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Population Status of Gold Fish *Carassius auratus* in Restored East Hammar Marsh, Southern Iraq

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*Abstract***.** The present study showed that *Carassius auratus* have a moderately long life span, with average of 6-7 years. The population was detected in the Hammar marsh throughout the year. The monthly catch was dominated by age group 3 and 4 years, which accounted for 60% of the catch. The seasonal pattern of the relative condition factor indicates that maximum value coincided with pre-spawning period. The growth rates of *C. auratus* in East Hammar differ from those expressed in other regions of its distribution. This may be related to either variations in the ecological conditions or to the applied method used in age estimation. Fully mature specimens (maturity stage 6 and 7) were defined as those that were ready to reproduce. They reached maturity in the second year of life .The monthly percentage of individuals in different maturity stages and direct observation of gonads of *C. auratus* population in Hammar Marsh revealed that spawning of this species took place in March to September suggesting that different individuals do not mature at the same time and that there is an extended spawning season. Moreover the presences of all maturity stages of *C. auratus* in the investigated area indicates that Hammar Marsh is the spawning ground of this species and that there is no evidence of spawning migration. Fecundity varied from a mean of 227,800 eggs per female at 110 mm in total length to a mean of 545916 eggs per female at 309mm. It was correlated significantly with age, fish length, body weight and gonad weight.

Introduction

The goldfish *C. auratus* is considered an exotic fish for Iraqi inland waters which was recorded for the first time by Coad (1991). This species is a memember of the family cyprinidae, which includes many other fish such as the common carp, they inhabit lakes, ponds and slow-

moving rivers throughout Europe and Asia (kottelat, 1997). This species is benthopelagic, non migratory and omnivorous fish living in fresh and brackish water (Sasi, 2008).

The goldfish is closely related to the common carp, and hybridization of this species with other carp species is not uncommon (Scott and Crossman 1973). The fish have the ability to burrow in mud in the dry season or during winter, tolerate cold, organic pollutants, and low oxygen levels in the water (Allardi and Keith, 1991). Reasons for the spatial expansion of Prussian carp are not so clear (Holcˇı´k, 1980a). Its expansion through aquaculture, together with the common carp *Cyprinus carpio* L., is historically known, and has continued recently (Barusˇ and Oliva, 1995). Intensive migrations of the species in reverine systems are another possible explanation. Some authors have argued that the Prussian carp has high migration ability on the basis of its frequent occurrence in running waters and high concentrations below weirs (Slavik and Bartos, 2004), however, accurate data describing migrations of the species are missing.

The gibel carp *Carassius gibelio* is known as one of the most hazardous fish species for native fish communities (Crivelli, 1995; and Kalous *et al*., 2004). It can easily become one of the dominant species in stagnant and slow running waters and may change the flow of nutrients in the entire ecosystem (Paulovits *et al*., 1998). According to Crivelli (1995), the turbidity of the water in Lake Mikri Prespa increased after the introduction of *C. gibeli* the crucian is a medium sized cyprinid, which rarely exceeds weight of over 1.5kg. Although they are not commonly available commercially, mainly because they are not in particularly high demand due to the presence of more colorful fish such as the kori or orfi.

However they are one of the most important aquaculture species. In 2005 they were the species with the 10^{th} highest production globally (FAO, 2005). The culture of crucian species was initiated in China, aquaculture of species was limited to China and Japan until the mid 1960, since then it has gradually expanded to many other countries and regions, including Taiwan province of China, Belarus, Republic of Korea and Uzbekistan, the major producer has always been China whose production has expanded from less than 2000 tons in 1950 to nearly 1 million tons in 2002 (99.6 percent of global data) (FAO, 2005). The objective of this paper is to assess the population characteristic such as frequency

distribution, length-weight relationship, relative condition factor, growth and mortality rate, food habit and reproduction of this species which consist major component of Iraqi inland fisheries during last period (2000-2008) beside, the clarification of some biological parameters of each species is essential for management of water resources and fisheries.

Materials and Methods

A total of 1372 specimens were captured during the study period between September 2007 and August 2008 from East Hammar. The fish were collected monthly using gillnets with various mesh sizes (18-55 mm). The total length (T. L) and weight (W) were taken to the nearest (mm) and (0.01g) respectively. The length-weight relationship was obtained by fitting the equation W=aL^b where W= fish weight in (g), L=total length in (mm) a, b are constants (LeCren, 1951). Relative condition factor (kn) was calculated from formula kn=w-/w where w- = the observed weight and w= the calculated weight, scale were taken for ageing.

Six to eight scales from the left side of the body between the lateral line and dorsal fin were removed and mounted dry between two slides for aging by microscopic study. The length cohort analysis (Jones, 1984) was applied to provide information on the growth and mortality rates of the species. A value of $L\infty$, was taken as 32.63 cm for comparison, the largest individual measured in the samples was 31.0 cm (Taylor, 1958). To estimate the (K) value, the following equation was used: (K= ln [(($L\infty$ -L1)/ ($L\infty$ -L2)) 1/t), where, L1 and L2 are observed lengths relevant to two ages of time t apart (Jones, 1984). The mean K value obtained was 0.24. An estimate for the total mortality rate (Z) was attempted from cohort analysis of length frequency distribution (Jones, 1984). The natural mortality rate (M) was obtained by applying Pauly's equation (Pauly, 1980). The annual mean water temperature of the study area input in the equation was 22.4 ^{o}C. Fishing mortality rate (F) was estimated from the equation (F= Z-M) and the exploitation rate (E) was obtained from the equation (E= F/Z) (Gulland, 1969).

The stomach contents for each fish and percentage degree of fullness was identified and their relative contribution to the stomach fullness was estimated. The method is similar to the points methods of Hynes (1950). Ovarian maturity was macroscopically classified into stages according to

Nikolsky(1963). The spawning period was estimated from the gonad development (Gonado-Somatic Index; GSI), direct observation of the gonads and monthly variations of individual in different maturity stages (Lagler, 1966). GSI was calculated from the equation,

$$GSI\ \% = (Wg / Wt) \times 100.$$

Fecundity was estimated by gravimetric method (Bagenal, 1978). The procedure is as follows; the subsamples of 1 or 2 g according to the size of the eggs were taken from the front, middle and back parts of the ovaries. The number of the sub-samples was multiplied up to the weight of the ovary. For histological study a small piece of ovary preserved in Bouin"s fluid section were cut to 5 microns stained with haematoxylin and counterstained with eosin. Maturation stages of germ cells are based on the description of Abu-Hakima(1984).

Results

I- Growth

Results of cohort analysis of 1372 individuals ranging from 2.0 to 31.0 cm are presented in Table 1. The growth curve of *C. auratus* is constructed by plotting the length against relative age (Fig. 1). It suggests that *C. auratus* might attain a size of 7.5, 12.5, 17.0, 20.5, 23.0 and 25 cm at the end of each year from the first to sixth year of its life, respectively. Table 2 illustrated the differentia between mean total length of the age group for *C. auratus* which were determined by scale reading and cohort analysis.

Table 1. Length Cohort analysis of *C. auratus* in in Hammar marsh.

Length group (cm)	No. of fish	Relative age (years)	Ln (N/Δt
2.0-2.9	9	0.32	4.295
3.0-3.9	61	0.46	6.175
4.0-4.9	33	0.60	5.526
5.0-5.9	28	0.75	5.326
6.0-6.9	55	0.91	5.965
7.0-7.9	106	1.07	6.582
8.0-8.9	129	1.23	6.739
9.0-9.9	114	1.41	6.573
10.0-10.9	79	1.59	6.163
11.0-11.9	107	1.78	6.421
12.0-12.9	116	1.97	6.455
13.0-13.9	110	2.18	6.352
14.0-14.9	99	2.40	6.194

Table 1. Contd.

Length group (cm)	No. of fish	Relative age (years)	Ln (N/Δt
15.0-15.9	66	2.63	5.733
16.0-16.9	78	2.88	5.841
17.0-17.9	44	3.14	5.206
18.0-18.9	27	3.41	4.651
19.0-19.9	31	3.71	4.718
20.0-20.9	21	4.03	4.252
21.0-21.9	18	4.38	4.015
22.0-22.9	11	4.76	3.432
23.0-23.9	8	5.17	3.014
24.0-24.9	8	5.63	2.903
25.0-25.9	4	6.15	2.085
26.0-26.9	6	6.75	2.348
27.0-27.9	1	7.44	0.390
28.0-28.9	1	9.32	-0.060
29.0-30.0	2	10.73	0.297

Table 2. Mean total length of different age group for *C. auratus* determined by scale reading and Cohort analysis.

Age group	Cohort analysis (cm)	Scale reading (cm)
I	7.5	8.5
Ii	12.5	13.9
Iii	17.0	16.5
Iv	20.5	20.9
V	23.0	22.2
Vi	25.0	25.8
Vii		29.5

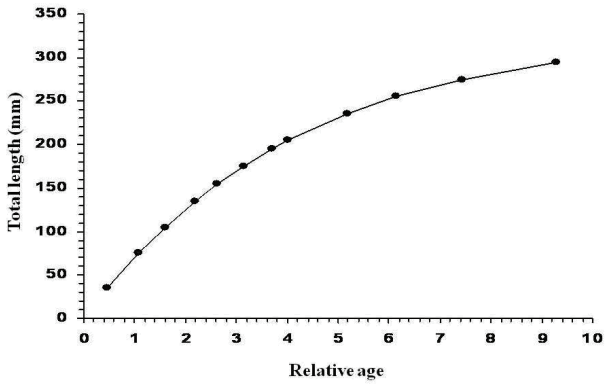

Fig. 1. The growth of C. *auratus* in Hammar Marsh.

2- Mortality

A length-converted catch curve for *C. auratus* is shown in Fig 2, which is based on the data presented in Table 1. The total annual

mortality rate (Z) was 0.922 for fish in the total length from 8.0mm to 29.9cm. The natural mortality rate (M) was estimated as 0.622; therefore, the fishing mortality rate (F) was 0.300 and the exploitation ratio (E) was 0.326.

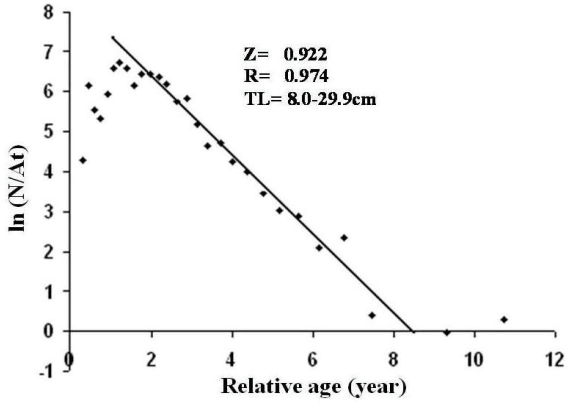

Fig. 2. The catch curve of C. *auratus* in East Hammar Marsh.

3- The Length-Weight Relationship

The relationship between length and weight for 1372 specimens of lengths (2.2 to 30.9 cm) and weights (0.15 to 554.6g) of *C. auratus* after grouping them by 1cm-length intervals, was $W=0.0160\ L^{2.9872}$ (r2 = 0.998) (Fig .3). No statistically significant difference of (b) was found from the value 3 t= 0.651, P >0.05), which means an isometric growth pattern.

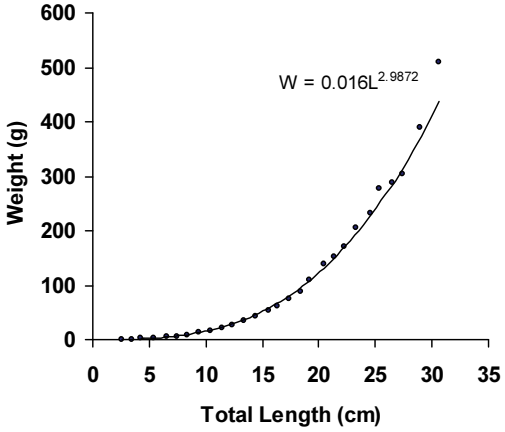

Fig. 3. Length- weight relation ship of C. *auratus* in Hammar Marsh.

4- Relative Abundance

A total of 1372 individual were collected from the Hammar Marsh, the highest number (270) was in January and the lowest number (39) was in December (Fig. 4).

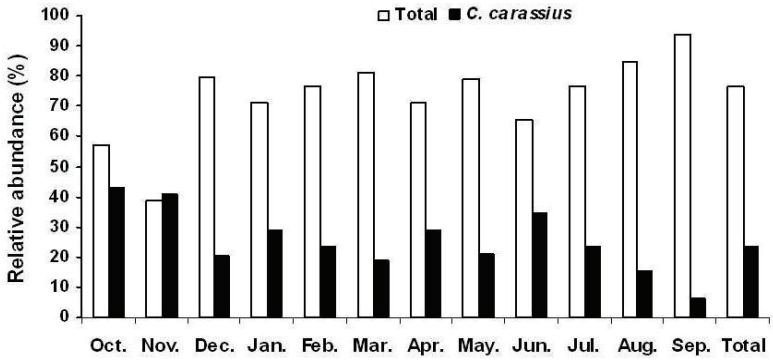

Fig. 4. Monthly variation in the relative abundance of C. *auratus* in Hammar Marsh.

5- Relative Condition Factor

The monthly relative condition (kn) values of *C. auratus* are illustrated in (Fig. 5). The fluctuation in kn values during the period from June to October coincided with the variation in GSI values. The data showed a peak in February (1.92) when the fishes were in pre spawning period while the minimum value (0.86) was in November during post spawning period.

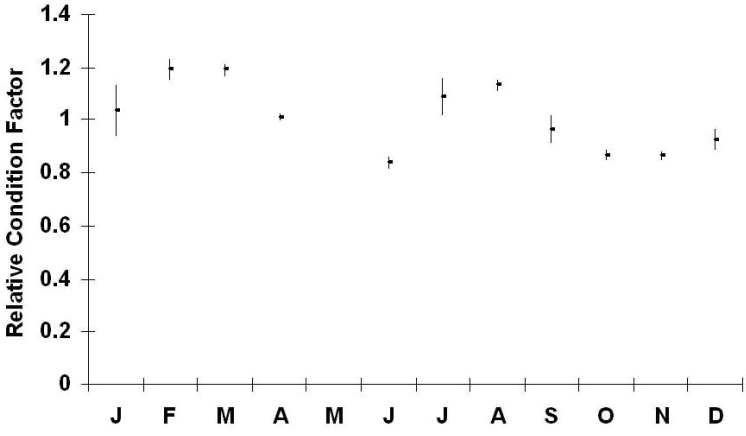

Fig. 5. Monthly variation in the relative condition factor of C. *auratus* in East Hammar Marsh.

6- Length Frequency Distribution

A length frequency distribution of *C. auratus* caught during the study period is shown in (Fig. 6). The diagram showed a big mode around size (12-14 cm), these results indicated that all age groups of *C. auratus* were present in East Hammar. The smallest fish was 2.2 cm T.L caught during April while the largest one was 30.9 appeared in January. Twenty percent of the total number was captured during April and only three percent were caught in December.

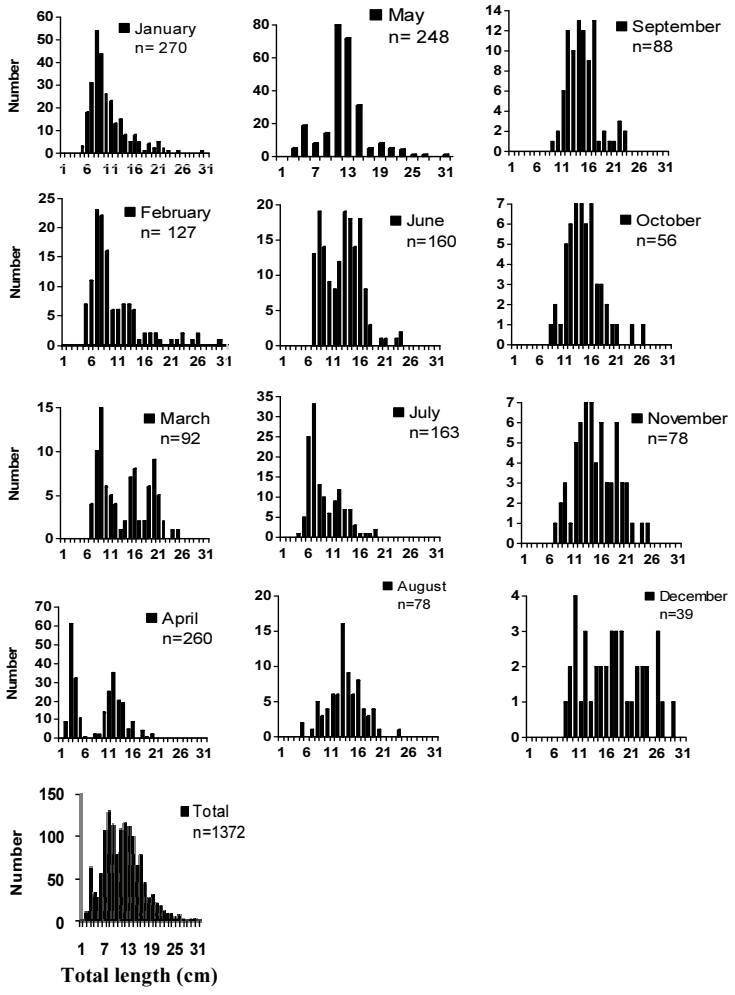

Fig. 6. Monthly total length frequencies of *C. auratus* in East Hammar marsh.

7-Fecundity

Only fish with well developed ovaries were used in the determination of fecundity, details on the fecundity are given in Table 3. This table indicated that the number of eggs produced per fish varied widely within nearly the same length and between individuals of the same age group. Specimens examined ranged in length from 110 to 309 mm, weight from 20.3 to 554.6 g. The eggs produced per female ranged from 227.800 to 545.916 respectively.

Table 3. Absolute fecundity of *C.aurtuas* indifferent weight & length.

T.L (mm)	T.W (g)	Age	G.W	Absolute Fecundity
245	325.0	VI	31.73	251.724.6667
303	463.0	VII	59.05	442.875.0000
262	264.5	VI	25.66	189.627.4000
180	118.8	III	21.76	194.606.9333
264	408.4	VI	90.50	673.621.6667
263	371.9	VI	42.30	344.040.0000
230	232.0	V	21.99	214.036.0000
309	554.6	VII	54.47	545.916.4967
110	20.3	II	2.68	227.800.0000
183	98.6	III	11.90	64.188.6000
209	148.5	IV	17.00	124.666.6660
190	107.8	IV	8.16	46.443.8640
171	75.2	III	7.13	51.098.3330
212	164.9	IV	17.11	137.830.0000
211	162.4	IV	17.29	115.266.6660
254	245.0	VI	25.75	195.923.9130

Fecundity was related here to different parameters of the fish, namely length (L), weight (W), the equations obtained were as follows.

$$F=219939L^{1.6752},\ R=0.653$$

$$F= 9E+07W^{0.5722},\ R= 0.840$$

In all the relations the coefficient of correlation (r) was significant at 0.01 level. The lowest (r) were with length (0.65) while the highest were with weight (0.84) (Fig.7 & 8).

8-Reproductivity

A- Age at Sexual Maturity

In this study, specimens which were fully mature were defined as those which were ready to reproduce. The captured fish had sexual maturity at second year of age (II). The minimum size of fish (TL) at sexual maturity were calculated as 12.5 cm.

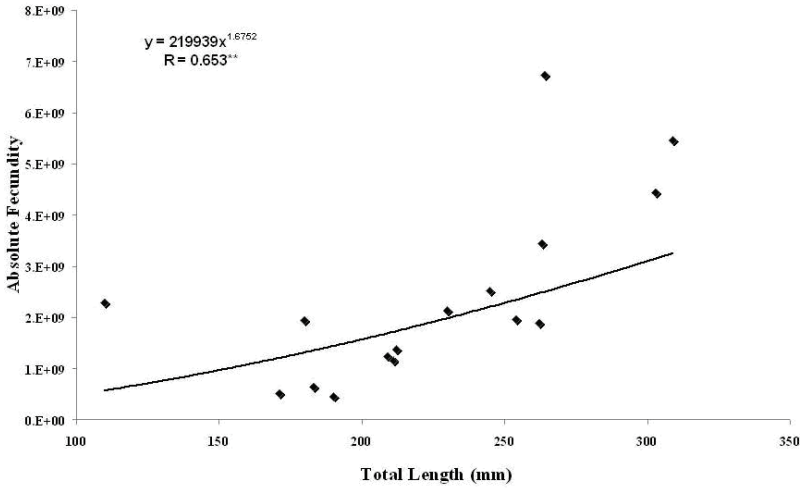

Fig. 7. The relationship between absolute fecundity (number of mature eggs in the ovary) and fish length for females of C. *auratus* in East Hammar Marsh.

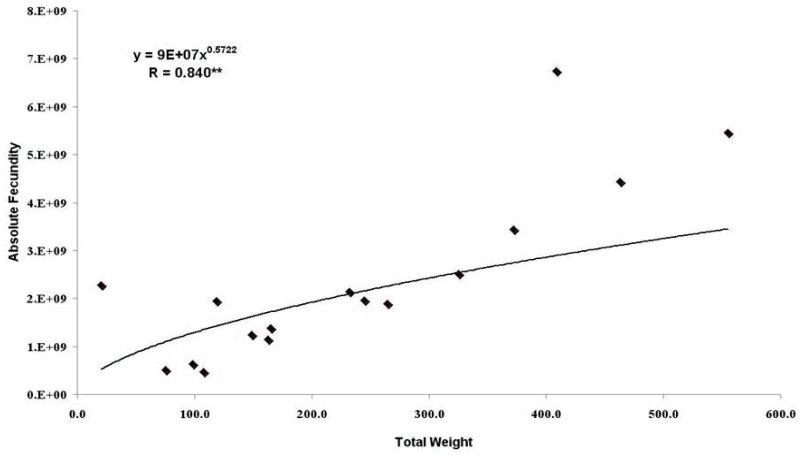

Fig. 8. The relationship between absolute fecundity (number of mature eggs in the ovary) and fish weight for females of C. *auratus* in East Hammar Marsh.

B-Seasonal Occurrence of Mature Stages

The percentage of individual in different maturity stages was determined in each monthly sample from September 2006- August 2007 (Fig. 9). The result showed that reproductive strategy of this species was that individual in different length groups spawn at different times, and spawning season extended from March to September. Fish in Maturity stage began to appear in the catch during the period from December to

July while no fish in this stage was caught during August to November. Ripe fish were found during January to May and were most common in January (53.8%). Spent fish first appear in the March sample where they formed 22.22% and continuously recorded in the catch until September where they formed 57.1%.

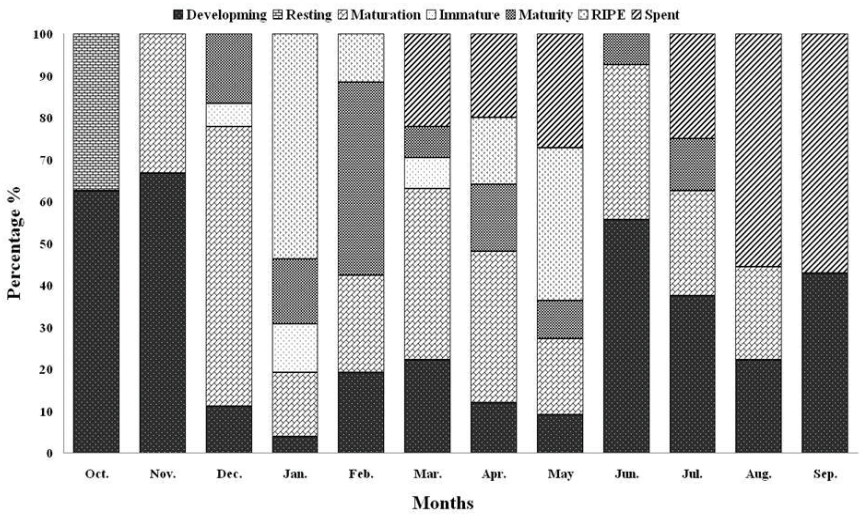

Fig. 9. Monthly distribution of the maturity stages of female C. *auratus* in East Hammar Marsh.

C-Gonado Somatic Index

The monthly changes in gonad weight take place during maturation cycle. It increased into a peak in February (8.94), then the weight decreased gradually during March-September, which may indicate that the release of oocytes is somewhat lengthly (Fig. 10). The fluctuation in GSI value coincided with proportion of fish in the different maturity stages to determine the spawning season.

D-Histology of the Ovary

From November to December the ovary was in quiescence and contained mainly resting oocytes (Fig. 11a). In the pre reproductive period (January-February) ovarian lamellae contained oogonia and oocytes either in primary growth phase or in early vitellogenesis (Fig. 11b). From March-August the ovary was in the reproductive period and all stages of oocytes were found (Fig. 11c). In the post reproductive period (September -October) the ovarian lamellae included oogonia, number of resting oocytes and various types of atretic bodies (Fig. 11d).

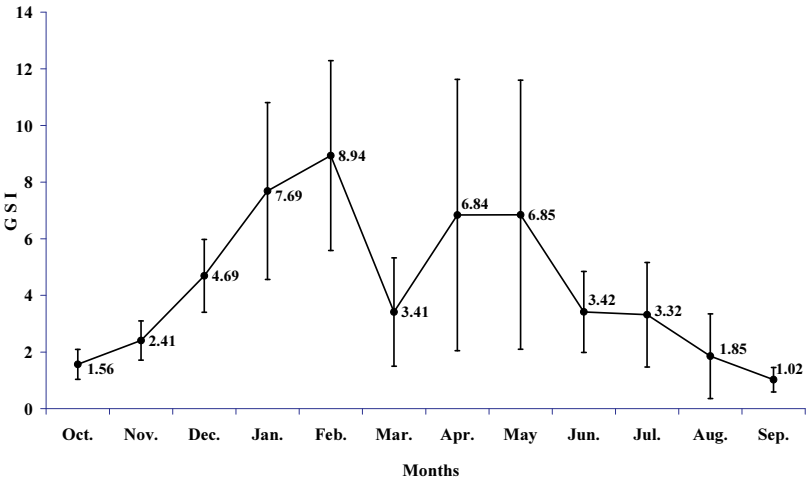

Fig. 10. Seassonal variation of gonadosomatic for female of C. *auratus* in East Hammar Marsh.

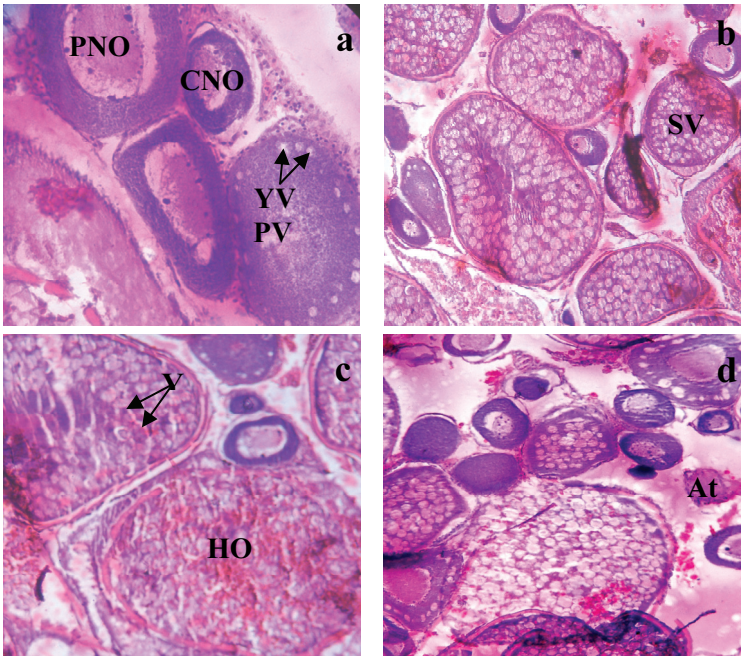

Fig. 11. Seasonal change in the structure of the ovary of *C. auratus* . Histological sections (H & E) (a) quiescent phase, (b) pre reproductive phase, (c) reproductive phase, (d) post reproductive phase. (CNO) Chromatinnucleolar oocyte, (PNO) Perinucleolar oocyte, (PV) Primary vitellogenesis, (SV) Secondary vitellogensis, (TV) Tertiary vitellogenesis, (HO) Hylaine oocyte, (Yg) Yolk granules, (Yv) Yolk Vesicles, (At) Atreia.

9-Food

The analysis of stomach content of *C. auratus* which was expressed by point and occurrence method, revealed that it feeds mainly on algae. They were the dominant food item forming 85% of total points (the food items which represent more than 10% relative importance were considered to be major items in the diet of the species) followed by zooplankton which constituted (15%) of the total food (Table 4).

Table 4. Food habits of *C.auratus* in East Hammer Marsh.

Major taxis	Species	Percentage
Diatoms	*Synedra ulna, Diploneis pseudovalis* *Cocconeis placentula,Pleurosigma delicatulum* *Cymbella aspera, Amphora ovalis* *Cymbella turgida,Cymbella stuxbergii.* *Melosira varians, Nitzschia* sp. *Rhopalodia gibba, Cymbella tumida.* *Synedra fasciculate,Cymbella ventricosa.* *Cymbella cymbiformis var. nonpunctata.* *Epithemia zebra, Epithemia sorex.* *Cymbella affinis, Gomphoneis lanceolatum*.	60%
Green algae	*Euastrum gemmatum,Scenedesmus bijuga* *Cosmarium punctulatumScenedesmus quadricauda* *Spirogyra* sp., *Shizomeris leibleinii*	20%
Blue green algae	*Oscillatoria* sp.	5%
Zooplankton	*Chydrous sphaericus, Daphinia* sp.	15%

Discussion

Fish age, length, weight and growth are important elements of fish population biology. A number of factors are known to influence the length–weight relationship in fish, including growth phase, season, degree of stomach fullness, gonad maturity, sex, size range, health, and general fish condition and preservation techniques (Tesch, 1971).

C. auratus are known to have a moderately long life span,with average duration of 6-7 years. It was found throughout the year in Hammar Marsh. The monthly catch of species were dominated by age group 3 and 4, which accounted for 60% of the catches.. Moreover, this species was not recorded previously from this region, therefore comparsion was made with other studies executed in other Iraqi water and abroad.

The relative abundance of individuals in Hammer Marsh was correlated with water temperature and prefers shallow waters with dense vegetation. Saat and Kikas (2002) concluded that Water temperature play substantial role in increase of commercial catches of *C. auratus* as a warm water species and shallow sites exhibited highest abundance, also in densely vegetated coastal areas.

The length frequency distribution of *C. auratus* in East Hammer include the most expected length groups of this species, especially for the largest one which may reach 30.9 cm as stated by Fischer & Blanachi (1984).

The low abundance of lengths less than 6cm in the study area was due to dispersal of this species within adjacent parts of the marsh. The asymptotic length (&) reasonable to the largest specimen caught and the growth Coefficient (k) indicate that it may be categorized as a moderate life span which rapidly attains its maximum length. The growth rates of *C. auratus* in East Hammer differ from those expressed in other regions of its distribution (Tsoumani *et al*., 2006). This may be related to either variations in the ecological conditions or the age and growth estimation method applied. However the difference of age and growth among *C. auratus* stock in East Hammer and other regions may be due to different races of this species occupying these regions.

The distinct exploitation rate concentrated on length groups of v14-15 cm may indicate the drift gill net of 2.5cm as a main fishing gear used, which may not influence population of other length groups. The minimum level of exploitation rate obtained may explain the lowest fishing effort. The present study indicated that the length weight relationship was best described by general equation and the regression coefficient was (2.98) lower than other stock due to the absence of very large and juveniles. Tsoumani *et al*. (2006) indicated values of exponent b for length–weight relationships of the *C. gibelio* ranged from 2.33 to 3.38, and varied with the trophic state of the lake. In eutrophic lakes these b values were significantly ($P < 0.001$) lower than in oligotrophic or mesotrophic lakes. According to Ricker (1975), b values outside the range of 2.5–3.5 are generally recorded from omnivorous fish species feeds on detritus, zooplankton, considered to be erroneous.

The seasonal fluctuations of relative condition factor indicated that maximum value obtained could be due to pre spawning period. The

occurrence of different food items in the diet during certain time of the year was considered. Small specimens feed on plankton and detritus, while large specimens prefer benthos and relatively large plankton. Shawardi (2006) showed that the food of Curcian carp in Tharthar arm and Tigris River consisted mainly of detritus which formed the main part of the food. Specziar *et al*., (1997) showed that *C. gibelio* fed on zoobenthos and macrophytes.

In this study, fully mature specimens (maturity stage 6 and 7) were defined as those which were ready to reproduce, they reached maturity in the second year of life. Berg (1964) reported the bulk of the population attains maturity in the 4th year of life while in Marmara lake (Turkey) sexual maturity was noticed at 3 years old (Balik *et al*., 1991). According to GSI values, cellular activity of the ovaries, the monthly percentage of individual in different maturity stages and direct observation of gonads of *C. auratus* population in Hammar Marsh revealed that spawning of this species took place in March to September suggesting that all individuals do not mature at the same time and that there was an extended spawning season. Moreover, the presence of all maturity stages of *C. auratus* in the sampled area indicated that Hammar Marsh was the spawning ground of this species and that there was no evidence of spawning migration. Shawardi (2006) determined that spawning period of *C. carassius* in the Tharthar Arm and Tigris River occurred from May to July. McEnvoy and McEnvoy (1992) stated that many species of multiple spawning fish have a rhythmic periodicity of reproductive behavior. Balik *et al*. (1991) determined that spawning of *C. carassius* in Marmara Lake occurred from April to July and the spawning of *C. giblio* in the south was from March to August in Agion Region (Aydin-Turkey) and suggesting that it is multiple spawner (Sasi, 2008).

Fecundity varied from a mean of 227,800 eggs per female at 110 mm total length to a mean of 545916 eggs per female at 309mm. It was correlated significantly with age, fish length, body weight and gonad weight. It was increasing along with increase of fish length, weight, gonad weight and age and larger old fish had higher fecundity. Shawardi (2006) stated that fecundity varied from a mean of 19470 to 95232 per female at length between 139 and 260 mm respectively in Tharthar Arm and Tigris River. The fecundity of the *C. gibelio* in Amur reservoir varies from 160,000 to 383,000, averaging 254,000 eggs (Berg, 1964). Although, Balık *et al.* (1991) reported that maximum of fecundity was

380,000 eggs/female, maximum egg diameter of *C. carassius* population living in Marmara Lake (Turkey) was 1.229 mm. Investigations have given that fecundity increased as fish length, weight, age and gonad weight increased. Fecundity was affected by age, size, species, feeding of fish, season and environmental conditions, as well as between populations of the same species and did not remain constant from year to year (Nikolsky, 1969). Based on these results and evaluation it could be assumed that the increasing population density of *C. auratus* results from its successful reproductive strategy and high ability to colonize new environments.

The main cause of its reproductive success is usually attributed to gynogenesis, where females are able to use sperms of particularly phytophylous cyprinids but even also unspecific salmonids (Penˇ a´ z *et al*., 1979). Further factors in the species successful reproductive strategy includes multiple spawning, low mortality of eggs, long spawning period, high fecundity and early maturation (Holcˇ ı´k, 1980a). Another finding of the present study was the predominance of female which was in a close agreement with observation of Penˇ a´ z and Dulmaa (1987). Female gibel carp were often predominant, for example ranging from 79% to 97% in three Mongolian and from 88% to 97% in the Eravno-Charigniskije ozera lake system of Russia (Karasjev *et al*., 1983).

Finally based on current results and evaluation this species have to be caught all season and had a considerable and negative impact on native species and economically important species *C. carpio* due to competition on food resources. Moreover, this species can be caught during the whole year from the Eastern Hammar Marsh.

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حالة مجتمع الأسماك الذهبية *Carassus auratus* في أهوار شرق الحَمار المعادة جنوب العراق

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المستخلص. أظهرت الدراسة الحالية أن أقصى عمر مسجل لأعمار *C.auratus* في منطقة الدراسة كان ٦–٧ سنة، وأظهرت مجموعة العمر ٣–٤ سنة سيادة على المجاميع العمرية الأخرى في الصيد الشهري، وشكلت ٦٠٪ من الصيد الكلي ، كما اقترنت أعلى قيم لمعامل الحالة النسبي للأفراد مع بداية موسم التكاثر للأفراد. تفاوتت معدلات نمو أفراد هذا النوع في منطقة الدراسة الحالية عن مثيلاتها في المناطق الأخرى من العالم، وهذا قد يعود إلى الاختلاف في الظروف البيئية أو في الطرق المستخدمة في تقدير العمر. أما فيما يتعلق بحياتية تكاثر النوع فقد بينت نتائج الدراسة الحالية إن العمر عند النضج الجنسي الأول كان ٢–٣ سنة ، كما حددت فترة الوضع بين آذار وأيلول بالاعتماد على النسبة الشهرية للإفراد في مراحلها النضجية المختلفة والفحص المباشر للمناسل، إن طول فترة الوضع قد يعود إلى وجود أفراد مختلفة تتكاثر في أوقات مختلفة أثناء موسم التكاثر، كما أن تسجيل جميع المراحل النضجية في منطقة الدراسة يؤكد كون هذه المنطقة هي منطقة تكاثر للنوع ولا توجد هجرة تكاثرية. وبصدد خصوبة النوع فقد تراوحت بين٢٢٧٨٠٠ عند طول ١١٠ملم و٥٤٥٩٦٠ عند طول ٣٠٩ ملم وأظهرت علاقة مع العمر والطول والوزن الكلي ووزن المناسل.