

Original Research Article

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Seasonal Changes in Physiological Conditions of Female Amur Common Carp (*Cyprinus carpio haematopterus*)

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ABSTRACT

Physiological changes corresponding to sex, age group and seasons are connected with the reproduction stages of fish. Gonadosomatic indices (GSI), hepatosomatic indices (HSI) Fulton's condition factor (K) and somatic condition factor (Ks) of two age groups (2+ and 1+ year age) of female Amur common carp were measured during different seasons (spring, summer, autumn and winter). Significant differences ($p < 0.05$) were observed for both the age groups in relation to age, seasons and interaction (age and seasons) for GSI, HSI, K and Ks level. Levels of GSI, HSI, K and Ks were higher in female 2+ year's age group as compared to 1+ year's age group in all four seasons. Pearson's correlations ($p < 0.01$) showed a significant +ve correlation of GSI with K and Ks and also between K and Ks whereas significant -ve correlation was observed between HSI with GSI and Ks. The physiological indices observed in 1+ and 2+ year's age female Amur common carp indicated the presence of developed/mature gonads throughout the year with two major peaks – one in spring and other during summer season. Higher index value in 2+ year's age groups signified their superior reproductive potential than younger (1+ year) age group.

Keywords

Amur common carp, Physiological indices, seasonal

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Introduction

Common carp (*Cyprinus carpio*, Linnaeus, 1758) belonging to the cyprinidae family and considered as the largest family freshwater fishes, is one of the oldest domesticated and mostly widely cultured fish species in the world (FIGIS, 2011). The relevance of physiological studies relies on the influence of body conditions on the performance of the

organism with species having a relatively healthier physiological condition being considered to have improved fitness for activities such as reproduction, migration etc (Brosset *et al.*, 2015a & b). Relatively easy, cost effective and numbers of simple condition-based indices requiring minimal training for assessing physiological conditions of an organism are use thus making it more attractive to the monitoring agencies and now

widely used in fisheries management. These indices tend to be relatively insensitive to short-term (i.e., acute) changes in environmental conditions making it favourable tool for seasonal based studies. Considering the physiological, sex, age group and seasonal changes associated with the pre- and post-reproduction, the following study was undertaken on female Amur common carp during four different seasons (spring, summer, autumn and winter).

Materials and Methods

Fish were collected and segregated from hatchery breed Amur common carp from experimental fish pond and held in two separate groups designated as Pond A (for 1+ year's old group) and Pond B (for 2+ years' old groups) in two earthen pond. The fishes were fed once daily @ 3% body weight with supplementary pelleted diet containing 25% protein till July after which 1:1 ratio soya bran and mustard oil cake at the same ratio due to shortage of pelleted feeds. The experimental site is located in Tarai region of Shivalik range of the Himalayas having sub-tropical climatic condition characterized by very hot, humid and dry summer and very cold winter. The monsoon period falls between mid of June till the end of September. Clove oil (Velisek *et al.*, 2005) was used to anaesthetise prior to regular handling or experimental procedure.

Condition factor

Comparing the relative length and weight of an individual or groups can provide the information on general well-being and change associated with the reproduction and gonad development of the species. Fulton's condition factor (K) (Fulton, 1904) and somatic condition factor (Ks) of female fishes were calculated from the individual fishes as follows:

$$\text{Condition Factor (K)} = \frac{\text{Weight (g)}}{\text{Length (g)}^3} \times 100$$

$$\text{Somatic Condition Factor (Ks)} = \frac{\text{Body Weight (g)} - \text{Gonad Weight (g)}}{\text{Length}^3 \text{ (cm)}} \times 100$$

The factor 100 is used to bring K and Ks value close to unity.

Organosomatic indices

Liver, gonads and the viscera of the individual female were removed and weighed to the nearest measurement. The hepatosomatic indices (HSI) gonadosomatic indices (GSI) were expressed as below:

$$\text{HSI} = \frac{\text{Wt. of liver (g)}}{\text{Total body wt. (g)}} \times 100$$

$$\text{GSI} = \frac{\text{Wt. of the gonad (g)}}{\text{Total body wt. (g)}} \times 100$$

Results and Discussion

Observations on physiological indices (GSI, HSI, K and Ks) of 1+ and 2+ year's age groups female Amur common carpin four different seasons are shown in Table 1. Observations on GSI, K and Ks in both age groups showed similar trend with highest level in spring season, which decreased in summer and reached to the lowest level in autumn with slight recovery in winter season.

Hepatosomatic index (HSI) in both age groups showed highest level in autumn season, which decreased in winter and reached to the lowest level in spring followed by slight increase in summer season. Significant differences ($p < 0.05$) were observed for both age groups of Amur common carp in relation to age, seasons and interaction (age and seasons) for GSI, HSI, K and Ks level. Levels of GSI, HSI, K and Ks were higher in 2+ year's age group female as compared to 1+ year's age group in all four seasons. Pearson's correlations ($p < 0.01$) showed significant positive correlation of GSI with K and Ks and also between K and

Ks. Significant negative correlation were observed between HSI with GSI and Ks.

In the present study, GSI level in both 1+ and 2+ year's age groups of female Amur common carp was high throughout the study period but showed significant seasonal variations with high level in spring followed by summer season. This indicates that gonads in Amur common carp remained active throughout the year with major peak in spring season coinciding with the main spawning season. Next minor peak in summer/monsoon signifies the low spawning activity level during that period. Abassi *et al.*, (2011) reported high level of GSI during the month of May and another highest level during mid-August month that suggested about multiple spawning behaviour of *Cyprinus carpio* dependent upon environmental factors. Seasonal changes in GSI level in relation to reproductive activities have been reported in *Sciaenops ocellatus* (Craig *et al.*, 2000), *Tinca tinca* (Pinillos *et al.*, 2003), Japanese Dace-*Tribolodon hakonensis* (Ma *et al.*, 2005), spotted murrel-*Channa punctatus* (Basak *et al.*, 2016) and *Capoeta trutta* (Eroğlu and Şen, 2017).

Higher GSI levels in females compared to males have been correlated with the accumulation of yolk in the developing eggs to sustain the embryos during embryonic development and larval stages (Snyder, 1985). Oscillations in GSI reflects the accumulation, development and release of eggs or sperm with peaks occurring prior to spawning and sharp decline in post-spawning period in plains minnow, *Hybognathus placitus* (Pisces: Cyprinidae) (Taylor and Miller, 1990). Direct relationship of GSI level with increased in ovarian size signalling spawning activities during final oocyte maturation have also been reported in *Rutilus frisii kutum* (Sabet *et al.*, 2009) and *Cherax albidus* (Coccia *et al.*, 2010). Inverse correlation between GSI and

HSI are indicative of role of liver in gonadal development and energy mobilisation for the same. Role of liver in energy mobilization from liver and other energy reserves for gonadal development resulting in lowering of HSI have been reported in *Heteropneustes fossilis* (Singh and Singh, 1979), *Cirrhinus mrigala* (Singh and Singh, 1984), *Pagrus auratus* (Scott and Pankhurst, 1992), *Clarias batrachus* (Singh and Singh, 1983; Hussain and Singh, 2004), *Notopterus notopterus* (Sudarshan and Kulkarni, 2013), *Mystus vittatus* (Sreevalli and Sudha, 2014) *Cyprinus carpio carpio* (Vazirzadeh *et al.*, 2014) and *Tilapia mossambica* (Satheesh and Kulkarni, 2016).

Seasonal variations of HSI levels in both 1+ and 2+ year's age female group observed during the present study showed higher HSI level in 1+ year as compared to 2+ year's age group, which might be due to proportionate transfer and mobilisation of more energy for reproductive processes in 2+ year's age group, as indicated by higher GSI level. The relationship between HSI and energy reserves is seasonal and highly variable depending on feeding, growth period and reproductive activity as reported in three-spined stickleback (Chellappa *et al.*, 1995), brown bullheads (Yang and Baumann, 2006), *Cyprinus carpio* (Desai and Singh, 2009) and whitefish (*Coregonus muksun* and *Coregonus lavaretus*) (Borvinskaya *et al.*, 2016).

Observations on K levels in both age groups showed seasonal variations with 2+ years having higher level than 1+ year's age group. This might be an indication of better overall health conditions in older groups with better physiological performances like reproduction as the species ages. An increase in K level from pre-spawning phase to gonadal maturation and decline after post-spawning have been reported in *Notopterus notopterus* by Shankar and Kulkarni (2014).

Table.1 Physiological Indices of 1+ and 2+ Year’s old Female Amur Common Carp in Different Seasons

Age Groups	Indices	Summer season	Autumn season	Winter season	Spring season
2+	GSI	14.34±0.82	7.21±0.21	10.06±0.20	18.53±0.66
	HSI	1.09±0.09	1.55±0.06	1.24±0.10	0.82±0.13
	K	1.79±0.03	1.62±0.04	1.71±0.03	1.94±0.07
	Ks	1.54±0.02	1.50±0.04	1.54±0.03	1.58±0.06
1+	GSI	8.41±0.46	3.18±0.24	4.88±0.31	16.54±0.34
	HSI	1.32±0.09	1.69±0.11	1.22±0.11	1.02±0.07
	K	1.55±0.07	1.32±0.02	1.50±0.02	1.86±0.03
	Ks	1.42±0.06	1.27±0.02	1.43±0.02	1.56±0.02

[Data are given as mean±SEM (n=5)]

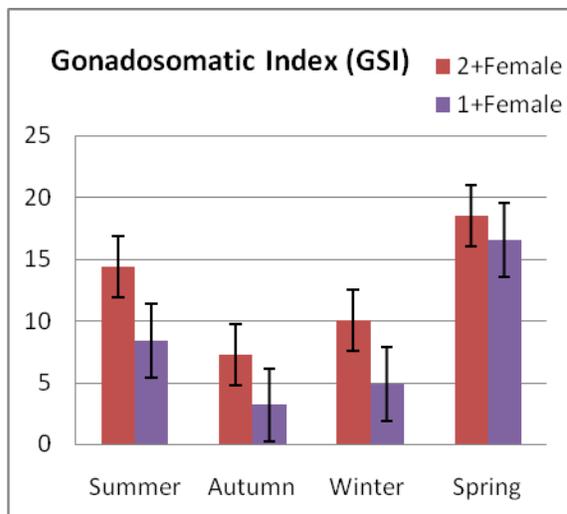


Fig.1 GSI of 2+ and 1+ years old

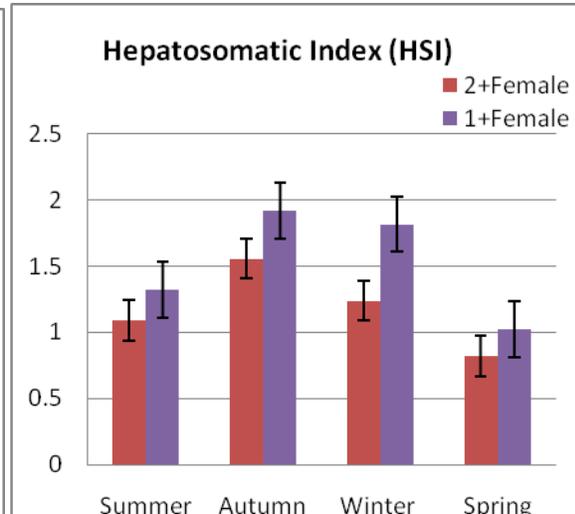


Fig.2 HSI of 2+ and 1+ years old

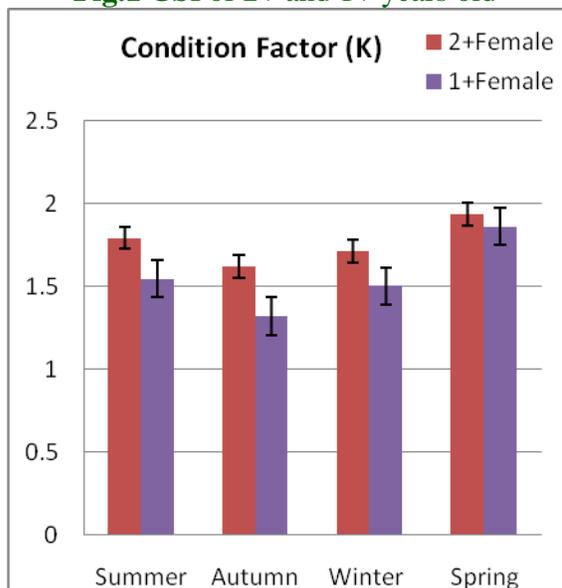


Fig.3 K value of 2+ and 1+ years old

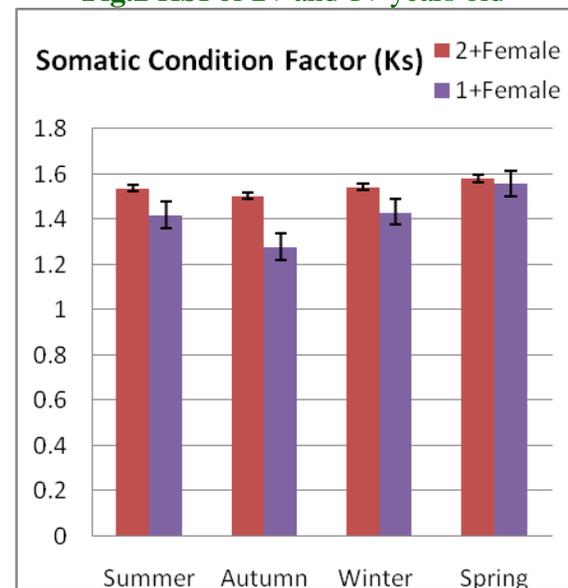


Fig.4 Ks value of 2+ and 1+ years old

For mature fish declined in the K level may be correlated with gonadal development and spawning behaviour, since substantial amount of energy gets invested during the reproductive period of fish life cycle (Jobling, 1994). Changes in the K level have been reported in different fishes in relation to their reproductive cycle - *Monopterusuchia* (Narejo *et al.*, 2002). Other factors like seasonal factor - *Acrossochilus haxagonolepis* (Dasgupta, 1988), physico-chemical factors - *Daysciaena albida* (Cuv.) and *Gerres filamentosus* (Cuv.), age - *Labeo dussumieri* (Kurup and Samuel, 1987; Kurup, 1990), physiological status - Carangid *Alepes para* (Kalita and Jayabalan, 1997) etc have also been reported to influence the K value. The somatic condition factor (Ks) in the present study the pattern similar to K level in both 1+ and 2+ year's age groups of Amur common carp. Seasonal variations in Ks level during breeding season due to changes in the gonadal maturity were reported in *Gastersteus aculatus* (Wootton *et al.*, 1978). Seasonal changes in K and Ks value due gonadal maturity and reproductive cycle was observed in *Channa punctatus* (Singh, 2010). Satheesh and Kulkarni (2016) which were attributed to extensive use of energy in reproductive activities and reduced feeding activity as the main cause for the decline of Ks value during off seasons (autumn and winter) in *Tilapia mossambica*.

Physiological indices in 1+ and 2+ year's old Amur common carp showed similar trend in different seasons. Levels of GSI, K and Ks were recorded at highest level in spring season, which decreased in summer and reached to the lowest level in autumn with slight recovery in winter season. Hepatosomatic index showed highest level in autumn season, which decreased in winter and reached to the lowest level in spring followed by slight increase in summer season. Levels of GSI, HSI, K and Ks were higher in 2+

year's age group as compared to 1+ year's age group in all four seasons. Pearson's correlations showed significant positive correlation of GSI with K and Ks and also between K and Ks while HSI exhibited negative correlation with GSI and Ks. The physiological indices observed in 1+ and 2+ year's age Amur common carp indicated presence of developed/mature gonads throughout the year with two major peaks – one in spring and other in summer season. Higher age groups (2+ years) had higher index value, which signified their higher reproductive potential than younger (1+ year) age group.

Based on the physiological indices spring season was found to be most potent period for reproduction seed production of Amur common carp, in the Tarai region of Uttarakhand. This study might be helpful in formulating for future research programmes towards achieving off season breeding and seed production of Amur common carp. Seasonal changes in physiological along with the hormones and biochemical parameters were found to have profound effect on the scale of success of reproduction of Amur common carp, *Cyprinus carpio haematopterus*, during spring and summer seasons and 2+ year's age group showed better reproductive potential.

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References

- Abassi, Z., Shaikh, S. A. and Abbassi, J. 2011. Serum cholesterol level during vitellogenesis of teleost fish, *Cyprinus carpio*. *Pakistan J. Zool*, 43(4): 739-745.

- Basak, R., Roy, A. and Rai, U. 2016. Seasonality of reproduction in male spotted murrel *Channa punctatus*: correlation of environmental variables and plasma sex steroids with histological changes in testis. *Fish physiology and biochemistry*, 42(5): 1249-1258.
- Borvinskaya, E. V., Sukhovskaya, I. V., Kochneva, A. A., Vasilyeva, O. B., Nazarova, M. A., Smirnov, L. P. and Nemova, N. N. 2016. Seasonal variability of some biochemical parameters in the whitefish (*Coregonus muksun* and *Coregonus lavaretus*). *Contemporary Problems of Ecology*, 9(2): 195-202.
- Brosset, P., Fromentin, J. M., Ménard, F., Pernet, F., Bourdeix, J. H., Bigot, J. L., Van Beveren, E., Roda, M. A. P., Choy, S. and Saraux, C. 2015a. Measurement and analysis of small pelagic fish condition: A suitable method for rapid evaluation in the field. *Journal of Experimental Marine Biology and Ecology*. 462: 90-97.
- Brosset, P., Ménard, F., Fromentin, J. M., Bonhommeau, S., Ulses, C., Bourdeix, J. H., Bigot, J. L., Van Beveren, E., Roos, D. and Saraux, C. 2015b. Influence of environmental variability and age on the body condition of small pelagic fish in the Gulf of Lions. *Marine Ecology Progress Series*. 529: 219-231
- Chellappa, S., Huntingford, F. A., Strang, R. H. C. and Thomson, R. Y. 1995. Condition factor and hepatosomatic index as estimates of energy status in male *three-spined stickleback*. *Journal of Fish Biology*, 47(5): 775-787.
- Coccia, E., De Lisa, E., Di Cristo, C., Di Cosmo, A. and Paolucci, M. 2010. Effects of estradiol and progesterone on the reproduction of the freshwater crayfish *Cherax albidus*. *Biol Bull* 218:36-47
- Craig, S. R., MacKenzie, D. S., Jones, G. and Gatlin, D. M. 2000. Seasonal changes in the reproductive condition and body composition of free-ranging red drum, *Sciaenops ocellatus*. *Aquaculture*, 190(1): 89-102.
- Dasgupta, M. 1988. Length-weight relationship and condition of Copper mahseer *Acrossochilus hexagonolepis* (McClelland). *Matsya*: 14: 79-91.
- Desai, A. S. and Singh, R. K. 2009. The effects of water temperature and ration size on growth and body composition of fry of common carp, *Cyprinus carpio*. *Journal of thermal Biology*, 34(6): 276-280
- Yang, X. and P. C. Baumann. 2006. Biliary PAH metabolites and the hepatosomatic index of brown bullheads from Lake Erie tributaries. *Ecol. Indicat.*, 6: 567-574
- Eroğlu, M. and Şen, D. 2017. Reproduction cycle and monthly alteration of serum testosterone, estradiol and cholesterol in *Capoeta trutta* (Heckel, 1843). *Journal of Scientific and Engineering Research*, 4(4): 99-105.
- FIGIS. 2011. Fisheries Global Information System (FAO-FIGIS) – Web site. Fisheries Global Information System (FIGIS). FI Institutional Websites. In: FAO Fisheries and Aquaculture Department [online]. Rome. (Available at: www.fao.org/fishery/figis/en)
- Fulton, T. W. 1904. The rate of growth of fishes. Fisheries Board of Scotland, Annual Report 22 part 3, pp. 141-241.
- Jobling, M. 1995. Environmental Biology of Fishes. Chapman and Hall, London. 435 pp.
- Kalita, N. and Jayabalan N. 1997. Age and Growth of the Carangid *Alepes para* (Class: Osteichthyes) from Mangalore Coast. *Indian Journal of Marine Science* 26: 107-108.

- Kurup, B. M. 1990. Population characteristics, bionomics and culture of *Labeo dussumieri* (Val), Final Report Submitted to Indian Council of Agricultural Research, 108 p.
- Kurup, B. M. and Samuel, C. T. 1987. Length-weight relationship and relative condition factor in *Daysciaena albida* (Cuv.) and *Gerres filamentosus* (Cuv.) *Fishery Technology* 24: 88-92
- Ma, Y. X., Matsuda, K. and Uchiyama, M. 2005. Seasonal variations in plasma concentrations of sex steroid hormones and vitellogenin in wild male Japanese Dace (*Tribolodon hakonensis*) collected from different sites of the Jinzu River Basin. *Zoological science*, 22(8): 861-868.
- Narejo, N. T., Rahmatullah, S. M. and Rashid, M. M. 2002. Length-weight relationship and relative condition factor (Kn) of *Monopterusuchia* (Hamilton). *Indian Journal of Fisheries*, 49(3): 329-333.
- Pinillos, M. L., Delgado, M. J. and Scott, A. P. 2003. Seasonal changes in plasma gonadal steroid concentrations and gonadal morphology of male and female tench (*Tinca tinca*, L.). *Aquaculture Research*, 34(13): 1181-1189
- Sabet, S. S., Reza, I. M., Bagher, A. F. and Saeed, G. 2009. Study on sexual maturity and levels of gonad steroid hormones in female kutum *Rutilus frisii kutum* (Kamenskii, 1901) during spawning season from river Sefid-Rood of the Southern Caspian Sea. *J Cell Anim Biol* 3:208-215
- Satheesh, D. and Kulkarni, R. S. 2016. Studies on condition factors, gonadosomatic and hepatosomatic indices of the fresh water female fish, *Tilapia mossambica* from an aquatic body. *Indian Journal of Research*, 5(12): 217-219
- Scott, A. P., Sumpter, J. P. and Stacey, N. 2010. The role of the maturation-inducing steroid, 17, 20 β dihydroxypregn-4-en-3-one, in male fishes: a review. *Journal of fish biology*, 76(1): 183-224.
- Shankar, D. S. and Kulkarni, R. S. 2014. Tissue cholesterol and serum cortisol level during different reproductive phases of the female freshwater fish *Notopterus notopterus* Pallas. *Journal of Environmental Biology*, 28(1): 137-139
- Singh, A. K. and Singh, T. P. 1979. Seasonal fluctuation in lipid and cholesterol content of ovary, liver and blood serum in relation to annual sexual cycle in *Heteropneustes fossilis* (Bloch). *Endokrinologie*, 73(1): 47-54.
- Singh, C. P. 2010. "Biological characterization of gonadal maturity in yearlings of murrel *Channa punctatus* (bloch) in nature and captive conditions of Tarai region of Uttarakhand". Thesis, Ph. D., G. B. P. U. A & T, Pantnagar.198.
- Singh, I. J. and Singh, T. P. 1983. Annual changes in the total gonadotropic potency in relation to gonadal activity in the freshwater catfish (*Clarias batrachus* L.). *J. Interdiscipl. Cycle Res.*, 14(3): 227-239
- Singh, I. J. and Singh, T. P. 1984. Changes in gonadotropin, lipid and cholesterol level during annual reproductive cycle in the freshwater teleost, *Cirrhinus mrigala* (Ham.). *Annales d' Endocrinologie*, 45(2): 131-136.
- Snyder, D. E. 1985. Fish eggs and larvae. In 'Fisheries Techniques'. (Eds L. A. Nielsen, D. L. Johnson & S. S. Lampton). pp. 165-197. (American Fisheries Society, Maryland)
- Sreevalli, N. and Sudha, H. R. 2014. Total protein, glycogen and cholesterol content in the ovary and liver during post spawning and resting season of

- Mystus vittatus* (Bloch). *Current Biotica*, 7(4): 321-325.
- Sudarshan, S. and Kulkarni, R. S. 2013. Determination of Condition Factor (K) and Somatic Condition Factor (Ks) Hepatic and Gonadosomatic Indices in The Freshwater Fish *Notopterus notopterus*. *International Journal of Scientific Research*. 2(11):524-526
- Taylor, C. M. and Miller, R. J. 1990. Reproductive ecology and population structure of the plains minnow, *Hybognathus placitus* (Pisces: Cyprinidae), in central Oklahoma. *American Midland Naturalist* 123: 32-39
- Vazirzadeh, A., Mojazi Amiri, B. and Fostier, A. 2014. Ovarian development and related changes in steroid hormones in female wild common carp (*Cyprinus carpio carpio*), from the south- eastern Caspian Sea. *Journal of animal physiology and animal nutrition*, 98(6): 1060-1067
- Velisek, J., Svobodova, Z., Piackova, V., Groch, L. and Nepejchalova, L. 2005. Effects of clove oil anaesthesia on common carp (*Cyprinus carpio* L.). *Vet Med*, 50(6): 269-275.
- Wootton, R. J., Evams, G.W. and Mills, L. A. 1978. Annual cycle in female three spined stickle back (*Gastersteus aculatus* L.) from an upland and lowland population. *J. Fish. Biol.*, 12: 331-343.

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