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Nutritional Compositions in a Locally Available Fresh Water Fish, *Notopterus notopterus* : A Review

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Abstract: The nutritive value of fish is recognized all over the world and fishes are more nutritive and relishing than plant food. Fish proteins are generally preferred to those of beef and egg because of their easy digestibility. In this review we have provided information on the edible fish *Notopterus notopterus* which is a prominent fish found in the aquatic bodies in and around the Gulbarga region. The present study includes the normal biochemical contents (protein, glycogen, lipid and cholesterol) in the liver, muscles and brain; changes in biochemical contents in liver and muscles during reproductive cycle of *Notopterus notopterus*; age related changes in biochemical contents in some tissues and effects of testosterone on protein, glycogen, lipid and cholesterol contents of liver and muscle.

Keywords: Protein, Lipid, Glycogen, Cholesterol, Liver, Muscle, Brain, *Notopterus notopterus*, Testosterone, Reproductive cycle

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Introduction

The development and improvement of fisheries in an area depend upon knowledge of biology of local fishes. The study on the biology of a particular fish to local environmental conditions is not only prerequisite for commercial exploitation but also for their application in fish culture practices. Fishes with over 30,000 species are

known to represent the most diverse group of vertebrates and they have provided with a wealth of forms variable not only in morphology but also in their habitat, and endocrine regulated physiological problems imposed by their environment (Schreibman *et al.*, 1973). A large number of fishes are being looked upon as an important source of food

for the ever-expanding human population in a protein deficient world. Hence, they occupy a significant position in the socio-economic fabric of the country (Talwar and Jhingran, 1991).

The basic biological data are the foundations on which assessment of fisheries resources are built. These include parameters such as size and age composition of the population and catch (both landed and discarded), the growth rates and maturation. The most assessments include age specific estimates of stock biomass, mortality rates, and predictions of future stock conditions. These require knowledge of size and age composition of the catch and indices of relative abundance by age.

Aquaculture is one of the fastest growing food production system in the world, which has emerged as an industry possible to supply protein rich food throughout the world (Prasad, 1996; Ahmed and Maqbool, 2017; Kumar *et al.*, 2017; Chakraborty *et al.*, 2018; Al-Muhanna *et al.*, 2019; Amitha *et al.*, 2019 Paul *et al.*, 2019). The annual growth rate of world aquaculture at compound interest formula is 9% per year. The world aquaculture production increased from 10.4 million metric tones in 1984 to 22.6 million metric tones in 1993 (FAO, 1995). Currently varieties of marine and brackish water species of fin fishes and shellfishes are cultured in over one million hectares for food in several Asian countries (Broak, 1991). Matty (1985) stated that with worldwide development of scientifically based fish farming and aquaculture, the endocrinology of fishes has taken a new turn for many years. Presently, aquaculture is facing heavy production loss both in hatcheries and grows out systems due to disease outbreak. Further, feed related

soluble and solid waste accumulation is also posing environmental problems in aquaculture. The high biological value of fish meal for many species has led to heavy demands on this commodity in diets used for high density fish production. Many attempts have been made to substitute other proteins either wholly or in part for fish meal but until such substitutions have resulted in a marked fall in growth.

For developing fishery, it is necessary to understand their population dynamics – how fast they grow and reproduce their size and age at which they spawn, their mortality rates and its causes, on what they prey upon along with other biological process. The theory of population dynamics is a division of general theory of the development of life, which deals with the laws of reproduction, growth and causes of death of living organism (Nikolsky, 1969). They are concerned with the continuous process of the replacement of generations in time, the birth of generation, its growth and death. The details of the process are governed by specific adaptation and by the relationship of the years with the environment.

The ultimate aim of the research conducted on the fisheries is to increase the production of animal protein to meet the needs of fast growing population producing high prices of commodities or exports and utilizing large area unproductive idle land and water bodies for food production (Neelkantan *et al.*, 1989). Knowledge of biology of fish breeding is extremely important for the development of fish culture.

Nutritional importance:

The nutritive value of fish is recognized all over the world. Fishes are more nutritive and

relishing than plant food. They are also known to be the most efficient among farm animals in converting feed into nutritious food. Fish proteins are generally preferred to those of beef and egg because of their easy digestibility. It is therefore, obvious that understanding the chemical composition and nutritional quality of a fish is important in its use as food and for formulation of balanced food products from plants, cereals and fish (Shendge and Mane, 2005).

Fish and other marine foods were one of the primitive man's foods in his earliest days as a hunter food gather. In Asia, nearly 30% of total animal protein consumed is derived from fish (James, 1994). In India, fish and fish eating has been widely prevalent but a sizable number of people being vegetarians do not consume fish at all. The cost of fish is high and poor Indian population is deprived of the direct nutrition and health advantage of eating fish and their products.

It is most economical for man to consume directly food of plant origin (cereals, millets and legumes) rather than to convert plants into animal foods. However, fish are the most efficient of animals in converting food into body tissue. In recent years, aquaculture has contributed significantly to increase fish production and it can contribute to some extent to nutritional security of human and for production of 1 kg of cultured fish, 3 kg of wild fish is needed (Hoffmann, 1991). Since fish is more healthy food than pork, mutton and beef, incorporation of fish meal or fish oil in fish feeds was earlier considered to be better than feeds of farm animals. The unique value of foods of animal origin in upgrading the nutritional quality of human diets is well recognized. Animal foods provide a good

source of protein of high biological value (high content of methionine and lysine). There are some differences between fish muscle and the muscle of land animals. Fish muscle has less connective tissue than muscle of terrestrial animals, resulting in a more tender texture. Therefore, cooking time and digestibility of fish protein is high, as compared to other meats. Fish can be categorized into white lean fish and oil rich fatty fish. The lean fish have high fat in the liver, whereas fatty fish store lipids in muscle. Fish has less cholesterol than other animal foods. The dark muscles, which are found in the flesh along the lateral line, have more lipids than the light muscle. Further, the lipid content of muscle increases from the tail portion towards the head.

Fish is a good source of vitamins A and D; fatty fish have higher levels than lean fish (British Nutrition Foundation, 1993). The contents of vitamins A, D and E in the liver of both fatty and lean fish are higher than that in the muscle of the fatty fish. The vitamin B contents in fish muscle are generally similar to that in other meats. Various organs of fish are good sources of B₂ and B₁₂ and fish is a good source of iodine and biologically available iron. Sardines eaten with bones, is rich source of calcium and phosphorous (British Nutrition Foundation, 1993). Fishes have efficient ability to assimilate heavy metals, pesticides and polychlorinated biphenyls from the environment in which they live (British Nutrition Foundation, 1993; Schmidt, 1997). Both national and international agencies should ensure that oceans, seas, rivers and lakes are not polluted. Quality assurance of fish and fish oils should emphasize on the lowest permissible limits of

heavy metals and pesticide residues in fish, fish oils and their value added products.

A major difficulty encountered with fish as a food is that it is perishable and rapidly spoils after catching. Traditionally fish with low lipid content were preserved by salting and drying in the sun and fish with high lipid were packed in layers interspersed with coarse salt in barrels and later canning of fish products was introduced. In modern times fish is transported and marketed in chilled or frozen conditions. A large proportion of total landed fish is not used or underutilized as they are unconventional species and are not acceptable for human consumption (Shahidi, 1998). Some of these are converted to fish meal for use in animal and fish feeds. However, current emphasis is to utilize low value fish species for preparation of value added products with wide range of applications in food industry (Shahidi, 1998; Kristinson and Rasco, 2000). This can ensure efficient utilization of marine resources for sustainable nutrition and health of human population.

Biochemical Constituents:

Biochemical composition of fish tissue is of considerable interest for their specificity in relation to food values of fish and evaluating their physiological needs at different periods of life. A number of workers have observed depletive effects of malnutrition and spawning in the chemical composition of fish.

Protein acts both as a nutrient and as an energy source. Consequently addition of energy to a diet not only increases energy intake but also lowers the protein energy; total energy ratio. Both factors are likely to influence nitrogen balance and their effects. Lack of attention to this point has led to loose statement "increasing the protein level with

constant energy always resulted in improved efficiency" (Page and Andrews, 1973). The synthesis of yolk protein in the liver with the onset of a new reproductive cycle is accompanied by marked changes in DNA and RNA. Seasonal variations in the content of these cellular macromolecules are the result of variation in external (environmental) and internal (sex steroids) factors.

Lipids are of immense nutritional importance from the stand point of both quality and quantity. They provide maximum energy, besides providing vitamins like A, D, E and K. Lipids are also source of some essential fatty acids. The fish use the liver and skeletal muscle for lipid storage. The relative importance of liver and skeletal muscle as the site of lipid storage varies in different species of fish. Generally, the liver serves as the storage site for lipid reserve in sluggish bottom dwelling fish, whereas skeletal muscles plays this role in more active species. With respect to the deposition of fat in the muscle, it is known that the red muscle contains more lipid than ordinary one. In fish the red and white muscle fibre areas are more clearly distinct. In Rainbow trout and Salmon the skeletal muscle is an important site of lipid storage and the red muscle is located along the lateral line. The utilization by salmon of the energy released by breakdown of lipids is most evident in fish that migrate without feeding.

In fish large amount of yolk nutrient including carbohydrate is transferred from body to the gonad for its subsequent growth and maturation during pre-spawning season. However, stored nutrient including carbohydrate in liver and muscle of the body are transferred to the gonad to ensure its

growth and maturation leading to subsequent spawning (Love, 1970). The changes in carbohydrate reserve in fish seems mostly to reflect the requirements of developing gonads specially females.

Fishes exhibit fast growth and short life history. There are over 30,000 species known worldwide and around 1030 fresh water fishes reported from India (https://www.fishbase.se/Country/CountryChecklist.php?resultPage=20&what=list&trpp=50&c_code=356&cpresence=Reported&sortby=a) have been identified to be present in Indian freshwater, out of which very few have been used for human consumption particularly major and minor carps. Among the edible freshwater fishes, *Notopterus notopterus* are abundantly found in Gulbarga area. Though considerable interest has been shown on this fish by local people as their food particularly the people having lower income group, it becomes necessary to understand biochemical organization of this fish. Considering the abundant distribution and paucity of information on this species the present study was undertaken.

Gulbarga is an inland city in the deccan plateau of India laying between longitude 76°-04' and 77°-04" and latitude 16°-12' and 17°-46'. The city is located on the undulating plain presenting a vast expanse of rich black cotton soil. The climate of this area comprises of summer setting in from middle of February to the middle of June. The monsoon sets from the middle of June till the end of September, October and November are the post monsoon periods. The period from December to mid February is the coldest that represents the winter season. Maximum temperature during winter season is 29.7 C and the minimum is

14.8 C. It is known that temperature and photoperiod are the important environmental cues for the fishes living in subtropical and tropical areas for their seasonal growth of gonads, and there is sufficient support that in most of the fishes of Indian freshwaters confined to annual calendar of gonadal development resulting in synchronizing in maturation of gonads.

Among the fish species available in Gulbarga area, *Notopterus notopterus* is a prominent fish found in freshwater habitats, although there are many other fish, they are not uniformly available. *N. notopterus* can be considered as commercially important fish since it is being consumed by large population particularly people with lower income group. Therefore, the biochemical profile of the tissues such as brain, liver and muscle has been studied in this fish. Brain is very important organ in any animal and liver and muscle are important tissues for fish and also from the point of nutrition to others.

Fish constitutes an important source of food for man and there are many programmes relating to the culture and their utility. The nutritive value of fish is recognized all over the world and fishes are more nutritive and relishing than plant food. They are also known to be the efficient farm animals in converting feed into nutritious food. Fish proteins are generally preferred to those of beef and egg because of their easy digestibility. Fishes exhibit fast growth and short life history. Among the edible freshwater fishes, *Notopterus notopterus* is one of the prominent fish found in the aquatic bodies in and around Gulbarga region. This commonly available fish captured regularly by local fisherman, since it is popular food fish

particularly for economically down trodden communities as its flesh is well flavored. It has tremendous potential for improved productivity and these fishes are known for their nutritive and therapeutic qualities. The availability of this fish in large numbers throughout the year from most of the aquatic bodies of Gulbarga indicates the favourable environment and successful breeding.

(I) Normal Biochemical contents in some tissues of the freshwater fish N. notopterus:

The primary biochemical composition include, proteins, carbohydrates and lipids which act as source of energy for various physiological function of tissue and also speaks about the nutritional status of the fish as a source of food. An attempt to determine the biochemical composition such as protein, glycogen, lipid, cholesterol and heavy metals, has been made in the important tissues such as liver, muscle and brain of a normal harvestable sized fish, *Notopterus notopterus* during active breeding period.

Protein: Fish flesh provides an excellent source of protein for human diet, its protein has relatively high digestibility, biological and growth promoting value. The amount of protein is found to be higher in the hepatic tissue compared to muscle and brain. However, the amount of protein content in the brain is more as compared to muscle (Table 1).

Glycogen: The carbohydrates are stored in liver as glycogen; The glycogen was estimated in liver, muscle and brain. The result indicates that the high glycogen content in the brain compared to liver and muscle (Table 1).

Lipid: Lipids are of utmost importance in maintaining the structural and physiological

integrity of cellular and sub cellular membranes. Under stress conditions, stored lipids undergo catabolism, releasing energy in the form of ATP. The lipid content found to be less in hepatic tissue in comparison to muscle and brain (Table 1).

Cholesterol: Cholesterol forms a major component of lipid. It plays a major important role in the physiological and metabolic process of the animal. The cholesterol content found to be high in brain and relatively it was less in liver and muscle (Table 1).

Heavy metals: Aquatic organisms are adversely affected by heavy metals in the environment. The water concentration of heavy metals such as copper, cadmium, lead, chromium, nickel has been studied from which the fish *N. notopterus* was caught indicate that the water content of heavy metals were less (Table 2) and similarly, the muscle concentration of these heavy metals (Table 3) was also found to be less as compared to the certified values.

(II) Biochemical changes in some tissues in relation to reproductive cycle:

Analysis of variations in the biochemical compositions of tissues due to changes in the reproductive phase of the fish will provide information on the utilization of biochemical contents for reproductive activities specially for vitellogenesis and spermatogenesis. Since, the fish organization is oriented towards seasonal activities particularly their preparedness for approaching breeding season, it becomes necessary to understand changes in the biochemical contents in the important tissues in relation to reproductive phases and also helps in determining the nutritional status of the fish during different periods of the reproductive cycle. In the

Table 1: Showing biochemical constituents in tissues (Muscle, Liver, Brain) of the fresh water fish, *Notopterus notopterus*

Organ	Protein	Glycogen	Lipid	Cholesterol
Muscle	3.32 ± 0.01	0.63±0.01	1.9±0.19	4.33±0.12
Liver	24.±0.14	1.05±0.01	0.96±0.03	4.93±0.01
Brain	13.95±0.08	3.72 ±0.04	10.8 ±0.34	5.5±0.16

Tissue expressed as mg/g
Each value is expressed as mean ±SE (N= 6)

Table 2: Analysis of heavy metal concentration in the water sample

Phases	Preparatory	Post-spawning
Cu	0.122±0.05***	0.061±0.0097
Fe	0.349±0.075	0.355±0.073
Mn	0.422±0.079**	0.266±0.082
Zn	0.132±0.0092	0.121±0.0093
Pb	0.227±0.025	0.209±0.020
Ni	0.550±0.133	0.621±0.125*

Tissue expressed as mg/50 g
Each value is expressed as mean ±SE (N=6)
*=significant P<0.05 ; **=significant P< 0.01, ***=significant P< 0.001 , when compared between the phases.

Table 3: Analysis of heavy metal concentration in the muscle of the fresh water fish *N. notopterus* during different reproductive phases (ppm/g)

Phases	Preparatory	Post-spawning
Cu	0.059±0.011	0.073±0.012
Fe	0.150±0.018	0.157±0.014
Mn	0.179±0.015	0.182±0.016
Zn	0.427±0.093	0.403±0.101
Pb	0.193±0.020	0.228±0.01**
Ni	0.473±0.207	0.818±0.207***

Tissue expressed as mg/50 g

Each value is expressed as mean ±SE (N=6)

*=significant P<0.05 ; **=significant P< 0.01, ***=significant P< 0.001 , when compared between the phases.

present study the condition factor (K), somatic condition factor (KS), gonad somatic index (GSI), hepatosomatic index (HIS) and the changes in the biochemical contents of liver and muscle of the freshwater water fish *N. notopterus* has been studied during four different reproductive phases (Tables 4, 5, 6). The hepato-somatic index (HSI) has been correlated with gonad-somatic index. The GSI in the fish *N. notopterus* found to be increased during preparatory and pre-spawning and decline during spawning and post spawning phase indicates that the gonad undergo seasonal growth of gonads and depletion. Whereas the HSI value was high during preparatory phase and decreased in all other subsequent phases (Table 6). The highest value of HSI indicates heavier liver.

Protein: The biochemical contents such as protein, glycogen, lipid and cholesterol has been studied in the fish *N. notopterus* during different phases of the reproductive cycle.

The result indicate that the hepatic protein content found to be increased during preparatory and decreased during pre-spawning and post-spawning phases. The protein content increased during spawning phase (Table 4). The reduction of protein suggests the involvement of hepatic protein for gonadal development.

Glycogen: The hepatic glycogen was less during preparatory and pre-spawning and increased during post-spawning phase (Table 4). In case of muscle the glycogen content was increased during preparatory and post-spawning phase (Table 5). The decline in glycogen content of muscle during pre-spawning indicates that glycogen has been utilized as a source of energy required for the maturation of gonads.

Lipid: In the present study the hepatic lipid increased during preparatory and starts decreasing in pre-spawning and spawning.

Table 4: Showing hepatic biochemical contents in the fresh water fish, *N. notopterus* during different reproductive phases

Phases	Protein	Glycogen	Lipid	Cholesterol
Preparatory	21.33±1.40***	0.96±0.11	10.33±0.90**	4.19±0.27
Pre-spawning	0.93±0.10	0.62±0.02	2.76±0.38	1.33±0.04*
Spawning	24.3±0.14***	1.05±0.01	1.9±0.19	4.93±0.01
Post-spawning	9.33±0.70	1.36±0.08	5.66±0.58**	4.98±0.18

Tissue expressed as mg/50 g

Each value is expressed as mean ±SE (N=6)

*=significant P<0.05 ; **=significant P< 0.01, ***=significant P< 0.001, when compared between the phases.

Table 5: Showing biochemical contents of muscle in the fresh water fish *N. notopterus* during different reproductive phases

Phases	Protein	Glycogen	Lipid	Cholesterol
Preparatory	4.50±1.33***	0.90±0.12	4.6±0.38***	1.16±0.07
Pre-spawning	0.76±0.05*	0.56±0.03*	1.56±0.05*	3.4±0.13*
Spawning	3.32±0.01***	0.63±0.01	0.96±0.03	4.33±0.12
post-spawning	1.10±0.09	0.73±0.09*	1.3±0.07*	1.8±0.05***

Tissue expressed as mg/50 g

Each value is expressed as mean ±SE (N=6)

*=significant P<0.05 ; **=significant P< 0.01, ***=significant P< 0.001, when compared between the phases.

Again it increased in post-spawning phase (Table 4). The reduction of hepatic lipid during spawning may be because of its contribution to gonads for promoting growth. The muscle lipid in the present study shows an increase in the lipid value during preparatory phase and decreased in all other phases (Table 5).

Cholesterol: In liver cholesterol increased during preparatory and decreased during pre-spawning phase. It is increased during spawning and post-spawning phase (Table 4). The muscle cholesterol increased from preparatory to spawning and found to be decreased during post spawning phase (Table 5).

(III) Age-related biochemical contents in some tissues:

The study of aging is being carried out to understand progressive changes taking place in an organism and such studies are less in fishes particularly on the biochemical changes taking in the tissues and organs in relation to age. Hence, in the present study changes were determined in liver and muscle in four age groups of the fish. The study also aimed at to suggest harvestable size and age of the fish for nutritional purpose. Age related nutritional components in the tissues show that as the age increases the contents of protein, glycogen, lipids and cholesterol increased (Tables 7, 8).

Table 6: Showing condition factor (K), somatic condition factor (KS), hepatic and gonadosomatic indices in the fish, *N. notopterus* during different reproductive phase

Phases	K	KS	GSI	HSI
Preparatory	0.68±0.01	0.70±9.07	0.52±0.01	0.98±0.01*
Pre-spawning	0.65±0.01	0.78±0.01	0.62±0.01*	0.54±0.04*
Spawning	0.59±0.01	0.75±0.07*	0.50±0.08	0.48±0.01
Post spawning	0.61±0.01	0.66±0.01	0.49±0.02	0.51±0.01

Tissue expressed as mg/50 g

Each value is expressed as mean ±SE (N=6)

*=significant P<0.05 when compared between the phases.

Table 7: Determination of hepatic biochemical constituents in different age group of the fresh water fish, *N. notopterus*.

Age of the fish	Proten	Glycogen	Lipid	Cholesterol
1 year	7.0±0.85	1.19±0.13	5.33±0.98*	3.73±0.34*
2 year	7.33±1.52	1.15±0.05	5.66±0.95*	4.38±0.59*
3 year	8.00±1.15*	1.25±0.16	5.83±1.16	4.4±0.55*
4 year	9.33±0.04*	1.36±0.08*	5.66±0.58*	4.98±0.18*

Tissue expressed as mg/50g

Each value is expressed as mean ±SE (N=6)

*=significant P<0.05 , when compared between the phases.

(IV) Effects of testosterone on tissue biochemical contents:

The use of steroid hormones as dietary supplements for growth promotion is an accepted practice. A variety of hormones, both natural and synthetic have been evaluated for their anabolic properties and in fish androgen have given more consistent results than estrogens. Hence, in the present study an attempt was made to understand effects of testosterone on tissue biochemical changes to understand its metabolic role in enhancing the tissue biochemical contents for nutritional purpose. The hepatic and muscle

protein is found to be increased in the testosterone treated fish (Tables 9, 10).

The hepatic lipid in testosterone treated fish was found to be maximum during preparatory phase (Table 9). In muscle, lipid content in testosterone treated fish was found to be increased in all the reproductive phases (Table 10).

Conclusion

(i) The fish *N. notopterus* were available in large numbers in most of the aquatic bodies of Gulbarga indicates the favourable condition for its survival and breeding activity. (ii) The

biochemical studies indicate that, the fish tissues such as liver and muscle contains all the important nutritional components needed for human consumption. (iii) The fish, *N. notopterus* can be harvested when it attains the age of 4 years and above, since the fish tissues has all the biochemical

contents in proper proportions. In order to propagation of the species lower aged fish should not be harvested. Hence, harvestable size of fish should be of the fish having length of 25 cm, weight 180 g and age of 4 years and above. (iv) Hormones play significant role in biochemical compositions of tissues.

Table 8: Determination of muscle biochemical constituents in different age group of the fresh water fish, *N. notopterus*.

Age of the fish	Protein	Glycogen	Lipid	Cholesterol
1 year	1.10±0.09	0.73±0.09	1.3±0.07	1.8±0.05*
2 year	1.35±0.10	0.86±0.13	2.84±0.20*	2.05±0.56*
3 year	2.15±0.15*	1.02±0.10*	2.41±0.12*	2.05±0.56
4 year	1.17±0.20*	0.91±0.08*	2.90±0.20*	2.53±0.38*

Tissue expressed as mg/50 g

Each value is expressed as mean ±SE (N=6)

*=significant P<0.05 when compared between the phases.

Table 9: Determination of hepatic biochemical contents of the fresh water fish, *N. notopterus* during different reproductive phases after testosterone treatment

Parameters	Preparatory		Pre-spawning		Spawning		Post-spawning	
	Control	Treated	Control	Treated	Control	Treated	Control	Treated
Protein	21.33±1.40	23.57±1.00	0.93±0.10	17.53±0.53***	24.3±0.14	29.04±0.83	9.33±0.70	3.88±0.01**
Glycogen	0.96±0.11	0.71±0.04	0.62±0.02	0.43±0.02	1.05±0.01	2.19±0.24*	1.36±0.08	3.36±0.04**
Lipid	10.33±0.90	28.24±0.97**	2.76±0.38	1.73±0.16*	0.96±0.03	0.72±0.02	5.66±0.58	4.10±0.20
Cholesterol	4.15±0.27	2.4±0.32	1.33±0.04	0.93±0.19*	4.93±0.01	8.09±0.39**	4.98±0.18	7.44±0.01*

Tissue expressed as mg/50 g

Each value is expressed as mean ±SE (N=6)

*=significant P<0.05 ; **=significant P< 0.01, ***=significant P< 0.001 , when compared between the phases.

Table 10: Determination of muscle biochemical contents of the fresh water fish, *N. notopterus* during different reproductive phases after testosterone treatment

Parameters	Preparatory		Pre-spawning		Spawning		Post-spawning	
	Control	Treated	Control	Treated	Control	Treated	Control	Treated
Protein	4.50±1.33	5.46±0.433	0.76±0.05	2.01±0.25**	3.32±0.01	4.16±0.26	1.10±0.09	3.29±0.02*
Glycogen	0.90±0.12	1.34±0.29*	0.56±0.03	0.81±0.14	0.63±0.01	1.71±0.16*	0.73±0.09	2.74±0.03
Lipid	4.6±0.38	6.05±0.34*	1.56±0.05	1.93±0.31	1.9±0.19	2.13±0.28*	1.3±0.07	2.90±0.03
Cholesterol	1.16±0.07	0.77±0.14*	3.4±0.13	1.49±0.21**	4.33±0.12	2.70±2.22**	1.8±0.05	10.81±0.01

Tissue expressed as mg/50 g

Each value is expressed as mean ±SE (N=6)

*=significant P<0.05 ; **=significant P< 0.01, ***=significant P< 0.001 , when compared between the phases.

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