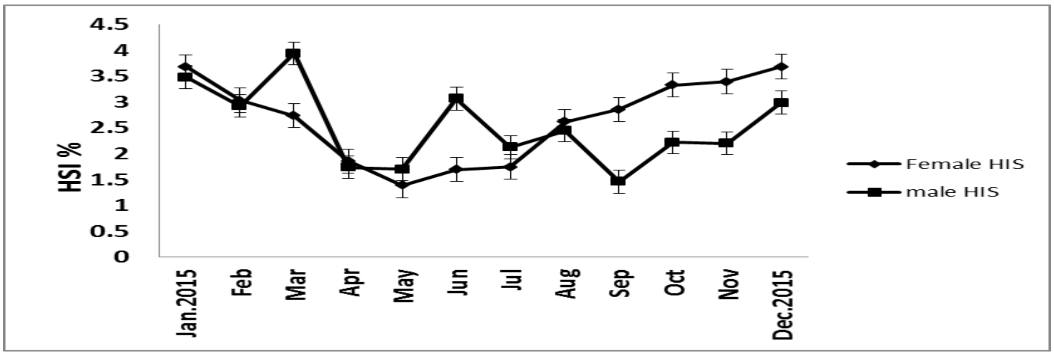

Figure (3): Monthly variation of the Hepatosomatic index (HSI) of females and males grass carp, *Ctenopharyngodon idella* during the period from January to December, 2015.

FECUNDITY

A-The Relation between Absolute Fecundity and the Total Body Length:

The absolute fecundity of females grass carp, *Ctenopharyngodon idella* showed a sharp increase with the progressive lengths as detected by plotting the relation between absolute fecundity and the total body length Fig. (4). these relations can be expressed in the following mathematical equation:

$$y = 26081x - 1E+06$$
$$R^2 = 0.986$$

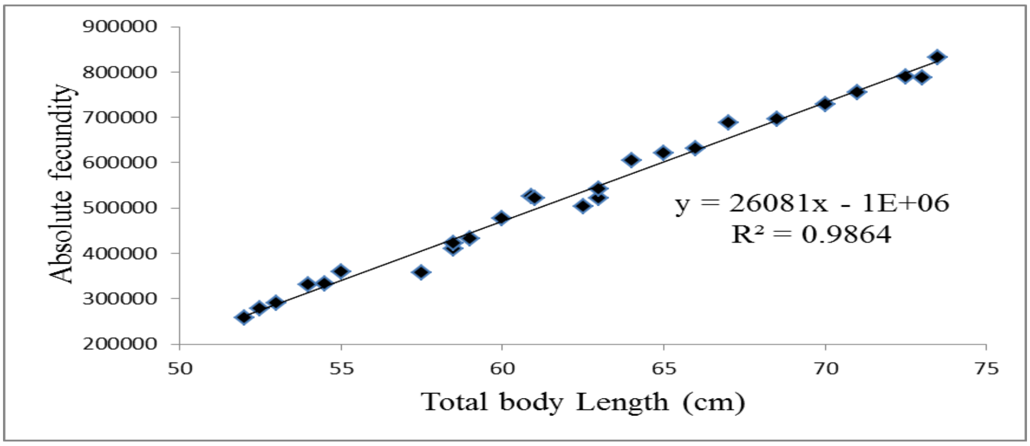

Figure (4): The relation between absolute fecundity and total body length grass carp, *Ctenopharyngodon idella* during the spawning season.

B-The Relation between the Relative Fecundity and Total Body Length:

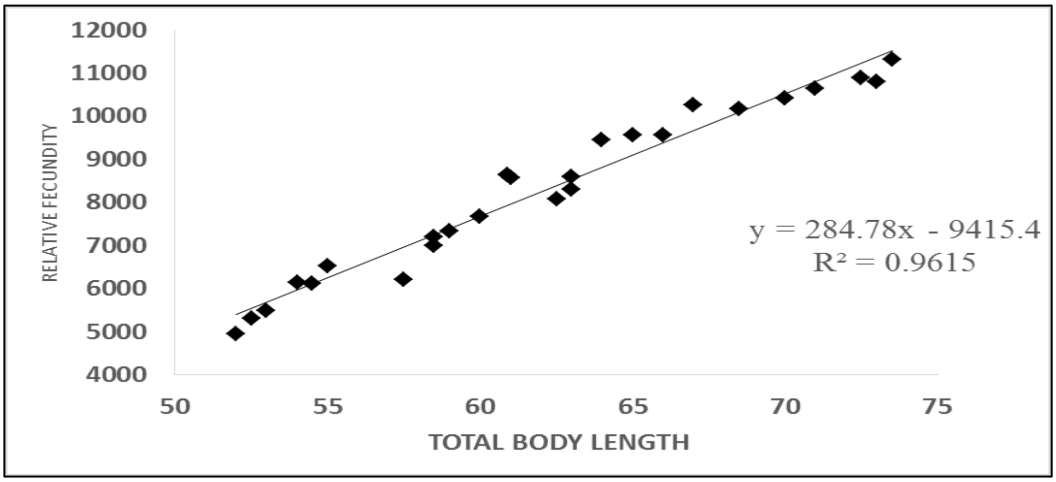

Figure (5): The relation between relative fecundity and total body length of grass carp, *Ctenopharyngodon idella* during the spawning season.

The relation between relative fecundity and total body length showed strong relation, since correlation coefficient recorded R^2 =0.961 and the relation expressed with this equation y =284.78x-9415.4 (Fig.5).

C-The Relation between Absolute Fecundity and the Total Body Weight:

The value of the correlation coefficient was (R^2 = 0.993) expressed with this equation y = 210.36x – 2204 indicating that a very strong relationship was found between absolute fecundity and total body weight,

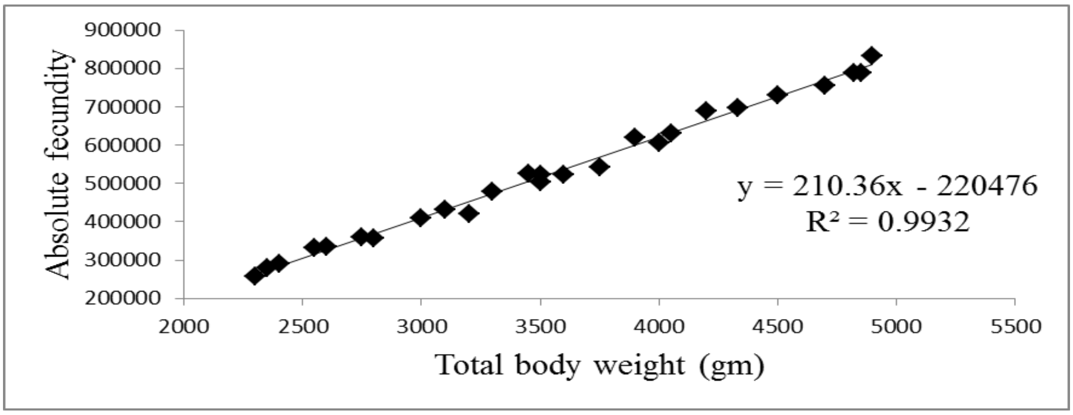

Figure (6): The relation between absolute fecundity and total body weight grass carp, *Ctenopharyngodon idella* during the spawning season.

D-The Relation between the Relative Fecundity and Total Body Weight:

While the relation between relative fecundity and the total body weight was expressed with linear equation y= 0.0187x +78.194 showed strong correlation R^2 =0.916 as recorded in Fig. (7).

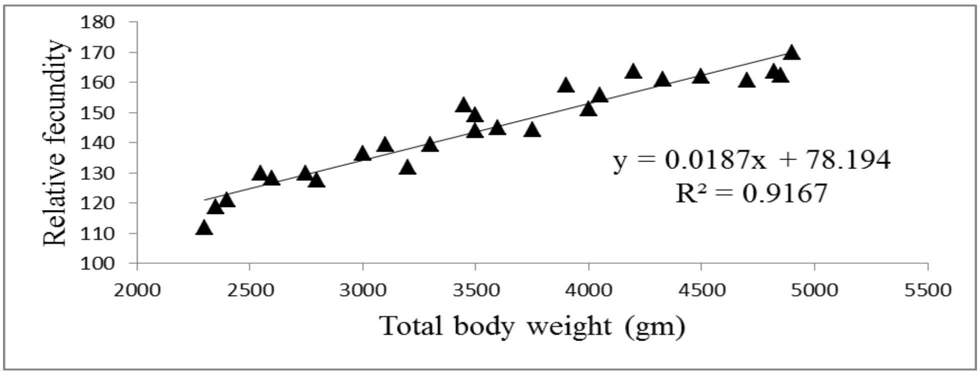

Fig. (7): The relation between relative fecundity and total body weight grass carp, *Ctenopharyngodon idella* during the spawning season.

E-The Relation between Absolute Fecundity and the Gonad Weight:

As the gonadal weight increased, the average of absolute fecundity increased as shown in Fig. (8) this relationship expressed mathematically y = 22669x+221098 R^2 =0.9844

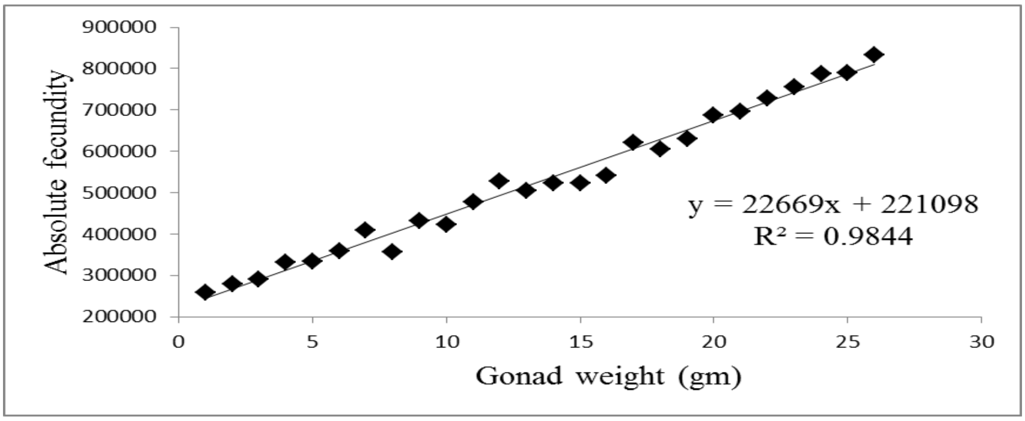

Figure (8): The relation between absolute fecundity and gonad weight of grass carp, *Ctenopharyngodon idella* during the spawning season.

F-The Relation between the Relative Fecundity and Gonad Weight:

As the gonadal weight increased, the average of relative fecundity increased as shown in this relationship expressed mathematically as in the following linear equation:

y=1.6763x-783.27

R^2 =0.6312.

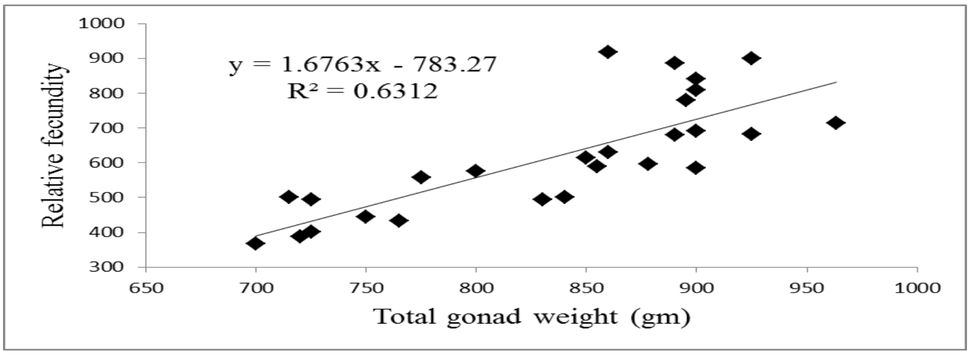

Figure (9): The relation between relative fecundity gonad weights of grass carp, *Ctenopharyngodon idella* during the spawning season.

A-Length at the First Sexual Maturity:

In female, the mature fishes became the dominant over immature female and at length of 60cm with percentage 67%. The length at the first sexual maturity of females which 50% of female became matured was in length 62cm as showed in Fig. (10).

While the first indication of the first sexual maturity of male grass carp which 50% of male became matured was expressed at 53cm length as shown in Fig. (11).

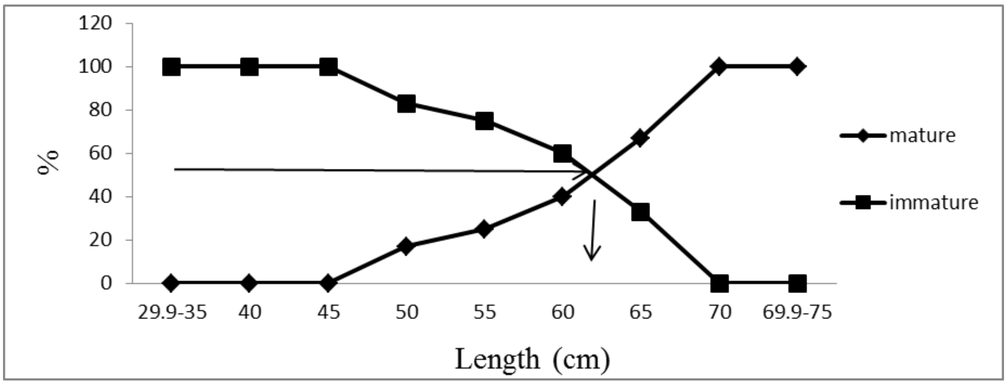

Figure (10): The maturity stage at first length of female grass carp, *Ctenopharyngodon idella*.

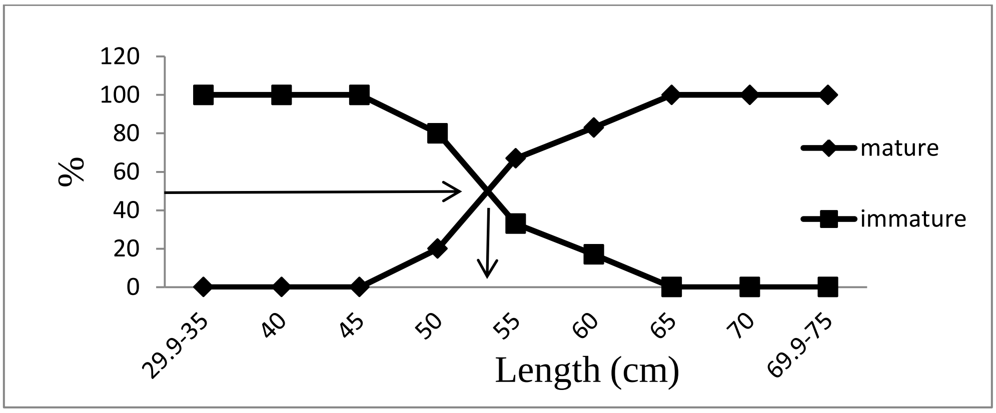

Figure (11): The maturity stage at first length of male grass carp, *Ctenopharyngodon idella*.

Annual Reproductive Cycle:

In case of grass carp female, immature stage not detected through May and June and the immature stage formed 100% in January and February and from September to December as shown in Fig. (12). Maturing stage was detected only during three months only and not detected throughout the months of year, while all sample was in ripe stage at May and late of April.

Spawning stage was not detected during the period of study. Atretic stage was detected only through three months from late of June 46% July 70% and August 11% and this stage was not detected during the other months of spawning season. In case of male immature stage not detected only in April and May months, while ripe stage was estimated in April with percentage of about 100%. Atretic stage was detected only in three months late of June23% July 90% and August 75% as shown in Fig. (13).

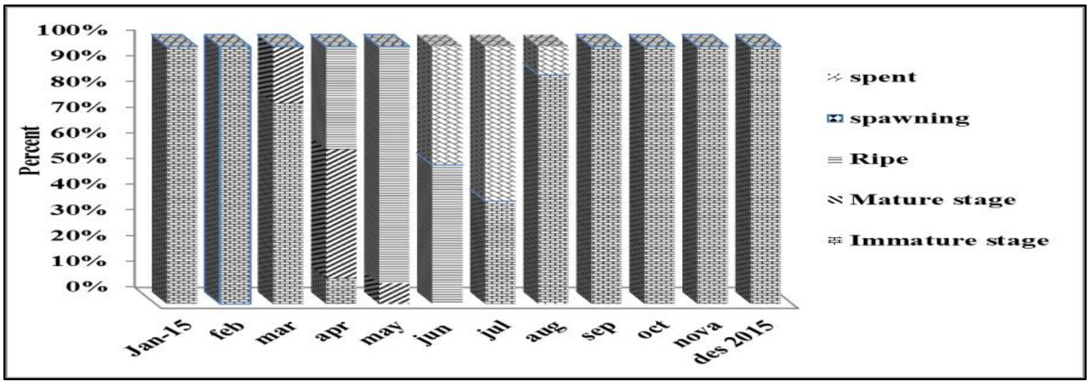

Fig. (12): Monthly distribution of the maturity stages of the ovary of grass carp, *Ctenopharyngodon idella*.

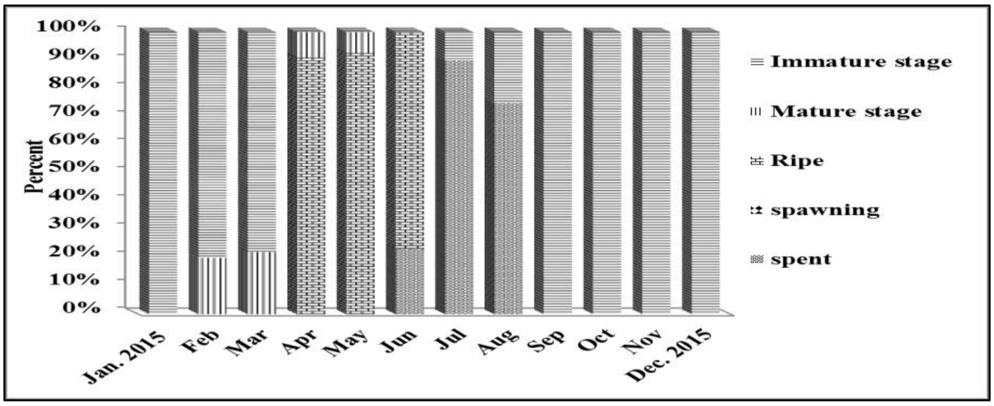

Fig. (13): Monthly distribution of the maturity stages of the testes of grass carp, *Ctenopharyngodon idella*.

DISCUSSION

The importance of biological parameter for fish farming and hatcheries is used to estimate the productive power for fish species and to determine the spawning season.

The gonadosomatic index (GSI) increased with the maturation of fish and peaked during the period of maturity (Nandikeswari and Anandan, 2013).

In the present study, the results showed that GSI of male was increased from February and peaked in April, then decline in May till July. However, in female of grass carp, the GSI increased in April and peaked in May then decreased in June. Grass carp male tend to be mature before female with one month in timing and the spawning season extended from late of March to the late of June. These results can be conducted from the HSI of female grass carp, where the lowest value of HSI was recorded in May, in which the spawning activity is recorded. Barnabe (1994) reported that high GSI of sea bass were found at the peak of spawning season.

Shaikh and Lohar (2011) also reported that low GSI of *Labeo rohita, Catla catla* and *Cirrhinus mrigala* carp fish during October to January may be due to dormancy of gonads in post breeding season. Nandikeswari and Anandan (2013) reported that the abrupt decrease in GSI indicates the beginning of spawning in June and considered as the time of spawning of grass carp. Also, Agbugui (2013) reported increasing of GSI for both male and female *Pomadasys jubelini* in the months of September and October, suggesting the possible spawning period of *P. jubelini* which coincided with the rainy season. Rodriguez *et al*., (2006) concluded that in a reproductive season of an adult carp fish, pre-breeding season from June to September, while the period from February to May is breeding season and the post-breeding season extend from October to January.

Total spawners produce a large number of small eggs which are released through short period of time, while multiple spawners produce large and limited eggs during a long breeding period (Lowe-McConnell, 1987).

During annual cycle only one peak GSI was detected for male and female, this indicate that all matured egg ovulated once time during annual cycle of maturation, so grass carp in our study considered as total spawners according to Lowe-McConnell (1987).

Faryshev and Bashunov (1980) reported both spawning patterns (single- and multiple-batch) occur in the Ili River, the single-batch spawners in the lower Ili River within a period that did not exceed 1.5 months, while multiple-batch, attained in the upper Ili River exceeded 3 months, in case of *C. Carpio* two peak of GSI was detected, first one from July to August and second from January to March (Ashwini *et al*., 2012). Results are similar to observations recorded in *Ethmalosa dorsalis* according to Brewer *et al.*, 2008. The timing of breeding season is coincided with elevation of the temperature and increasing day length which is suitable time for food proliferation.

In the present study, the annual fluctuation of HSI of male did not showed any relation with fluctuation of testis maturation state and irregular fluctuation may be related to feeding state and nutritional condition of fish.

The study on fecundity attracted more attention of many authors Lambert *et al*., (2003), Lowerre-Barbieri (2009), Armstrong and Witthames, 2012, Adebiyi, 2013 and Costa *et al*., 2016 due to its importance in the field of reproductive biology, spawning activity and breeding studies.

In the present investigation, the absolute fecundity of female grass carp increases with the total body weight and ranged from 275774±13673.2 to 778926±34859.36. In European latitudes fecundity of grass carp ranged between an average 500,000 to 700,000 eggs in fish with average weight between 6-8 kg as recorded by Prikhod'ko and Nosal' (1963) and Vinogradov *et al*., 1966. While Chen and Lin (1935) reported fecundity was more than 100,000 eggs for 6 kg in female weight in the Yangtse (China). The absolute fecundity of grass carp in China and Japan ranged from 29,000 to 960,000 eggs. In the Amur River drainage, the estimated grass carp fecundity ranged from 237,000 to 1,687,000 eggs and averaged 820,000 eggs as recorded by Gorbach (1972).

The present result on of fecundity showed that a strong relationship between absolute fecundity with total body weight, body length and gonad weight. This relation concluded from the value of regression correlation coefficient R2, since the value near to be 1. This relation varied from species to another, since Adebiyi (2013) in this filed reported that the fecundity of *Pomadasys jubelini* was more related to body length than body weight, while in *Pomadasys jubelini* the weight was more important to fecundity than its length according to Agbugui (2013). In our results the relative fecundity in relation to total body weight and body length are strong than gonad weight, since regression in correlation coefficient R2 was weak and declined to 0.6312.

The present results showed that the length at first sexual maturity for grass carp female was attained in length 62cm, while in male at 52cm, so male matured earlier in length than female. In Turkmenistan, the total body length ranged from 45–75cm body length, while in the Amur River drainage 70 cm in body length, in the Amur River drainage (Bogutskaya *et al*., 2017). While Hickling (l960) reported that maturity of grass carp occur at lengths from 58 to 67cm in females and males.

Population of grass carp Ili River (Kapchagay) matured at length ranged from 30–60cm, but the majority (50–70%) of grass carp reached maturity at the body lengths of 35–50cm as stated by Abou Shabana *et al*., 2012. The length at first sexual maturity of female *Argyrosomus regius* fishes started at larger lengths than males and recording 47cm for females and 45cm for males. This result in coincided with the general consideration that state males generally mature in a year earlier than females as reported by Opuszynski and Shireman (1995).

The variation of the length at first sexual maturity for female grass carp may be due to effect of geographical variation as reported by Krishnamurthy & Krishnamurthy (1976) and Brown-Peterson & Warren (2001). This variation is associated with differential environmental conditions or/and food availability.

In female, monthly variation of the ovarian stages through annual cycle is used to estimate the period of resting and activity period of fish gonads. It is also useful in define the spawning season and breeding period. The present studies showed that the resting stage was the dominant stages throughout the annual cycle expect during April, May and June since, maturing stage was dominant stage during these months. The ripe stage was the only stage detected in May, so the spawning activity occurred in this month, while in Syr Darya River, upstream of Chardara Reservoir, grass carp spawned in the latter half of May and June as stated by Bogutskaya *et al*., 2017. The spawning stage in our study is not detected during the period of spawning season because grass carp after reached to ripe stage failed to ovulate, then the atretic activity rapidly accelerated toward the dormancy stage (resting stage).

CONCLUSION

It can be concluded that grass carp is synchronous fish and has a short spawning season extended from April to May. The studies on the fecundity showed strong relationship between total body weight, length, gonad weight and absolute fecundity. However, the correlation between relative fecundity and weight of gonad showed a weak correlation. Due to a short of spawning season of grass carp in Egypt, the ripe fish failed for breeding. So, reproduction achieved only by using injection with extraction of mature pituitary gland or with exogenous hormonal injection. These observations will be taken in our consideration in the future investigations.

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