Lipid Classes and Their Fatty Acids Present in The Flesh and Hepatopancreas of *Scylla Serrata* (Forsskål 1775)

Mohua Das[1], K. K. Misra[2]
[1]*Department of Zoology, Shyampur Siddheswari Mahavidyalaya*
[2]*Department of Zoology, Asutosh College, Kolkata*

***Abstract*—The paper evaluates the major lipid classes and their fatty acids from the flesh and hepatopancreas of a marine mud crab *Scylla serrata* by thin layer chromatography and Gas liquid chromatography. This work is focused on the nutritionally valuable fatty acids present on the species which are vital nutrients of humans. The fatty acid composition in muscle (claw and breast) and hepatopancreas of the mud crab were analyzed by gas chromatography. Polyunsaturated fatty acids (PUFA) were the predominant group of fatty acids found in *S. serrata* (39%-43%) and Oleic acid (C 18:1 n-9) was the most abundant fatty acid (16%-21%). Oleic acid (C 18:1 n-9), Gondoic acid (C 20:1), Eicosapentaenoic acid (C20: 5 n-3), Docosatetraenoic acid (C22: 4 n-6) and Docosahexanoic acid (C22: 6 n-3) contents are substantially present in flesh. The contents of Oleic acid (C 18:1 n-9), Gondoic acid (C 20:1) and Docosatetraenoic acid (C 22:4 n-6) were notably different in flesh and hepatopancreas. It is concluded that claw and breast meat are good sources of *n*3 PUFAs and n6 PUFAs. The results suggest that flesh of the mud crab is an appropriate nutrient for human health**

***Index Terms*—Fatty acids; GLC; Lipids; Mud crab; Saturates; Unsaturated; PUFA**

I. INTRODUCTION

The mud crab, *Scylla serrata* (Forsskål 1775), is one of the highly consumed and widely distributed crab species in the Indo-west pacific region. Mud crab is predominantly estuarine, but depends on the marine environment for spawning and early larval life. *S. serrata* is one of the major species of crabs which has a very good market around the world. Several studies have concluded that diets in which unsaturated fatty acids replace the saturated ones are associated with low incidence of coronary diseases. Taking these facts into account, all attempts to reduce the risk of the earlier-mentioned diseases, especially cardiovascular diseases, emphasize the importance of an increased consumption of fish or fish products, which are rich in polyunsaturated fatty acids of the ω3 family and poor in polyunsaturated fatty acids of the ω6 family. The purpose of the present study aims to evaluate the major lipid classes and their fatty acid profile of the marine water inhabiting crab, *S. serrata*, collected from local fishermen of Uluberia, Howrah, West Bengal. Investigation on the fatty acid profiles of the edible tissues may provide information on the relative nutritional quality of the flesh of the crab species under study. The hypothesis of the present work is that *S. serrata* might be enriched with good lipid and PUFA so that the crab may be beneficial to human health and hygiene and would be a good supplement in diet. Most of the earlier work was done on the flesh of the crab. The role of hepatopancreas was not considered earlier. Detailed accounts of lipid classes and their fatty acids of mud crab were not studied. The present study highlights the fatty acid and lipid classes in the flesh of Indian marine mud crab, *Scylla serrata*, found in the coastal area of Bay of Bengal. The work is therefore to characterize the lipid content of flesh of *Scylla serrata* details of which has not yet been done before. The aim of the present study is to provide a comprehensive account about the details of lipid classes and their fatty acid compositions of the flesh as well as hepatopancreasof this crab.

II. MATERIALS AND METHOD

Materials

Phylum	Arthropoda [Ruppert and Barnes, 1994]
Subphylum	Crustacea
Class	Malacostraca
Subclass	Eumalacostraca
Genus	*Scylla*
Species	*serrata*

Live marine water crab, *Scylla serrata*, was collected from the local fisherman of Uluberia, Howrah, and West Bengal, India. Samples with a carapace length of (L = 80.0 mm, W = 112.0 mm, F = 22.0mm (L = Length of carapace, W = Wide of carapace, F = Front of carapace) of the crab were considered for the resent study. These are collected from the coastal region of Purba Medinipur district (erstwhile Midnapore). The individual samples were packed in polythene bags, immediately chilled and put into crushed ice from outside of the bags and transported to the laboratory. In the laboratory carapace length and weight of individuals were measured and the exoskeleton was removed, flesh and hepatopancreas were dissected out from the crab. Tissues were pooled from 15 individuals and are repacked in labeled polythene bags and frozen at 4˚C until further analysis.

Method

Flow chart of the method is presented in Figure 1.

Extraction of total lipids from the crab:

The total lipids were extracted from the samples following the method of Bligh and Dyer (1959) using methanol-chloroform-water (2:1:0.8, v/v/v), and then again with the first solvent system.

Fractionation of total lipids into various classes was done by Column Chromatography:

According to Rouser *et al.* (1976) a portion of the total lipid of the samples was subjected to Column Chromatography using Silicic acid.

Separation of Neutral Lipid:

Neutral lipid components were separated by Thin Layer Chromatography (TLC).

TLC was performed to separate hydrocarbon, wax ester, phospholipids components.

Purification of FAME:

According to the method of Mangold (1969) and Misra *et al.* (1984) fatty acid methyl esters were purified by thin layer chromatography using solvent system of n-hexane diethyl-ether (90:10, v/v)

GAS LIQUID CHROMATOGRAPHY (GLC):

Analysis of fatty acid methyl esters (FAME) was done by gas liquid chromatography.

The detailed work procedure was followed as per Das et al. (2015a).

III. RESULT

Lipids of body flesh and hepatopancreas (HP) have been studied for mainly September, October and November, 2014. *Scylla serrata* is commonly known as ‘’Nona kankra’’ found in marine environments exclusively. The percent composition of Total lipid (TL) and other three lipid classes; Neutral lipids (NL), Glycolipids (GL) and Phospholipids (PL) of *S. serrata* were presented in table 1. The TL content of the flesh was only 0.82% to that of the wet weight of the tissue (Fig.2).

Table 2 represents all lipid fractions of both the organs. Among the lipid classes, PL was found to be the major component in comparison to its NL (27.45%) and GL (11.73%) (Fig.3). In the PL fractions (Table 3), the amount of saturated fatty acids (SFAs) were dominant in Phosphatidylinositol (PI) (69.3%), Monounsaturated fatty acids (MUFA) in Phosphatidylcholine (lecithin) (PC) (34%), and Polyunsaturated fatty acids (PUFA) in Phosphatidylethanolamine (cephalin) (PE) (9.4%). On the other hand, among PL, cardiolipin (CL, 26.28% w/w of phospholipids) and sphingomyelin (SPH, 9.37%) were estimated as the major and minor components respectively (Fig.4).

In NL fractions, the highest percentage of SFA (66.6%) in wax ester (WE), DUFA (20.3%) in Triacylglycerol (TAG) and PUFA (6%) were found in WE whereas MUFA (25.1%) was in SE (Table 4). In NL fraction (Fig.5), the combination of WE+HC+SE appeared high in flesh (90.1%). However, the fraction of TAG was found to be significantly lower (8.35%). In comparison to this combination Hydrocarbons (HC) were estimated in the highest amount (97.24%) among wax esters (WE, 2.18%) and steryl esters (SE, 0.58%). In NL fraction, the combination of WE+HC+SE appeared high in flesh (90.1%). However, the fraction of triacylglycerols (TAG) was found to be significantly lower (8.35%). In comparison to this combination Hydrocarbons (HC) were estimated in the highest amount (97.24%) among wax esters (WE, 2.18%) and steryl esters (SE, 0.58%).

Figure 6 demonstrates that monoene was the maximum amount followed by saturates, dienes and polyenes (MUFA > SFA > DUFA >PUFA). SFA was estimated to be major in PL (46.6%), whereas MUFA (32.8%) is high in NL, TL and DUFA (25.32%) is high in TL. Similarly, PUFA n-3 (31.5%) in GL and n-6

(26.04%) were found to the highest extent in TL. SFAs and MUFAs mainly had carbon chain lengths varied from C14- C24, while for PUFAs it lied mostly in the range of C18- C22. Comparison of C-18 total and C-16 total fatty acids classes in all lipid fractions (TL, NL, GL, and PL) show that in all cases C16-fatty acid is present in higher amounts than that of C18-type (Fig.7). Among SFA, palmitic acid (C16:0) was the highest (26.6%) in the NL, stearic acids (C18:0) in PL (15.5%) and behenic acids (C22:0) in GL (19.3%). Distribution of all essential fatty acids (EFAs) with eicosapentaenoic acid (EPA) (20:5ω3) and docosahexaenoic (DHA) (22:6ω3) among these classes was presented in Figure 8.

Among HCs, Table 5, n-alkanes were the major component; whereas the branched chain alkanes, viz. iso- and anteiso components were present remarkably in NL. Chain lengths of the n-alkanes were mostly varied from C-14 to C-28, whereas for iso- and anteiso- components the chain lengths were from C14-C26 and C-21 to C-26 respectively. Shorter-chain n-alkanes between C-14and C-28 predominated, with C-18 being the major component (11%). Table 6 specified a different composition of sterol. Cholesterol is present in good quality (81%) whereas stigmasterol is few (17%), campesterol is also found as marginal. A comparison of major lipid classes and fatty acid percentage in between Flesh of *Varuna litterata* (Das *et al*., 2015a) a freshwater crab and *S. serrata* is provided in Table 7.

On the other hand, Atherogenic index (A.I.) and Thrombogenic index (T.I.) were calculated as A.I. is highest in the flesh (Fig. 9). Assessment of n-3 and n-6 was also recorded (Fig.10). And n-6 is to be highest in the flesh of the marine crab.

IV. DISCUSSION

For aquatic animals including crabs, lipids are a major source of energy as well as they provide hydrophobic barriers which creates partitioning the aqueous contents of cells and subcellular structures. Lipids serve additional functions in the body, for example, some fat-soluble vitamins have regulatory or coenzyme functions, and the prostaglandins and steroid hormones play major roles in the control of the body's homeostasis.

The TL content of marine crab has 4.32% in HP and 0.82% in flesh. The amount of fat in crayfish necks ranged from 0.4 to 0.9% Walkowiak (1979). Zafar et al. (2004) reported that the biochemical composition of *S. serrata* changes seasonally. Wild caught *S. serrata* have 0.65% TL in flesh is reported by Anas et al. (2009). It is shown that marine crabs have low amounts of TL in flesh. The mean content of fats in crayfish meat from Goplo lake and Brda river were 0.44% and 0.43% respectively (Stanek et al. 2010). The total lipid content of spiny cheek meat ranged from 0.92 to 1.10% (Stanek et al. 2011).

In the present study, total lipid in *S. serrata* though is less than 1%. The total lipid content from various crustaceans was found to ranges from 0.21-31.9% among them; freshwater crab *V. litterata* shows 1.03% TL value which considers it as lean shellfish category. However, TL content of *P. vigil*, *M. rosenbergii* (male), *M. rosenbergii* (female), *P. mansonia* ranges from 4.12-6.34%,3.35-5.35%,16.8-31.9%, 5.85% respectively, reflecting that all of them have high lipid content. In the present study the TL obtained from the crab flesh and hepatopancreas is separated into three major fractions namely- neutral lipid, phospholipid and glycolipid. The neutral lipids are further fractionated into triacylglycerol (TG), sterol (ST), hydrocarbon (HC), wax ester (WE) and steryl ester (SE). Again, the phospholipids are classified into cardiolipin (CL), phosphatidylcholine (PC), phosphatidylethanolamine (PE), sphingomyelin (SPH) and phosphatidylinositol (PI).

In the present study the abundance of recorded lipid classes in the flesh of the crab is NL > PL > GL. The low lipid content in the flesh of the crab makes it easily digestible. Purely marine fish species generally have higher levels of lipids as in case of pomfret with about 32.31% lipid in body muscles. As per Ackman's category this crab may be considered as low-fat crabs and consequently proposed as an ideal supplement for low fat protein to the patients suffering from obesity. Neutral lipids probably function as storage forms of fatty acids. It is reported that marine fishes have usually low amounts of NL in flesh (Addison et al. 1968; Banerjii et al. 1997; Pal et al. 1999). Triacylglycerols are stored in adipose tissue fundamentally as a long-term source of energy that can be used when the energy requirements of the animal exceed the energy available from the diet, particularly when the energy requirements of the animal are very high.

The most important simple lipid in all animals, including crab, is cholesterol. This is the most common of the tetracyclic hydrocarbon compounds, collectively called sterols, and can exist unesterified as an essential component of cell membranes. Cholesterol is a major component of plasma membrane and metabolic precursor of steroid hormones and bile acids. This lipid class is very abundant in marine zooplankton, particularly in calanoid copepods and red feed and krill that form major natural foods for many species of marine fish. In *Scylla serrata*, combined HC+ WE+ SE is noticeably high (90.1%) in flesh but low in HP (19.05%). HC in the flesh of *S. serrata* is much higher than HP (97.24%). Kaneda (1991) suggested that hydrocarbon chains in triglycerides determine the structure and functionality of fats, water-resistance of the hydrocarbons make them insoluble in water and also help in the formation of micelles. In this species presence of iso- and ante-iso hydrocarbon in fleshes probably for making the fat saturate and insoluble in water. Presence of higher amount of TG than WE in the flesh of the crab species suggests a need to meet a higher physical and metabolic activity rather than need for long term energy storage. ST is the lowest component among NL fractions in flesh while HP of *Scylla serrata* has highest. This can be assumed that HP may be used to provide energy to the animal for breeding like fish (Ahmed, 1995).

Phospholipids and sterols have important function as cytoplasm and membrane constituent of cells, affecting structural and physiological properties. Marine fish *C. reynaldi* also have highest PL in the flesh (Majumder et al. 2013). Among 50% of muscle lipids are phospholipids in *M. rosenbergii*, probably almost entirely due to the cellular membrane content (Cavalli et al. 2000). In *Scylla serrata* CL is highest followed by PC, PE, PI, PS and SPH respectively in both the tissues. In this study a unique phospholipid component cardiolipin was recorded. CL is an important constituent of mitochondrial lipids especially so heart muscle is a rich source. The marine crab has second highest position of PC. This is usually the most abundant lipid in the membranes of animal tissue. Studies by Li and Vance (2008) indicate that choline is recycled in the liver and redistributed from kidney, lung and intestine to liver and brain when choline supply is attenuated. Similar biosynthetic pathway may exist in crustacean system also.

The present work reveals that PI is more or less same in amount in both hepatopancreas and flesh of this crab. This component acts as precursor of second messenger as well as important constituents of cell membrane. SPH is found as a major component of the complex lipids of all animal tissues. It acts as a precursor for a number of sphingolipids metabolites that are involved in cellular signaling. It is reported that SPH in *S. serrata* is very poor in both HP and flesh. PS is weakly acidic lipid that is present in most tissue of animals. It is an essential cofactor for the activation of protein kinase C and it is involved in many other biological processes, including blood coagulation and apoptosis. In the present study, flesh containing large amount of PS, indicates most important biological processes like blood coagulation and programmed cell death. Glycolipids are fatty acid ester of sphingosine, carrying carbohydrate in addition (Voet and Voet, 1995).

It is well known that marine animals generally contain large amounts of polyunsaturated fatty acids with a long carbon chain, whereas terrestrial animals involve relatively large amounts of saturated C_{16} and C_{18} acids. As to the crustaceans, many reports have been presented about the fatty acid composition of lipids from different parts of world; for example, mysids, *Neomysis interger* (Linford, 1965); *Jasus lalandii* (de Koning and McMullan, 1966); shrimps, *Pandalus borealis* (Ackman and Eaton, 1967); *Homarus americanus* (Brockerhoff et al. 1968); *Euphausia* sp. (Saiki et al. 1959; Jeffrey et al. 1966); euphausids, *Meganyctiphanes norvegica* (Ackman and Eaton, 1967); and copepods (Ackman and Hooper, 1970; Morris, 1971); prawn, crabs, *Pleuroncodes planipes* (Pierce et al. 1969; Van der Veen et al. 1971); *Thysanoessa inermis* (Ackman et al. 1970); *Cancer magister* (Allen, 1971); *Xiphosura* (Limulus) *polyphemus* (van der Horst *et al*, 1973); lobsters, *Penaeus japonicas* (Guary, 1973). The present paper, emphasis has been given to the principal fatty acids out of 29 detected in the crab which do not correspond with that list, partly as a few of the fatty acids are either absent or not detected like 18:1n-7. The presence of γ-linolenic acid (18:3n-6) is very important, as it is a precursor of a family PUFA. These results are very similar to those reported from other tropical freshwater and marine water fish (Majumder et al. 2012; Dey et al. 2015a, b) and some invertebrates also (Manhas *et* al. 2013; Das et al. 2015a). The main products of fatty

acids are the saturated fatty acids 16:0 (palmitic acid) and 18:0 (stearic acid). In the present study, TL of flesh contains 28 fatty acids and 29 in HP. Number of fatty acids varies in different crustaceans. Marine krill *Euphausia pacifica* have 31 fatty acids (Kusumoto et al., 2004). Whereas 29 fatty acids were identified from the breast and claw meat and HP of *Callinectes sapidus* (Celik et al. 2004). While Sudha devi et al. (2015) have recorded 11 fatty acids in a freshwater crab *Travancoriana schirnerae*.

SFA contribute to major proportion of fatty acids in wild caught and cultured *P. monodon* (Croos et al. 2005). Palmitic acid ($C_{16:0}$) 20% in the flesh and HP have19.2%. Stearic acid ($C_{18:0}$) is 12.4% in HP and 4.6% in flesh of *S. serrata*. *S. serrata* collected from Negombo and Kalpitiya lagoon shows highest amount of palmitic acid (Anas et al. 2009) in body flesh which is quite similar to our results. In *E. pacifica*, Atlantic krill the major component is C-16:0 (Kusumoto et al. 2004). Among the flesh of this crab oleic acid ($C_{18:1n-9}$), linoleic acid ($C_{18:2n-6}$) and DHA ($C_{22:6n-3}$) is high in all the findings whereas arachidonic acid ($C_{20:4n-6}$) is found lower. The presence of 20:5n3 and 22:6n3 in this crab suggests that this crab can convert 18:2n6 to 18: 3n3 and 20:5n3 to 22:6n3. Eicosatrienoic acid ($C_{20:3n3}$) is found in all the fractions of lipid classes of both HP and flesh. Both 18:2n6 (linoleic acid) and 20:4n6 (AA) have significant biological role; especially with respect to eicosanoids derived from 20:4n6 that are physiologically active in fish and are essential for reproduction and cellular signal transduction in fish (Bell and Sargent, 2003). This crab has good amount of AA and LA in flesh concludes that these fatty acids also have active role in their physiology especially cellular signaling. Presence of EPA, DHA and AA indicates nutritional quality of *S. serrata*. Diets rich in monounsaturated fatty acids (MUFAs) resulted very efficient in reducing the risk of coronary diseases. Indeed, MUFA have been recognized as beneficial as the PUFA's n3 class for human health because of their effect in lowering blood cholesterol, in particular the DHA. A recent study on *V. litterata* reveals that flesh of this crab is a good source of MUFA, EPA and DHA (Das et al. 2015a). The meat of brown male crab contains 37.0- 40.7 mg 100 g $^{-1}$ w/w cholesterol (Barrento et al. 2010). The cholesterol concentration in the leg and claw meat of green crab, *Carcinus maenas* L., ranged from 57.2 – 64.8 mg 100 g $^{-1}$ w/w (Skonberg and Perkins 2002). High cholesterol in the crab flesh under discussion is thus important constituents of the animal as well as human as food. Initially it was thought that plant sterols are beneficial in lowering LDLs and cholesterol in human. Lipid quality indicators that depend on the relative contents of particular groups of fatty acids are the Atherogenic Index (AI) and Thrombogenic Index (TI). These indices indicate the global dietic quality of lipids and their potential effects on the development of coronary disease. The crab flesh indicates low percentage of AI (0.4) and TI (0.3) than HP (0.5). AI ranged from 0.19-0.20 and TI value is 0.19 in the edible part of different crayfish (Stanek et al. 2011). In lobster meat the AI ranges from 0.22 -0.26 and TI was 0.14- 1.17 (Barrento et al. 2009). Barrento et al. (2010) also reported that in the crab meat the AI and TI index was 0.17 and 0.12 respectively. These values including the values obtained in the present study are lower than those recorded from the other food items. The n3 is relatively high in flesh of all lipid classes proves that the crab flesh is nutritionally good. On the other hand, n6 fatty acid promotes platelet aggregation, vasoconstriction, etc. It is suggested that n-3/n-6 ratio of 1.1 to 1.5 would contribute to a healthy human diet (Osman et al. 2001). It is seen that among the crustaceans under discussion, the marine water crab *S. serrata*, maintains the recommended ratio, making it as an important food source for human for an advanced protection of cardiovascular disease (CVD). It is observed from the results of the present study that this edible marine crab follows similar pattern of lipid and fatty acid distribution and contain sufficient amount of n3 and n6 fatty acids which can be said that these can maintain better cardiac health upon consumption by human. *Paratelphusha lamellifrons*, a freshwater crab is also a promising source of both n3 and n6 (Islam et al. 2017). It is suggested that *S. serrata* can compete with other edible invertebrates from its nutritional aspects. Presence of good fatty acids and essential fatty acids gives high nutritional value of this crab. The liver shows much higher level of major lipid classes than those of flesh; thereby suggesting that hepatopancreas is the chief site of lipid storage and synthesis. The higher amount of free fatty acid in hepatopancreas compared to flesh, point to this organ having very active enzymes. Free fatty acids are readily digested and nutritionally satisfactory, so it can be concluded that this species have high nutritional value for human.

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Table 1: Percentages of various classes of lipids obtained from Hepatopancreas (HP) and Flesh of marine water crab Scylla serrata.

Lipids	HP	Flesh
Total Lipid (TL)[a]	4.32	0.82
Neutral Lipids (NL)[b]	70.61	27.45
Glycolipids (GL)[b]	8.37	11.73
Phospholipids (PL)[b]	21.02	60.82
(HC+WE+Se) [c]	19.05	90.1
Triacylglycerol (TG)[c]	48.19	8.35
Total Sterol (ST)[c]	32.76	1.55
Hydro Carbone (HC)[d]	84.87	97.24
Waxester(WE)[d]	9.9	2.18
Sterylester(SE)	5.23	0.58
Caediolipin(CL)[e]	49.31	26.28
Phosphatidylethanolamine (PE)[e]	11.07	15.6
Phosphatidylcholine (PC)[e]	17.25	25.75
Phosphatidylinositol (PI)[e]	10.76	11.34
Sphingomyelin (SPH)[e]	4.64	9.37
Phosphatidylserine (PS)[e]	6.96	11.66

a) Expressed as % w/w of wet tissue
b) Expressed as % w/w of total lipids
c) Expressed as % w/w of neutral lipids
d) Expressed as % w/w of (HC+WE+SE)
e) Expressed as % w/w of Phospholipid

Table 2: Fatty acid composition of total lipids (TL), neutral lipids (NL), glypolipids (GL) and phospholipids (PL) of flesh and hepatopancreas of marine water crab, Scylla serrata as Determined by GLC of Methyl Esters (Expressed as % W/W of each component in total Fatty acids)

		TL		NL		GL		PL	
	Components	Flesh	HP	Flesh	HP	Flesh	HP	Flesh	HP
Saturates	14:0	1.3	0.8	3.5	1.3	0.3	1.6	0.7	0.8
	15:0	0.3	0.6	1.4	0.4	0.2	0.4	0.4	0.3
	16:0	20.0	19.2	26.6	21.2	6.7	14.8	19.3	16
	17:0	0.8	1.3	0.8	0.7	0.6	0.7	1.6	1.2
	18:0	4.6	12.4	7.9	6.5	4.7	5.6	15.5	14.4
	20:0	0.5	0.3	0.4	0.5	0.3	0.2	0.4	0.2
	22:0	4.5	10.0	5.1	2.2	19.3	3.3	8.4	13.7
	24:0	0.1	0.3	0.2	0.2	1.0	0.1	0.3	0.4
	∑SFA	32.1	44.9	45.9	33.0	33.1	26.7	46.6	47.0
MUFA	14:1	0.1		0.1	0.2		0.2		
	15:1	0.1	0.2	0.1	0.1	0.03	0.1	0.2	0.1
	16:1	2.8	2.9	2.8	2.5	2.7	4.6	2.9	2.0
	17:1	0.2	0.5	0.2	0.3	0.8	0.3	0.6	
	18:1ω9	28.8	19.4	28.8	31.9	18.4	37.2	21.1	14.7
	20:1ω9	0.4	0.3	0.4	0.5	0.3	0.3	0.3	0.2
	22:1ω11	0.1	0.1	0.1	0.1	0.3	0.2	0.4	0.1
	24:1	0.3	0.4	0.3	0.1	0.6	0.2	0.3	0.7
	∑MUFA	32.8	23.8	32.8	35.7	23.13	43.1	25.8	17.8
DUFA	16:2	0.02	0.2	1.0	0.1			0.1	
	18:2ω6	25.3	10.1	13.3	24.9	10.5	24.6	10.2	12.0
	20:2		0.1			0.01	0.02	0.1	0.01
	∑DUFA	25.32	10.4	14.3	25	10.51	24.62	10.4	12.01
PUFA	18:3ω6	0.1	0.2	0.2	0.1	0.2		0.2	0.1
	18:3ω3	0.7	0.8	0.5	0.6	0.9	0.7	0.8	0.6
	20:3ω6	0.5	1.0	0.9	0.5	1.3	0.5	1.2	0.8
	20:3ω3		0.01						
	20:4ω6	0.1	0.1	0.2	0.1	0.2	0.1	0.1	0.1
	20:4ω3	0.2	0.2	0.3	0.3	0.2	0.1	0.1	0.1
	20:5ω3	4.8	13.3	4.8	2.5	22.2	2.8	10.8	14.2
	21:5ω3	0.1	0.1	0.2	0.1	0.1	0.1		0.04
	22:5ω6	0.04	0.1	0.1		0.1	0.04		0.03
	22:5ω3	0.3	0.3	0.3	0.2	1.2	0.2	0.3	0.6
	22:6ω3	2.8	4.9	2.6	1.8	6.9	1.2	3.9	6.5
	∑PUFA	9.6	21.0	10.1	6.2	33.3	5.74	17.4	23.07
	Total-ω3	8.9	19.61	8.7	5.5	31.5	5.1	15.9	22.04
	Total-ω6	26.04	11.5	14.7	25.6	12.3	25.24	11.7	13.03
	n3/n6	0.3	1.7	0.6	0.2	2.6	0.2	1.3	1.6

Table 3: Fatty acid composition of phospholipid components of flesh and hepatopancreas (HP) of marine water crab Scylla serrata as determined by Methyl Esters.

		CL		PE		PC		PI		SPH		PS	
	Component	HP	Flesh	HP	Flesh	HP	Flesh	HP	Flesh	HP	Flesh	HP	Flesh
SFA	14:0	1.4	1.2	1.0	1.0	0.6	1.0	1.2				0.1	
	15:0	0.5	3.4	0.6	1.9	0.7	1.4	0.9				0.5	1.8
	16:0	20.1	22.3	16	20	19.5	31.7	29.6	21.9	23	22.5	23.5	28.0
	17:0	2.2	5.4	3.7	4.4	2.4	1.7	2.1	2.7	4.2	3.1	2.9	3.3
	18:0	15.4	15.0	17	19	15.9	6.8	12.5	38.0	31	29.6	18.2	32.9
	20:0	0.2		0.2	0.2	0.1	0.3	0.2	4.4		0.7	0.3	0.5
	22:0	6.3	3.0	13	5.1	12.2	4.5	3.5	1.6	2.5	2.0	7.4	1.7
	24:0	0.1	0.7	0.5	0.2	0.2	0.1	0.1	0.7	1.1	0.05	0.3	0.03
	∑SFA	46.2	51.0	52.0	51.8	51.6	47.5	50.1	69.3	62	58.0	53.2	68.2
MUFA	14:1											0.2	
	15:1	0.7	3.3	0.7	0.2	0.1							
	16:1	3.1	1.0	1.9	3.3	0.1	3.5	3.6	1.2	0.8	1.9	3.3	1.7
	17:1	1.0	2.8	1.2	0.7	0.5	0.6	0.5				0.3	
	18:1ω9	13.3	16.2	10.3	20.5	19.8	29.5	27.8	14.9	9.3	26.0	20.8	17.9
	20:1ω9	0.5	0.7	0.3	0.5	0.2	0.3	0.3	0.3		0.3	0.2	0.3
	22:1ω11	0.2	0.3	0.1	0.1	0.1	0.03	0.04			0.02	0.1	0.03
	24:1	0.6		1.0	0.3	0.3	0.1	0.1			0.04	0.2	0.1
	∑MUFA	19.4	24.3	15.5	25.6	21.1	34	32.3	16.4	10	28.3	25.1	20.0
DUFA	16:2			0.1	0.1	0.2						0.1	0.1
	18:2ω6	23	15.1	9.4	13	11.6	12.2	13.5	6.5	3.9	8.3	10.2	6.7
	20:2	0.6	0.9	0.1	0.3	0.1	0.03	0.1		0.4	0.9	0.3	0.5
	∑DUFA	23	16	9.6	13.0	11.9	12.2	13.6	6.5	4.3	9.2	10.6	7.3
PUFA	18:3ω6	0	0.05	0.1	0.1	0.1					0.03	0.1	0.3
	18:3ω3	1.2	1.2	0.3	0.7	0.3	0.7	0.3	0.4	7.9	0.1	0.1	0.1
	20:3ω6	2.0	2.0	0.9	1.9	0.5	1.0	0.6	1.2	1.7	1.0	0.3	1.0
	20:3ω3												
	20:4ω6	0.2		0.1	0.1	0.1	0.03	0.1			0.03	0.2	
	20:4ω3		0.2		0.1		0.04		0.3	7.8	0.4	0.2	0.2
	20:5ω3	5.2	2.8	15	4.3	8.7	3.1	2.4	1.2	2.5	1.9	6.6	1.4
	21:5ω3				0		0.02		0.5	1.4	0.04		0.1
	22:5ω6	0.7	0.8	0.2	0.3	0.1	0.2	0.1	0.3	0.9	0.4	0.3	0.4
	22:5ω3	0.2		0.5	0.2	0.4	0.2	0.1	0.2	0.1	0.2	0.4	0.05
	22:6ω3	1.6	1.4	4.7	1.7	3.4	0.6	0.6	0.4	0.9	0.5	2.6	0.5
	∑PUFA	11.1	8.5	21.6	9.4	13.6	5.89	4.2	4.5	23	4.6	10.8	4.05
	Total-ω3	8.2	5.6	20	7.3	12.8	4.6	3.4	6.2	21	3.1	9.9	2.3
	Total-ω6	25.5	17.9	11	15.0	12.4	13.4	14.3	8.0	6.5	9.7	11.1	8.4
	n3/n6	0.3	0.3	1.8	0.4	1.03	0.3	0.23	0.7	3.2	0.3	0.89	0.2

Table- 4: Fatty acid composition of Sterylester (SE) of flesh and hepatopancreas of Scylla serrata,marine water crab.

	Component	Flesh	HP
Saturates	12:0		
	13:0		
	14:0	3.1	

	15:0	7.8	36.4
	16:0	26.2	19.2
	17:0	9.3	1.1
	18:0	11.1	18.3
	20:0	1.3	3.6
	22:0	1.2	0.5
	24:0	0.7	0.2
	∑SFA	60.7	79.3
MUFA	14:1	2.7	
	15:1	1.9	
	16:1	2.5	
	17:1		
	18:1ω9	16.7	6.7
	20:1ω9	0.8	0.3
	22:1ω11	0.3	0.8
	24:1	0.2	0.6
	∑MUFA	25.1	8.4
DUFA	16:2	1.3	
	18:2ω6	6.7	6.1
	20:2		
	∑DUFA	8	6.1
PUFA	18:3ω6		
	18:3ω3	0.2	0.2
	20:3ω6	1.4	0.4
	20:3ω3		
	20:4ω6	0.2	0.7
	20:4ω3	0.8	0.1
	20:5ω3	0.8	0.2
	21:5ω3	0.4	1.0
	22:5ω6	0.1	0.6
	22:5ω3	0.009	0.03
	22:6ω3	0.5	2.3
	∑PUFA	4.4	5.5
	Total-ω3	2.71	3.83
	Total-ω6	8.4	7.8
	n3/n6	0.32	0.49

Table-5: Fatty acid composition of Hydrocarbons (HC) of flesh and hepatopancreas of Scylla serrata, marine water crab

Components	Flesh	HP
14:0	1.9	2.4
15:0	4.1	4.5
16:0	6	8.1
17:0	9.6	13.3
18:0	11	13.3
19:0	9.6	9.8
20:0	9.7	8.3

21:0	9	6.4
22:0	7.6	5.3
23:0	5.4	3.8
24:0	3.7	2.7
25:0	1.9	1.6
26:0	1.1	0.8
27:0	0.5	0.3
28:0	0.2	
14:iso	0.2	0.2
15:iso	1.3	1.2
16:iso	1.6	2.1
17:iso	3.3	4.5
18:iso	3.5	4.1
19:iso	3	3
20:iso	2.8	0.6
21:iso	0.3	0.2
22:iso	0.2	0.2
23:iso	0.2	0.2
24:iso	0.1	0.1
25:iso	0.1	0.2
26:iso	0.1	
20: anteiso		0.3
21: anteiso	0.4	0.2
22: anteiso	0.6	0.9
23: anteiso	0.6	0.9
24: anteiso	0.2	0.4
25: anteiso	0.1	
26: anteiso	0.03	

Table 6: Composition of Sterols obtained from Marine water crab Scylla serrata and analysed as silyl ether derivatives by GLC. (Expressed as % w/w)

Components	Flesh	HP
Unidentified	0.7	0.7
Cholesterol	81.7	94.9
Campesterol	0.6	-
Stigmosterol	17.0	4.4
β-sitosterol	-	-

Table7.Comparison of Major Lipid Classes and Fatty Acid Percentage In Between Flesh Of (Varuna Litterata Das Et Al., 2015) And S. Serrata.

Different classes of lipids and fatty acids	*Varuna litterata*	*Scylla serrata*
Glycolipids (GL)[b]	9.72	11.73
Phospholipids (PL)[b]	61.18	60.82
(HC+WE+Se) [c]	54.78	90.1
Triacylglycerol (TG)[c]	39.51	8.35
Total Sterol (ST)[c]	5.71	1.55

Hydro Carbone (HC)[d]	95.78	97.24
Waxester(WE)[d]	3.45	2.18
Sterylester(SE)	0.77	0.58
Caediolipin(CL)[e]	8.44	26.28
Phosphatidylethanolamine (PE)[e]	9.2	15.6
Phosphatidylcholine (PC)[e]	31.59	25.75
Phosphatidylinositol (PI)[e]	12.43	11.34
Sphingomyelin (SPH)[e]	12.81	9.37
Phosphatidylserine (PS)[e]	25.52	11.66
∑n3	17.62	8.9
∑n6	11.13	26.04
n3/n6	1.5	0.3
∑SFA	41.1	32.1
∑MUFA	29.7	32.8
∑DUFA	10	25.32
∑PUFA	19.05	9.6
AI	0.4	0.4
TI	0.3	0.3

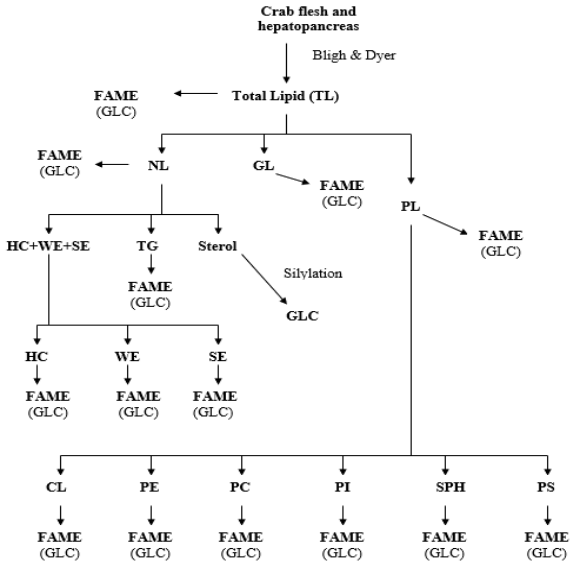


Figure-1: Flow diagram of the analysis of lipids and fatty acids of Flesh of Crab sample.

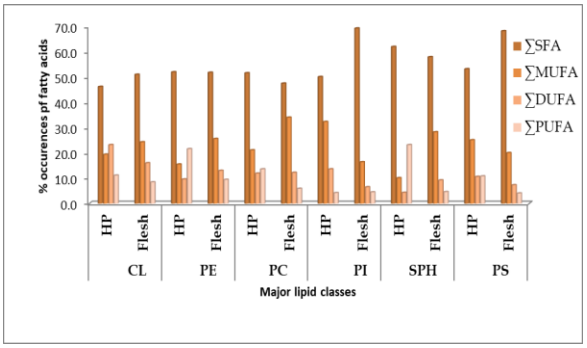
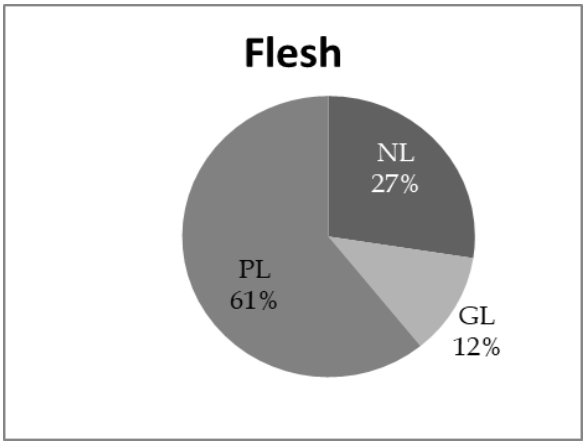


Figure2. Comparative distribution of Major lipids in the flesh and HP of *S.serrata*.



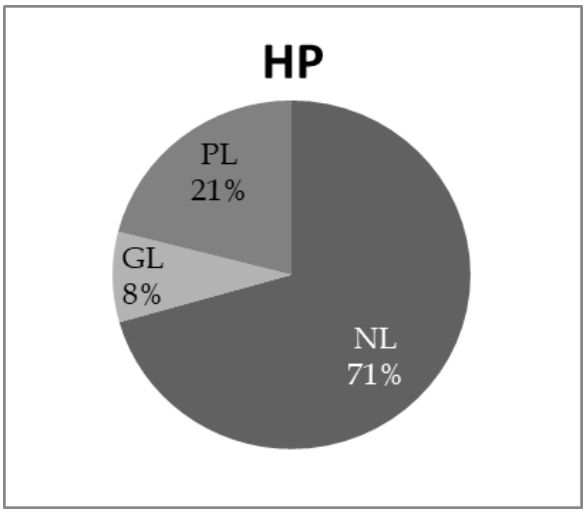


Figure3. Comparative distribution of fractions of TL in the flesh and HP of *S.serrata*.

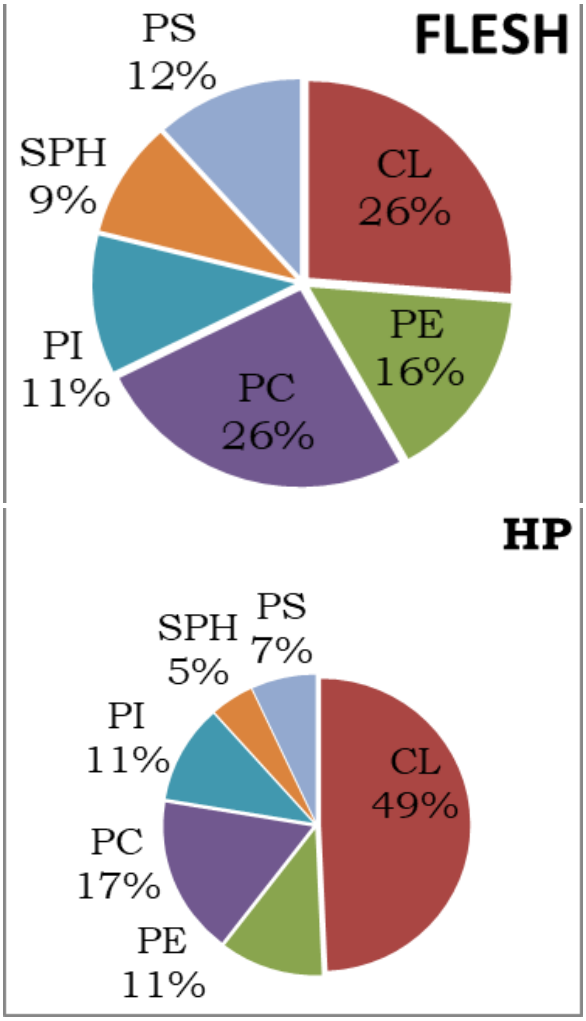


Figure4. Comparative distribution of fractions of PL in the flesh and HP of *S.serrata*.

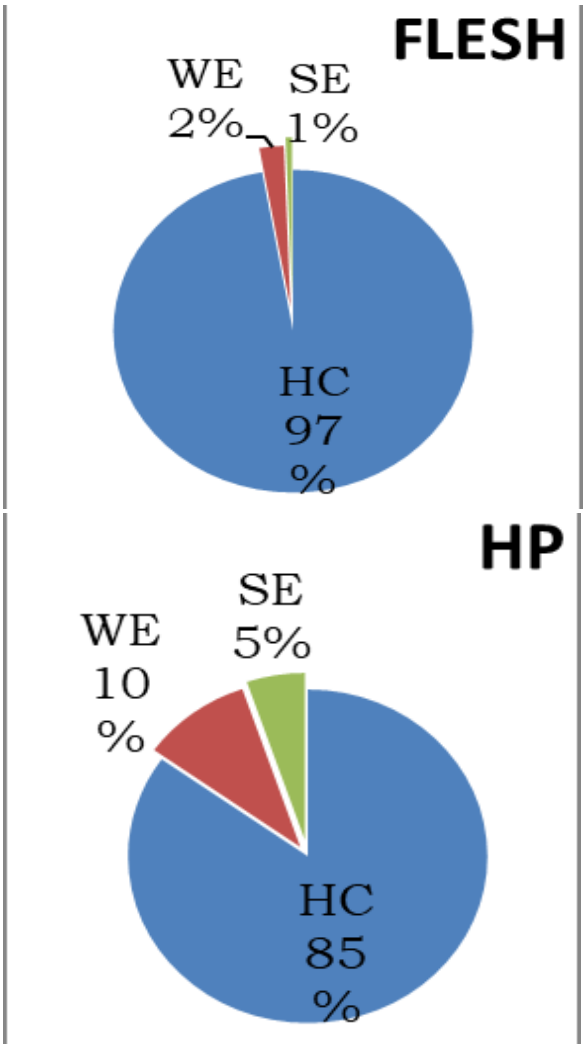


Figure5. Comparative distribution of fractions of NL in the flesh and HP of *S.serrata*.

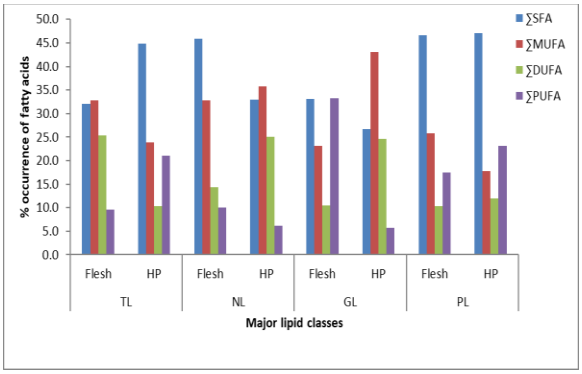


Figure6. Comparative distribution of Major fatty acid clases in the flesh and hepatopancreas of *S.serrata*.

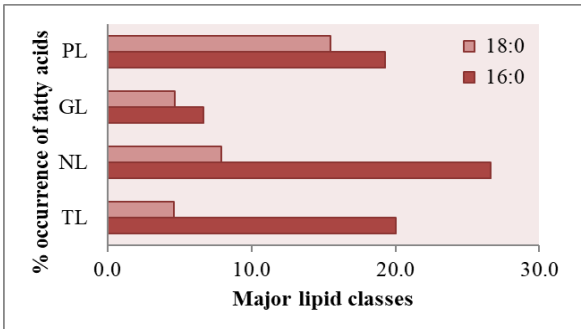


Figure7. Comparative distribution of C-16 and C-18 in the major lipid fractions of the flesh and HP of *S.serrata*.

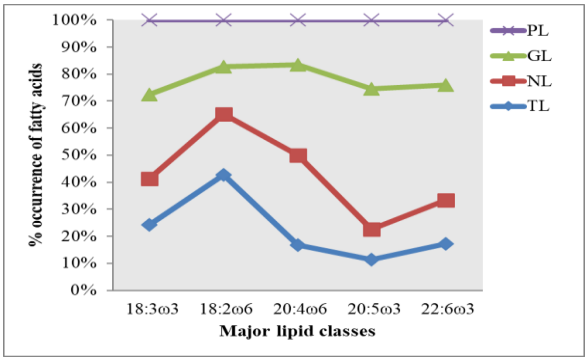


Figure8. Comparative distribution of Major fatty acids in the major lipid fractions of the flesh and HP of *S.serrata*.

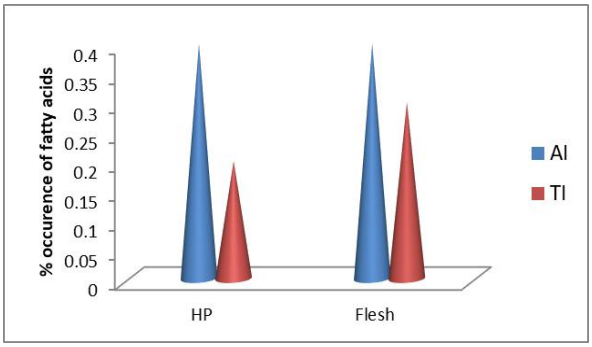


Figure9. Comparative distribution of AI and TI in TL of the flesh and HP of *S.serrata*.

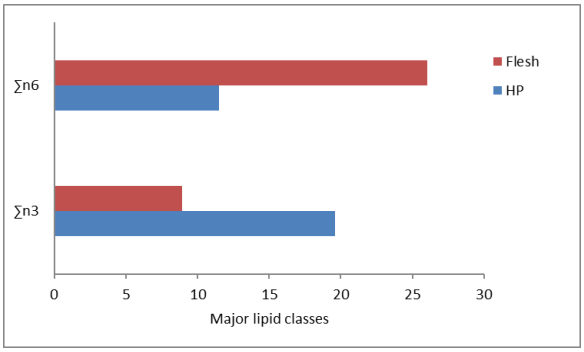


Figure10. Comparative distribution of n-3 and n-6 in TL of the flesh and HP of *S.serrata*.

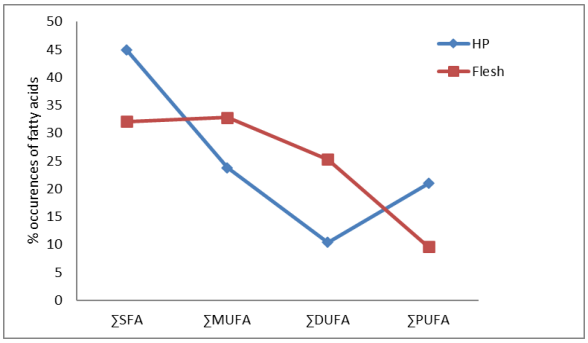


Figure11. Comparative distribution of saturated and unsaturates of the flesh and HP of *S.serrata*.