Indian Journal of Geo-Marine Sciences
Vol. 42(1), February 2013, pp. 75-81

Observations on the utilization of the biochemical constituents during maturation of the butterfish *Scatophagus argus* (L.1766) from Palk Bay, south east coast of India

V. Venkatesan, V. Gandhi [1] & P.U. Zacharia

Central Marine Fisheries Research Institute, PB.No.1603, Kochi-682018, India
[1]Regional Centre of Central Marine Fisheries Research Institute, Mandapam Camp-623520, India

[E-mail:venkatcmfri@yahoo.com.in]

Received 25 March 2011; revised 18 October 2012

Observations on the utilization of biochemical constituents of various tissues viz. liver, muscle and gonads of butterfish *Scatophagus argus* (L. 1766) with respect to sex and maturity stages were made from Mandapam water in Palk Bay. Investigation revealed that moisture content of muscle, liver and gonad in male and female butterfish was more or less same in all the stages with very little difference of 1-2% in both sexes. An inverse relationship of moisture content with carbohydrate and lipid was recorded in muscle, liver and gonad irrespective of their development stages. Protein level in muscle, liver and ovary of female and in testis of male decreased during maturation process. Muscle and liver carbohydrate content in female and male decreased indicating utilization of carbohydrate during maturation and spawning. In female, higher caloric value was recorded in stage I for both muscle and liver tissues while in ovary it was in stage IV whereas in male higher caloric values in muscle, liver and gonad were registered in stage VII.

[Key words: Proximate composition, maturity stages, Butterfish, Palk Bay]

Intdoduction

Fish has high protein content, low saturated fat and also contains Omega-3 polyunsaturated fatty acid (PUFA) known to support good health. Flesh quality can be influenced by the biochemical composition of fish fillets[11]. An increasing amount of evidences suggested that fish flesh and fish oil are beneficial in reducing the serum cholesterol due to its high content of PUFA[34].

Scatophagus argus, a cultivable ornamental butterfish, is used for edible purpose. Substantial amount of energy is required during maturation and spawning activity and hence a considerable change in biochemical composition of body takes place. Although several studies dealt with the biochemical constituents of many commercially important fishes, no work on similar lines has been carried out in *Scatophagus argus*, particularly from Mandapam water in Palk Bay. Present study was undertaken to understand the dynamics of biochemical composition of various tissues viz. liver, muscle and gonad of *S. argus* with reference to sex and maturity stages.

Materials and Methods

Fresh butterfish specimens were collected for biochemical analysis. Specimens of various maturity stages (i.e. stages I–VII) of males and females were utilized for estimating the biochemical constituents of liver, muscle and gonad. Specimens for the study were collected from the fish landing centers in and around Mandapam region (Lat. 79 10; long. 9 ° 15 ´) of the Palk Bay for a period of one year from January, 1997 to December, 1997.

Different stages of maturity of each sex of *S.argus* were collected and their collective weight was taken. The weight of tissues was measured at the nearest 1.0 mg. Estimation of the moisture content was carried out by drying the pre-weighed wet samples of liver, muscle and gonad at 45°C in a hot air-oven for 24 hours until a constant weight was obtained. The difference between wet weight and dry weight was taken as the moisture content. Then the dried samples were finely powdered and stored in desiccators for estimation of biochemical constituents. Biochemical analyses for lipid, protein and carbohydrate were carried out using standard methods.

Protein was determined by measuring nitrogen (N × 6.25) using the Kjeldahl method and total Carbohydrate by the phenol sulphuric acid method[8]. Lipid was estimated by the method of Bligh and Dyer[2]. All the values of biochemical components

were expressed in percentage dry weight basis (% DWB). The caloric content was determined by multiplying the concentration of various components with conversion factors 4.15, 9.4, and 5.65 for carbohydrate, lipid and protein respectively[27]. The caloric values were expressed as calories per gram (cal g^{-1} DWB). Mean of five samples were taken as representing sample value.

Results

Changes in biochemical compositions (% DWB) in different tissues viz. muscle, liver and gonad with respect to maturity stages of male and female are given in Figures 1a, 1b, 1c and 2a, 2b, 2c respectively. Each value represented the mean of at least five samples.

Male body tissue

Muscle

Moisture content in the muscle varied from 75 ± 0.4 to 77 ± 0.6 in stages I–VII with the minimum found in stage VI and the maximum seen in stage VII. Protein and lipid content varied from 19.87 ± 0.1 to 21.16 ± 0.07 and 1.76 ± 0.01 to 2.79 ± 0.03 respectively with the maximum recorded in stage I and the minimum recorded in stage V. The carbohydrate content ranged between 0.94 ± 0.01 and 1.12 ± 0.01 with the maximum noticed in stage I and the minimum noticed in stage VII (Fig. 1a).

Liver

Moisture content ranged from 72 ± 0.1 to 75 ± 0.3 with the maximum recorded in stage VI and minimum recorded in stage I. The protein content varied from 11.16 ± 0.18 to 13.91 ± 0.01 with the maximum observed in stage II and the minimum observed in stage VI. Lipid content varied between 6.67 ± 0.08 and 7.59 ± 0.11 with the minimum found in stage V and maximum found in stage I. Carbohydrate content ranged from 6.65 ± 0.24 and 7.9 ± 0.03 with the maximum seen in stage I and the minimum observed in stage VI (Fig. 1b).

Testis

The range of moisture content observed was from 74 ± 0.2 to 77 ± 0.7 with the minimum registered in stage III and the maximum registered in stage V. Protein and lipid content ranged from 8.22 ± 0.1to 9.45 ± 0.03 and 10.19 ± 0.07 and 11.99 ± 0.07 respectively with the maximum noted in stage I and the minimum noted in stage VII. Carbohydrate

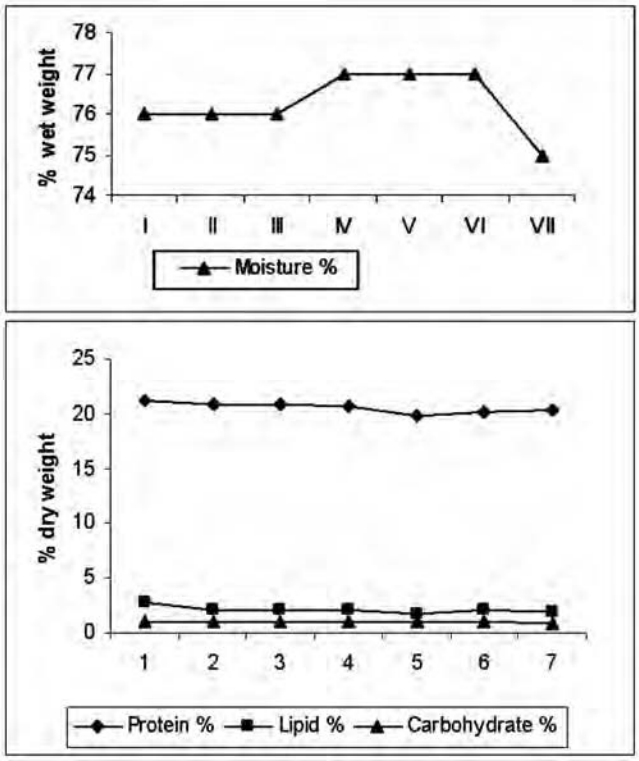

Figure 1a—Changes in gross biochemical composition (%dry weight basis) in different maturity stages of male muscle tissue.

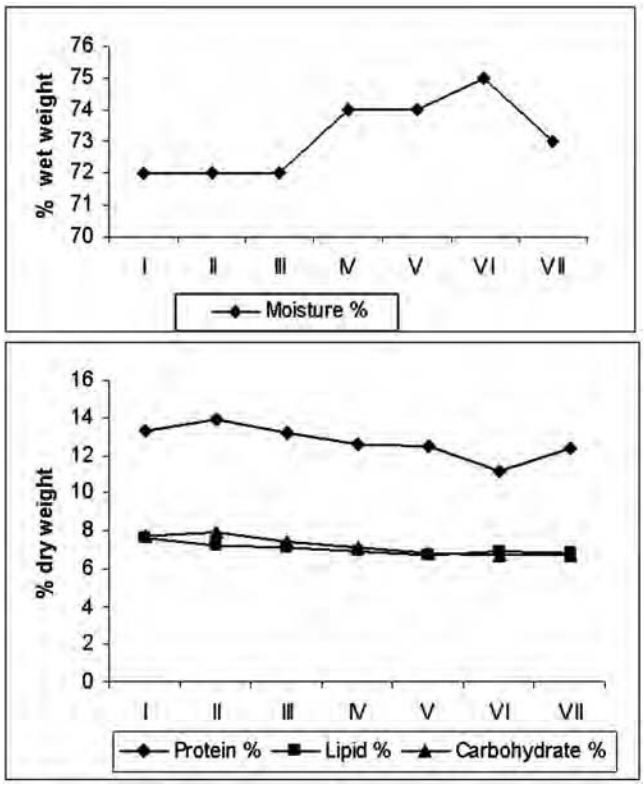

Figure 1b—Changes in gross biochemical composition (%dry weight basis) in different maturity stages of male liver tissue.

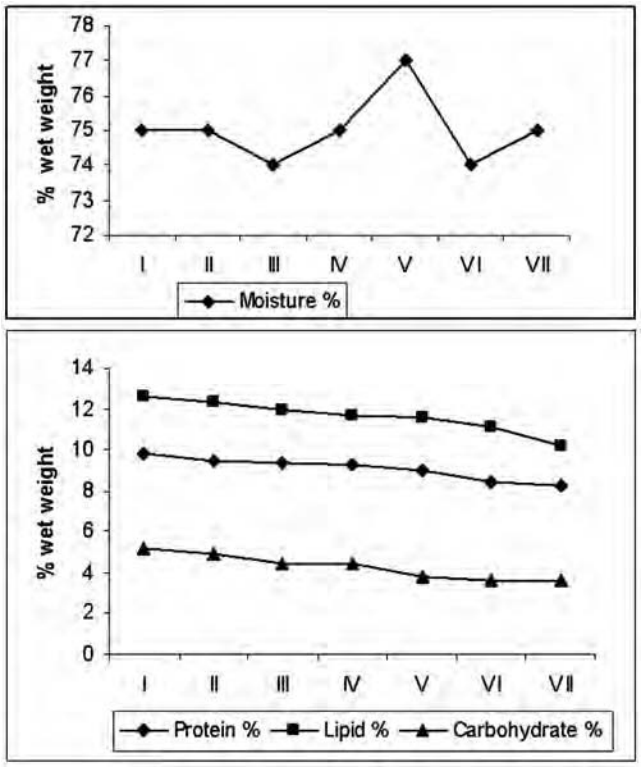

Figure 1c—Changes in gross biochemical composition (%dry weight basis) in different maturity stages of male testis.

content varied from 3.57 ± 0.03 to 5.17 ± 0.03 with the maximum registered in stage I and the minimum registered in stage VI (Fig. 1c).

Female body tissue

Muscle

Moisture content in the muscle ranged from 74 ± 0.2 to 76 ± 0.3 with the minimum seen in stages I, II, and IV and the maximum observed in stage VII. Protein content of muscle varied between 21.25 ± 2.15 and 23.22 ± 2.35 with the maximum found in stage II and minimum found in stage VI. Lipid content ranged from 1.33 ± 0.06 to 2.04 ± 0.04 with the maximum found in stage I and minimum found in stage VII. The range of carbohydrate content was from 0.87 to 1.06 ± 0.02 with the maximum seen in stage I and minimum seen in stage VI (Fig. 2a).

Liver

Moisture content of liver was 71 ± 0.1 to 73 ± 0.4 with the minimum observed in stage II and III and the maximum observed in stage I and IV. The range of protein content was from 10 ± 0.57 to 16.81 ± 0.63 with the maximum found in stage I and the minimum

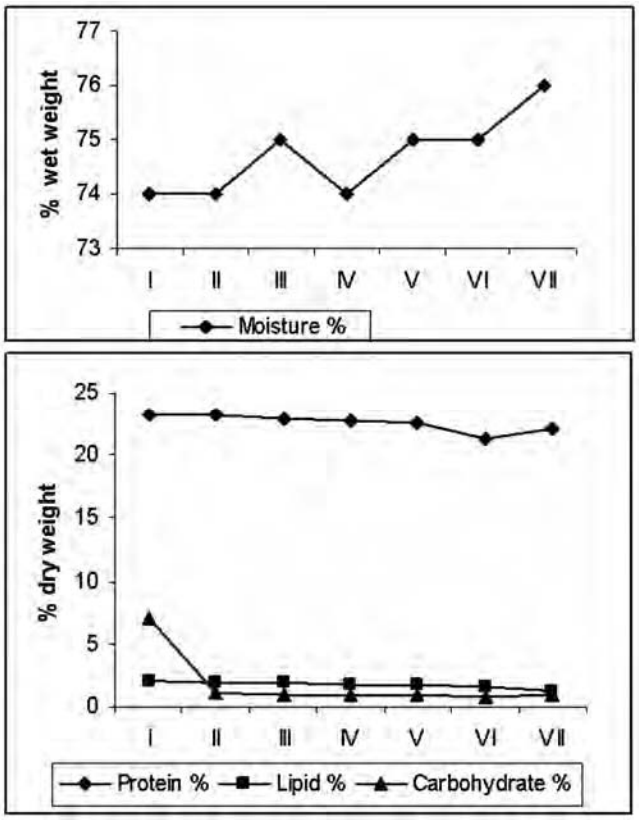

Figure 2a—Changes in gross biochemical composition (%dry weight basis) in different maturity stages of female muscle.

found in stage VI. Carbohydrate and lipid content varied from 5.52 ± 1.76 to 7.96 ± 3.98 and 5.87 ± 0.78 to 9.04 ± 1.71 respectively with the maximum noticed in stage I and the minimum noticed in stage VII (Fig. 2b).

Ovary

The range of moisture content was from 74 ± 0.2 to 76 ± 0.3 with the maximum registered in stage III and minimum registered in stages IV and VI. Protein content ranged from 13.66 ± 0.07 to 17 ± 0.2 with the maximum recorded in stage I and the minimum recorded in stage VII. Lipid content ranged from 6.47 ± 0.06 to 8.9 ± 0.04 with the minimum seen in stage I and the maximum found in stage VI. Carbohydrate content varied between 1.83 ± 0.01 to 2.49 ± 0.01 with the maximum found in stage II and the minimum found in stage VII (Fig. 2c).

Caloric content

The total caloric content of muscle, liver and gonad for the seven stages of male and female are given in

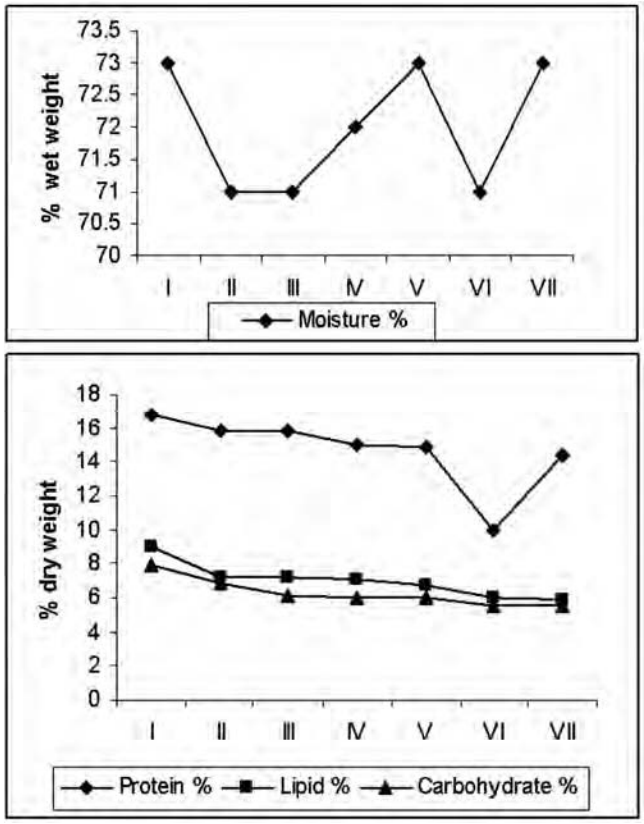

Figure 2b—Changes in gross biochemical composition (%dry weight basis) in different maturity stages of female liver

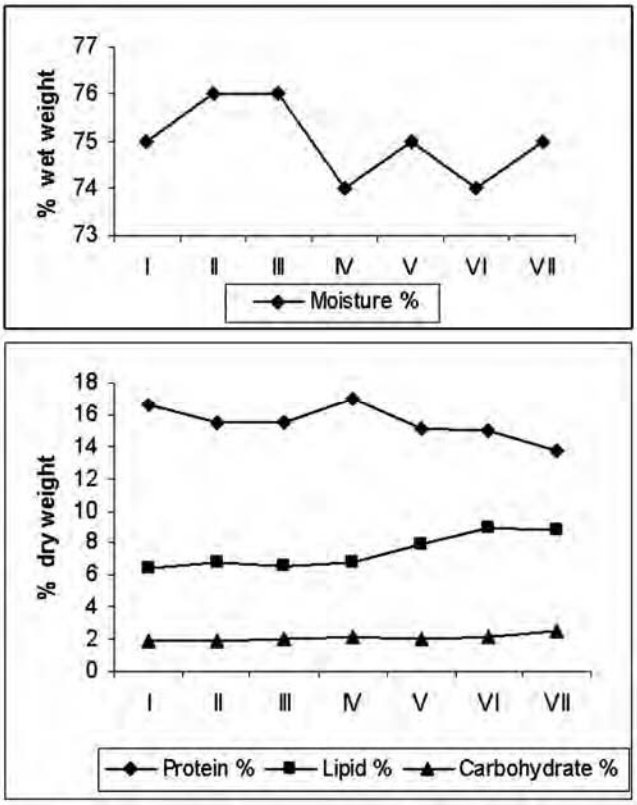

Figure 2c—Changes in gross biochemical composition (%dry weight basis) in different maturity stages of female ovary tissue

Tables 1 and 2. Each value represented the mean of at least five samples for each stage.

In Male muscle, liver and testis, maximum caloric value in stage VII and minimum in stage V were noticed. In case of female, maximum caloric value in stage I and minimum in stage VI were noticed for both muscle and liver tissues while in ovary, maximum caloric value in stage IV and minimum in stage VI were recorded.

Discussion

Existing literature on biochemical composition of Indian fishes revealed that only a few Indian marine teleosts have been investigated for their biochemical composition. For example, the biochemical composition of *Pseudosciaena aneus* and *Johnius carruta*[29], *Ambassis gymnocephalus*[35], *Mugil cephalus* and *Liza parisa*[18] and *Silago sihama*[16] has been studied. Biochemical composition of fish tissues is of significance because tissues constitute a rich source of nutrients and caloric value[19].

Moisture is a major constituent in animal body which plays an important role in regulating osmotic functions. It also serves as a medium by which nutrients and biochemical constituents are transported to various organs. The amount of moisture in fish is higher than that of all other higher vertebrates. Water is so important that an animal can lose practically all of its fat and half of its protein and still live, but loss of even 10% of its water can cause death[22].

During the present investigation, moisture content of three organs in male and female butterfish was more or less the same in all the stages with very little difference of 1-2%. The moisture was found to be inversely related to lipid content which has also been reported by Jafri[14,15] as well as Ramaiyan & Pandian[28]. In both the sexes, an inverse relationship of moisture content with carbohydrate and lipid was recorded in muscle, liver and gonad irrespective of their development stages. The inverse relationship has been reported earlier by Hart *et al*[10], Reinitz[30], Sivakami *et al*[32] and Jayasankar[16]. Chandra Shekhar *et al*[4] reported that the moisture content was low when other constituents (lipid, protein and carbohydrate) were high in *Labeo rohita.* The changes in moisture content observed in muscle of butterfish could be attributed to

Table 1—Caloric value of the biochemical composition of muscle, liver and gonad in different stages of maturity of male butter fish (dry weight basis)

Stages	Tissues	Protein ($calg^{-1}$)	Carbohydrate ($calg^{-1}$)	Lipid ($calg^{-1}$)	Total caloric value ($calg^{-1}$)
I	Muscle	3359	132	582	4072
	Liver	2980	1285	2672	6937
	Testis	1383	640	3252	5275
II	Muscle	3296	126	552	3975
	Liver	3007	1320	2605	6932
	Testis	1342	568	3073	4983
III	Muscle	3205	119	554	3878
	Liver	3112	1207	2514	6833
	Testis	1380	485	3051	4915
IV	Muscle	3262	114	528	3904
	Liver	2863	1140	2625	6629
	Testis	1478	519	2911	4908
V	Muscle	3243	116	470	3829
	Liver	2716	1071	2400	6887
	Testis	1448	446	2702	4596
VI	Muscle	3371	124	602	4097
	Liver	2839	1242	3047	7128
	Testis	1498	402	3196	5095
VII	Muscle	3483	127	741	4350
	Liver	3060	1287	3130	7477
	Testis	1619	446	3415	5480

Table 2—Caloric value of the biochemical composition of muscle, liver and gonad in different stages of maturity of female butterfish (dry weight basis)

Stages	Tissues	Protein ($calg^{-1}$)	Carbohydrate ($calg^{-1}$)	Lipid ($calg^{-1}$)	Total caloric value ($calg^{-1}$)
I	Muscle	3422	118	505	4044
	Liver	2764	779	2286	5828
	Testis	3166	269	2053	5488
II	Muscle	3454	110	475	4038
	Liver	2606	718	1959	5283
	Testis	3048	265	2220	5533
III	Muscle	3325	109	462	3895
	Liver	2528	622	1679	4829
	Testis	3089	290	2151	5530
IV	Muscle	3343	104	431	3877
	Liver	2244	625	1422	4291
	Testis	3363	315	2246	5923
V	Muscle	3230	94	363	3686
	Liver	2122	583	1499	4204
	Testis	2587	247	2252	5086
VI	Muscle	2810	79	271	3160
	Liver	1618	548	1309	3475
	Testis	2296	245	2276	4817
VII	Muscle	3357	110	469	3937
	Liver	2173	605	1406	4184
	Testis	2198	294	2361	4853

changes in lipid level directly and to spawning indirectly. This corroborates the findings of Das[7], in which low values of moisture content were noticed during the spawning season which could be due to the decline in food intake.

In the present study, protein level in the muscle of female decreased from stage II-VI, as the maturation of ovaries advanced, and in male protein content decreased from stage I-V (Fig. 1a) indicating utilization of protein for the development of testis. However, it was not as big as in the female. This was consistent with the finding of Hickling & Rutenberg[12], Love & Robertson[20] and Iles[13]. They reported that protein synthesized and accumulated in the somatic tissues during pre-maturation period would be utilized for gamete formation in addition to the growth of fish. Similarly decline of muscle protein content with the advancement of maturation in *Gadus morhua*[6] and *Cyprinus carpio*[21]has also been reported.

Liver protein content in female showed a decrease from stage I-VI during the advancement of maturation. However, in male, liver protein content decreased only to a lesser extent i.e., from 13.9% in stage II to 11.16% in stage VI during the maturation process. Ovary protein content also decreased from stage I-VII in female and testis protein content in male also decreased from stage I-VII again indicating utilization of protein during the maturation process. Similar observations in other teleosts were also made by Nuriyal & Singh[23] and Sivakami *et al*[32]. Parulekar[25] reported maximum protein content in the ripe fishes and the minimum in spent and early maturation phases. Protein content can be correlated with the phases of maturity and spawning, with high values when the gonads are ripe[26,7].

Muscle carbohydrate content in the female showed a general decline from stage I-VI with the advancement of maturation. However, it decreased only slightly in male indicating utilization of carbohydrate to a lesser extent with the advancement of maturation. In female, liver carbohydrate content decreased from stage I-VII and in male it decreased from stage I-VI. Similarly in male, the decline was from stage I-VI indicating utilization of carbohydrate during maturation and spawning. These observations corroborated well with the observations of

carbohydrate allocation during reproductive cycle studied in *Salmo salar*[5], *Mugil cephalus* and *Liza parsia*[19]. The low values of carbohydrates recorded in the present study suggest that glycogen in many marine animals does not contribute significantly to the total reserves in the body[17]. Vijayakumaran[35]stated that carbohydrate plays a minor role in energy reserves of *Ambassis gymnocephalus* and its depletion during the spawning season is insignificant.

At the time of maturation of gonads and spawning, lipid in fish is utilized mainly for three purposes, viz. 1) as endogenous source of energy for sustaining the fish, since most of them are known to abstain from feeding during spawning and for increased muscular activity of fish that have spawning migratory behavior, 2) for the synthesis of generative materials (eggs and sperms) and yolk deposition and 3) for the synthesis of steroid hormones. Depending upon the level of lipids in the fish muscle, fishes are classified into three categories viz. fat fish with > 8% average fat content, moderately fat fish with its content varying between 1 and 8% and lean fish with fat content < 1%[33]. Accordingly, *S. argus* having an average fat content of 1.95% falls into the second category.

During the present investigation, muscle lipid content in female decreased from stage I-VII and in male, it decreased from stage I-V indicating its possible mobilization towards gonadal development. Such depletion of muscle lipid in fishes has also been observed by Dambergs[6], Masurekar & Pai[21] and Sivakami *et al*[32]. Liver lipid content in female showed a decline from stage I-VII and in male it showed little decline from stage I-V indicating utilization of lipid for the development of gonads. During maturation, liver lipid content has been observed to decrease in some fishes[31]. In female gonad, lipid content decreased from stage I-VI and in male gonad it decreased from stage I-VII indicating diversion of lipid for gonadal maturation. Singh & Singh[31] and Carvalho[3] have also reported a similar decline in ovarian lipid during maturation in *Chirrhinus mrigala* and *Hypophthalmus edentatus* respectively. In general, lipid content in fishes has been found to decline during maturation and peak spawning period[29,9,24]. Bhuyan *et al*[1] reported higher fat and protein content in ripe and gravid fish, whereas a low level of fat and protein was recorded in spent and young fish.

The present study revealed that the utilization of biochemical constituents with respect to different maturity stages of butter fish is associated with reproductive cycle, storage and utilization of reserves. Moisture showed a negative relationship with lipid and carbohydrate content of in muscle, liver and gonad irrespective of their development stages. The biochemical composition in muscle, liver and gonad in both sexes are found higher in early stages of maturity and decreases during gonad maturation.

Acknowledgment

Authors are thankful to the Director, Central Marine Fisheries Research Institute, Cochin for providing the necessary facilities.

References

1 Bhuyan H R, Chowdhury M B, Nath K K, Seal P & Hag M A, Studies on the biochemical parameters of *Cynoglossids* in the Kutuboha Channel, Bangladesh, *Bangladesh J. Sci. Ind. Res.,* 38 (2003) 91-96.

2 Bligh E G & Dyer W J, A rapid method for total lipid extraction and purification, *Can. J. Biochem. and Physiol*., 37(8) (1959) 911-917.

3 Carvalho F M, Chemical composition and reproduction of the fish mapra (*Hypophthalmus edentatus*) (Siluriformes, Hypophthalmidae) of the lake of Castanho, Amagonas, Brazil, *Acta Amazonica*, 10 (1980) 379-390.

4 Chandra Shekar A, Rao P, & Abidi A B, Changes in muscle biochemical composition of *Labeo rohita* (Ham) in relation to season, *Indian J. Fish.,* 51(3) (2004) 319-323.

5 Chang V M & Idler D R, Biochemical studies on sockeye salmon during spawning migration, XII. Liver glycogen. *Can. J. Biochem. and Physiol*., 38 (1960) 553-558.

6 Dambergs N, Extractions of fish muscle-4 Seasonal variations of fat, water solubles, protein and water in cod (*Gadus morhua*) fillets, *J. Fish. Res. Board of Canada*, 21 (1964) 703-709.

7 Das H P, *Studies on the grey mullet, Mugil cephalus (Linnaeus) from the Goa waters*, Ph.D Thesis, University of Bombay, India, 1978.

8 Dubois M K, Gills A, Hamilton J K, Rebers P A & Smity F, Calorimetric method for determination of sugars and related substances, *Analyt. Chem.,* 28 (1956) 350-356.

9 ELMaghraby A M, Ezzart A & Saleh H N, Fat metabolism in *Tilapia zilli* II. Fat metabolism in *T. zilli* in relation to feeding and breeding, *Bull. Inst. Oceanogr. Fish.,* 25 (1972) 315-332.

10 Hart J L, Tester A L, Beall D & Tully J P, Proximate analysis of British Columbia herring in relation to season and condition factor, *J. Fish. Res. Board Can.,* 4 (1940) 478-490.

11 Hernandez M D, Martinez F J & Garcia Garcia B, Sensory evaluation of farmed sharpsnout seabream *(Diploduspuntazzo*), *Aquatic. Int.,* 9 (6) (2002) 519-529. [doi: 10.1023/A: 1020513931447].

12 Hickling C F & Rutenberg E, The ovary as an indicator of spawning period in fishes, *J. Mar. Biol. Assoc. U.K*., 21(1936) 311-317.

13 Iles T D, *The tactis and strategy of growth in fishes. In F. R. H. Jones, (editor)*, *Sea Fisheries Research*, (John Wiley New York) 1974, 331-345.

14 Jafri A K, Seasonal changes in the biochemical composition of the common carp, *Cirrhina mirgala* (Ham), *Broteria*, 36 (1968) 29-44.
15 Jafri A K, Seasonal changes in the biochemical composition of the fresh water cat fish *Wallago attu* (Bloch), *Hydrobiologia* 33 (3&4) (1969) 497-505.
16 Jayasankar P, *Studies on the reproduction of Indian whitings Silago sihama (Forskal) (Percoidei, Sillaginidae),* Ph. D. Thesis, Cochin University, India, 1989.
17 Jaya Sree V, Parulekar A H, Wahidulla S & Kamat S Y, Seasonal changes in biochemical composition of *Holothuria leucospilota* (Echinodermata), *Indian J. Mar. Sci.,* 23 (1994) 117-119.
18 Joseph E, *Studies on the histopathological and biochemical changes during spermatogenesis in Mugil cephalus (Linn.) and related species*. Ph. D. Thesis, Cochin University, India, 1987.
19 Joshi B D, Gupta D K & Chaturvedi L D, Biochemical composition of some tissues of a fresh water fish *Heteropneustes fossilis* during winter months, *Matsya* 5 (1979) 47-49.
20 Love R M & Robertson I, Studies on the North Sea cod. IV. Effects of starvation to changes in the distribution of muscle protein fractions, *J. Sci. Fd. Agric.,* 18 (1967) 217-220.
21 Masurekar V B & Pai S R, Observations on the fluctuations in protein, fat and water content in *Cyprinus carpio* (Linn.) in relation to the stages of maturity, *Indian J. Fish*., 26 (1979) 217-224.
22 Maynard L A & Loosli J K, *Animal nutrition* 5th edition, (McGraw Hill Book Co., New York.) 1962, 533 pp.
23 Nuriyal B P & Singh H R, Some biochemical changes in the reproductive cycle of a hill stream teleost, *Puntius chilinoides* (McClelland), *Proc. Indian Acad. Sci.* (*Anim. Sci.*), 94 (1) (1985) 67-72.
24 Pandey B N, Datta Munshi J S, Choubey B J & Pandey P K, Seasonal variation in body composition in relation to breeding cycle of an air-breathing fish, *Heteropneustes fossilis* (Bloch), *J. Inland Fish. Soc. India*, 8 (1976) 91-95.
25 Parulekar A H, *A study on Bregmaceros mcclellandi* (*Thompson*), Ph. D Thesis, University of Bombay, India, 1964.
26 Parulekar A H & Bal D V, Observations on the seasonal changes in chemical composition of *Bregmaceros mcclellandi, J. Univ. Bom.,* 38 (65) (1969) 88-92.
27 Phillips A M, *Nutrition, digestion and energy utilization. In: Hora, W. S. and Randall, R. J. (Eds.), Fish physiology*, (Academic press, London) 1969, pp. 391- 432.
28 Ramaiyan V & Paul Pandian A L, Biochemical studies on the fishes of the order clupeiformes, *J. Mar. Biol. Ass. India*, 18 (3) (1976) 516-524.
29 Rao T A, Fat and water content of the muscle and ovary during the maturation cycle of *Pseudosciaena aneus* (Bloch) and *Johnius carutta* (Bloch), *Indian J. Fish.,* 14 (1967) 293-297.
30 Reinitz G, Relative effect of age, diet and feeding rate on the body composition of young rainbow trout (*Salmo gairdneri*), *Aquaculture*. 35 (1983) 19-27.
31 Singh I J & Singh T P, Changes in gonadotropin, lipid and cholesterol levels during annual reproductive cycle in the freshwater teleost, *Chirrhinus mrigala* (Ham), *Ann. Endocrinol. (Paris),* 45 (2) (1984) 131-136.
32 Sivakami S, Ayyappan S, Rahman M E & Govind B V, Biochemical composition of *Cyprinus carpio* (Linn.) cultured in cage in relation to maturity, *Indian J. Fish.,* 33 (2) (1986) 180-187.
33 Srivastava C B L, *Fisheries science and Indian fisheries*, (Ketab Mahal, Allahabad) 1999, pp.527.
34 Stansby M, Fish or Fish oil in the diet and heart attack, *Mar. Fish. Rev.*, 46 (2) (1985) 60-63.
35 Vijayakumaran M, Chemical composition and caloric content of *Ambassis gymnocephalus*, *J. Mar. Bio. Ass. India*, 21 (1 & 2) (1979) 182-184.