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Correlation between Serum Steroid Hormones and Some Biological Parameters of Gonad of Common Carp (*Cyprinus carpio)* in Caspian Sea, Iran

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Abstract: A number of biological parameters of gonad (e.g. the number of egg in one gram, relative fecundity, gonadosomatic index and absolute fecundity) and weight and total length of female fishes were determined with serum steroid hormones, testosterone (T), 17β-estradiol (E2) and progesterone (P) in 12 female of the migratory population of Common carp (*Cyprinus carpio*) in southeast of Caspian Sea during year from May 2011 and May 2012. A negative correlation of 17-β estradiol, progesterone and testosterone with absolute fecundity, relative fecundity and gonadosomatic index was observed in spring season but these correlates were not significant. Also in summer and autumn season a negative correlation of 17-β estradiol, progesterone and testosterone with relative fecundity and gonadosomatic index and a positive correlation with total weight and total length was observed. In autumn season there was a significant correlation between 17-β estradiol and total weight ($P<0.05$). Also in winter season, relationship between progesterone and total length was positive ($P<0.05$).

Key words: *Cyprinus carpio* • Steroid Hormones • Gonadosomatic Index • Absolute Fecundity

INTRODUCTION

The common carp (*Cyprinus carpio* L. 1758) has been cultivated for several thousand years and nowadays it is abundantly cultured throughout of the world [1] and is one of the most important fishes in farm culture and due to being economical and because of its delicious meat, this fish has a special importance in many countries [2]. Egg quality traits could be helpful for fish farmers in order to assess fingerling production, hatching management, improving rearing techniques and evaluation of the quality of fish produced. For increasing the survival rate at different stages of fishes, it is necessary to study the potential factors affecting the growth and survival rate of incubating eggs, larvae and other larger stages [3]. Also early life stages of development are some of the most important phases of fish development, which include the replacement of embryonic adaptations and functions [4]. The association of changes in gonadal development with plasma levels of sex steroids has proven to be a valuable tool for understanding the endocrine control of reproduction [5, 6]. Sex steroids have long been recognized as key hormones regulating sexual differentiation, physiological aspects of reproduction and the development of primary and secondary sexual characteristics [7]. Cyclical changes in the reproductive hormones of teleost fishes are widely known to occur in association with reproductive cycles. Generally, these studies have followed plasma steroid levels over the course of a reproductive season or annual cycle [8]. It is well known that, in teleosts, vitellogenesis and final oocyte maturation are regulated by gonadotropins via steroids secreted by the follicular cells surrounding the oocyte. Of these steroids, 17β-estradiol stimulates in turn the hepatic synthesis and secretion of vitellogenin which is accumulated in the oocytes [9]. Testosterone has also been hypothesized to play an important role in maintaining post-vitellogenic oocytes until acquisition of maturational competence; Progesterone may directly enhance maturation through vitellogenesis stimulation or act as a precursor to Vitellogenesis Stimulating Ovarian Hormone (VSOH) [10]. In spite of the importance of sexual hormones on fertilization process of fish, this study with the objective of investigating the correlation of serum steroid hormones (testosterone, 17β-estradiol and progesterone) with body weight and total length of female

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fishes and number of biological characteristics of gonad (e.g. the number of egg/ gram, Absolute fecundity, relative fecundity, gonadosomatic index) in Common carp (*Cyprinus carpio*) was carried out.

MATERIALS AND METHODS

Broodstock Preparation: The study was conducted between May 2011 and May 2012. 12 specimens of female Common carp were captured from southeast of Caspian Sea during year and transported to Central Laboratory of Gorgan University of Agricultural science and Natural Resources, Gorgan, Iran. In each season, 3 specimens of female fish were captured. Total weight (937.08 ± 216.5 g) and total length (42.08 ± 3.5 cm) of the fishes were measured.

Measurement of Serum Steroid Levels: The blood samples were taken from caudal vein with a nonheparinized syringe and centrifuged for 10 min. at 3000×g and then serum was stored at-20°C until analyzed.

Measurement of Biological Parameters: The gonadosomatic index (GSI) of female fish was calculated by dividing the ovaries weight (WG) by the whole body weight (WT) and multiplying by 100 [11].

$$GSI= WG / WT \times 100$$

Determination of number of egg in gram belong to each broodstock was done as 3 replicates in sterile Petri dishes. The relative fecundity was calculated by dividing the total egg number by the total body weight.

AF = absolute fecundity, n = number of eggs in the following example, G = ovary weight, g = weight of the following examples [12].

$$AF = n \times G / g$$

Competition Relative to Reproduction Absolute: AF = weight of total fish TW × 100 is achieved [12].

$$RF = (AF / TW) \times 100$$

Statistical Analysis: The correlation sexual hormones and weight and total length of female fishes, biological characteristics of the gonad (e.g. the number of egg in one gram, relative fecundity, gonadosomatic index and absolute fecundity) were analyzed using the bivariate correlation coefficients of Pearson (SPSS, ver. 16).

RESULTS

Correlation between sexual hormones (testosterone, 17-β estradiol and progesterone) and biological characteristics of Common carp (*Cyprinus carpio*) in spring season are presented in table 1.

As shown in Table 1, in spring season progesterone was negatively correlated with three variables: absolute fecundity, relative fecundity and gonadosomatic index, but these correlates were not significant. The relationship between 17-β estradiol with evaluated parameters in the *Cyprinus carpio* was negative, but these correlates were not significant. With increasing in body weight and total length, the testosterone concentrations were increased but this increase was not significant. Also testosterone with absolute fecundity, relative fecundity and gonadosomatic index had a negative relation that was not significant.

Results showed that in summer season there was a negatively correlated between progesterone and testosterone with four variables: the number of egg/gram absolute fecundity, relative fecundity and gonadosomatic index, but these correlates were not significant (Table 2). The relationship between 17-β estradiol with relative fecundity and gonadosomatic index was negative, but these correlates were not significant.

Table 1: Reciprocal correlation between sexual hormones and biological characteristics of Common carp (*Cyprinus carpio)* in spring season

	Testosterone	17-β estradiol	Progesterone
Total Weight (g)	0.306	-0.774	0.500
Total length (cm)	0.189	-0.845	0.601
Number of egg (g)	0.064	-0.689	0.387
Absolute fecundity	-0.454	-0.223	-0.137
Relative fecundity	-0.484	-0.189	-0.171
Gonadosomatic index	-0.489	-0.173	-0.187

Table 2: Reciprocal correlation between sexual hormones and biological characteristics of Common carp (*Cyprinus carpio)* in summer season

	Testosterone	17-β estradiol	Progesterone
Total Weight (g)	0.242	0.849	0.463
Total length (cm)	0.391	0.922	0.597
Number of egg (g)	-0.349	0.402	-0.119
Absolute fecundity	-0.167	0.567	0.069
Relative fecundity	-0.770	-0.109	-0.599
Gonadosomatic index	-0.809	-0.990	0.925

Table 3: Reciprocal correlation between sexual hormones and biological characteristics of Common carp (*Cyprinus carpio)* in autumn season

	Testosterone	17-β estradiol	Progesterone
Total Weight (g)	0.982	1*	0.982
Total length (cm)	0.893	0.777	0.663
Number of egg (g)	-0.882	-0.762	-0.645
Absolute fecundity	0.392	0.187	0.023
Relative fecundity	-0.571	-0.734	-0.835
Gonadosomatic index	-0.236	-0.439	-0.580

*P<0.05

Table 4: Reciprocal correlation between sexual hormones and biological characteristics of Common carp (*Cyprinus carpio)* in winter season

	Testosterone	17-β estradiol	Progesterone
Total Weight (g)	0.307	-0.088	1*
Total length (cm)	0.422	0.037	0.996
Number of egg (g)	-0.121	0.274	-0.976
Absolute fecundity	-0.378	-0.708	0.745
Relative fecundity	-0.747	-0.947	0.376
Gonadosomatic Index	-0.664	-0.903	0.482

*P<0.05

As shown in Table 3, relationship between progesterone, testosterone and 17-β estradiol with relative fecundity and gonadosomatic index were negative, but these correlates were not significant. Also relationship between progesterone, testosterone and 17-β estradiol with total length and absolute fecundity were positive, but these correlates were not significant, but there was a significant correlation between 17-β estradiol and total weight (P<0/05).

Results in table 4 showed that in winter season there was a negatively correlated between 17-β estradiol and testosterone with three variables: absolute fecundity, relative fecundity and gonadosomatic index, but these correlates were not significant. The relationship between progesterone and total length was positive (P<0/05).

DISCUSSION

The association of changes in gonad condition with plasma levels of gonadal steroids has proven to be a valuable tool in the development of an understanding of endocrine control of reproduction in teleosts. Correlations between seasonal changes in plasma levels of gonadal steroids and gonad condition have been well documented in a number of freshwater fish species [13-18].

Three sex steroid hormones, 17β-estradiol (E2), 11-ketotestosterone (11-KT) and 17'', 20β, dihydroxy-4-pregnen-3-one (DHP), are well established as primary estrogen and rogen and progestin, respectively, in teleost fish. *In vitro* and *in vivo* assays suggest that 11-KT and E2 play primary roles in previtellogenic and growth of oocytes, respectively, whereas DHP is essential for induction of final oocyte maturation [19]. Sex receptors were identified in the early stages of a fish's gonads' development. Therefore, steroids can have an effect in early stages of the growth of fish and on gonad activity [20].

A negative correlation of 17-β estradiol, progesterone and testosterone with absolute fecundity, relative fecundity and gonadosomatic index was observed in this study in spring season but these correlates were not significant. A negative relationship between ovarian development and the level of steroid hormones was detected in the kuruma prawn, *Marsupenaeus japonicus* [21]. The inverse relationship between the gonad index and progesterone level in the ovaries of *S. mollis* was reported [22]. A positive correlation of 17-β estradiol, progesterone and testosterone with fertilization rate, relative fecundity and gonadosomatic index was observed in study of Azarin *et al*. [23]. High testosterone levels were demonstrated in the Russian sturgeon at the beginning of the river period of anadromous migration, despite the different states of the sex glands in fish of the spring and winter populations [24]. Also in summer and autumn season a negative correlation of 17-β estradiol, progesterone and testosterone with relative fecundity and gonadosomatic index and a positive correlation with total weight and total length was observed in this study. Body size and or weight have been traditionally considered key determinants of an organism's ecological and physiological properties [25].

Although the primary role of E2 is to aid in gonadal development, T is involved in other functions, such as positive and negative feedback control of the hypothalmo-pituitary-gonad axis and migratory behavior in sturgeons [26]. A number of studies have demonstrated that gonadal steroids act via a classical negative feedback loop to inhibit GTH release from the mammalian pituitary. In this regard, testosterone was shown to inhibit GTH secretion by impairing pulsatile release of GnRH. Testosterone has also been shown to stimulate GTH secretion by acting directly at the level of the pituitary. Both negative and positive effects of gonadal steroids on GTH production have also been demonstrated in teleost

species [27]. The process of oocyte growth was more directly correlated with the plasma concentrations of androgens rather than either estrogen [28]. Results showed that in winter season there was a negatively correlated between 17-β estradiol and testosterone with three variables: absolute fecundity, relative fecundity and gonadosomatic index, but these correlates were not significant. However, Sakomoto *et al.* [29] have proposed that variations in blood parameters among fish could be affected by other variables such as the sampling technique, the capturing method, the condition of captivity and the analysis techniques. It is evident that understanding the physiological indices of blood serum of *Cyprinus carpio* reveals normal indices for propagation, rearing and stocking of this species.

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