INTERNATIONAL JOURNAL OF BIOASSAYS
ISSN: 2278-778X
CODEN: IJBNHY
OPEN ACCESS

ORIGINAL RESEARCH ARTICLE

SEASONAL CLIMATE CHANGE OF WATER QUALITY INDICES AND IMPACT ON FEEDING HABITS AND BIOINDICES OF *CIRRHINUS MRIGALA*

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Received for publication: July 27, 2015; **Accepted**: August 18, 2015

Abstract: The biology of an economically important Indian major carp *Cirrhinus mrigala* was investigated seasonally for two calendar year. This study is aimed at assessing the bio indices in relation to changes in the water indices. Pond water temperature (20. 5-30. 50°C), pH (6. 8-7. 8), total alkalinity (111. 3-148. 7mgl[1]), dissolved oxygen (5. 8-7. 6mgl^{-1}), total soluble salt (175. 4-268. 2mgl^{-1}), ammonical nitrogen (0. 11-0. 18 mgl^{-1}) and total hardness (119. 6-145. 5 mgl^{-1}) have been studied during study period (2011-2013). On the basis of qualitative and quantitative analysis of gut content, the Preponderance Index showed Bacillariophyceae (29. 66 per cent) and detritus (19. 5 per cent) forms the most preferred food. The highest Gonad somatic index (GnSI) values (female: 12. 60% and male: 0. 39%) were observed in the rain which was the breeding period of the fishes. The hepatosomatic index (HSI) was more in post spawning season (winter: 1. 27per cent). Negative correlation was observed between condition factor and gnsi (r=-0. 314**), gsi and gnsi (r=-0. 552**), hsi and gnsi (r=-0. 543**). These parameters have been found very useful to evaluate the wellbeing of fish populations, their biology for scientific management of fisheries and stock assessment.

Key words: Water indices, Bio indices, Gut content, *Cirrhinus*

INTRODUCTION

Water is very precious for every living organism including fish on this earth (Kiran, 2010). In recent years aquaculture is being projected as possible solution to food problems faced by masses (Ali *et al.,* 2005). It gives higher productivity per unit as compared to agriculture and animal husbandry. Fish growth depends on water quality in order to boost its production and physicochemical parameters are known to affect the biotic components of an aquatic environment in various ways (Ligwumba and Ugwumba, 1993). In the presence of environmental stress such as low dissolved oxygen, high temperature and high ammonia (Boyd, 1981), the ability of organisms to maintain its internal environment is reduced (Ezra and Nwankwo, 2001). In view of this, monitoring of water quality parameters that include temperature, total hardness, dissolved oxygen, pH, ammonical nitrogen and total alkalinity are essential.

It is well known that the stimuli from fluctuating climatologically conditions impinge upon and modify innate breeding cycle. Many workers (Khan, 1972) conducted experiments in major carps to find out probable factors which synchronize spawning. The analysis of gonad somatic index values (GnSI), which provide a measure of gonad size relative to body weight (Wootton, 1991) can provide a quantitative assessment of the degree of gonadal development, the breeding season and the reproductive cycle (Gutiérrez-Estrada *et al.,* 2000). The condition factor (K) is another commonly-used index in the study of fish biology. It provides information on the physiological state of these animals, based on the assumption that individuals of a given body length are in better condition when their mass is greater (Anene, 2005). The inspection of the seasonal variation of the condition factor (k) is also being used as a complementary parameter aiming to describe natural cycles in reproduction and feeding ecology (Lizama *et al.,* 2002). However, the condition factor can suffer from any change related to the growth cycle of fish, a pattern already identified for perciforms and characiforms (Fontoura *et al.,* 2010). The understanding of these seasonal patterns provides an important baseline for the description of the fish biology and their role in aquatic ecosystems (Vazzoler, 1996).

However, scanty work has been carried out on seasonality of water quality and impacted changes as reflected in the bio indices of *Cirrhinus mrigala* in this locality. Hence the objective of the study is to provide a quantitative record of the seasonal changes of pond water parameters and their role on fish biology.

MATERIALS AND METHODS

Water Sampling

The pond is located in the Tankapani village, Khurda district of the State of Odisha which is 18 km from Bhubaneswar (19^{0}40"N to 20^{0}25"NLatitude and 24^{0}55"E to 36^0 05"E Longitude). Water samples were collected during the study period between 8. 00 and10. 00am at a depth of 30 cm below the water surface. Water parameter meters were measured as per APHA, 1989.

Fish Sampling

Fish were sampled from the same water sampling sites. Specimen were weighed (950±50g) and measured for total length (38. 5±1.5 cm) (Jayaram, 1999).

Biological indices

Condition factor (K): Total fish weight (g)/Length^3 (cm) X100 (Beckman, 1948)

Gastrosomatic index (GSI): Weight of the gut and its content (g)/Total fish weight (g) X100 (Desai, 1970)

Hepatosomatic index (HSI): Weight of the liver (g)/Total fish weight (g) X 100 (Singh *et al.,* 2008)

Gonadosomatic index (GnSI): Weight of gonad (g)/body weight (g) X 100 (Hopkins, 1979)

These parameters were expressed in per cent value.

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Feeding habits

The food of the fish was examined with reference to its frequency of occurrence, preponderance index and volume (Natrajan and Jhingran, 1961). Gut content emptied into separate Petridis with food items were identified as per method of Dewan *et al.,* 1991). The stomach content were examined and estimation of food organisms was done by the point method (Hynes, 1950). The Index of preponderance (I) for each food items was worked out applying the formula recommended byNatrajan and Jhingran (1961)

$$I = \frac{V_1 O_1}{\sum V_1 O_1} \times 100,$$

I = Index of preponderance, V_1 = Volume percentage, O_1 = Occurrence percentage

Statistical calculation

All Statistical analyses and correlation coefficients were calculated with MSTAT-C (1988) statistical software. The data were subjected to an analysis of variance (ANOVA), followed by comparison of means using Duncan multiple range test (Kramer, 1956) to determine significance recorded data.

Results and Discussions

Water analysis

The mean variations were recorded for physico-chemical parameters of sampled pond water (Table 1) in different season. The average temperature of pond water ranged from 20. 5°C (winter) to 30. 5°C (summer) during the study period. Season wise higher pH value was noted in the spring (7. 8) whereas lower value was in the rain (6. 8). The range of Dissolved oxygen (DO) varied from 5. 8 (summer) to 7. 4 mgl^{-1} (. winter). The recorded minimum and maximum range of total alkalinity during the experimental period was 111. 3 (rain) and 132. 5 mgl^{-1} (summer). The hardness of the water sample found to fluctuate from 119. 6 (autumn) to 145. 5mgl^{-1} (winter) in different seasons. Ammonia-Nitrogen (NH3-N) measures the unionized (NH3) and ionized (NH_4^+) form of ammonia present in the water body. Seasonal analysis showed ammonia-nitrogen varied from 0. 11 to 0. 18 mgl^{-1}between autumn and spring whereas total dissolved solids showed gradual variation during the entire study period from 175. 4 (rain) to 268. 2 mgl^{-1} (summer). The variations of each particular parameter over seasons were calculated using the ANOVA. Analysis of variance (Table2) showed significant differences in temperature (FValue=13. 64 807, p≤0. 01), pH (F Value= 1. 371094, p≥ 0. 05), Dissolved oxygen (F Value =4. 53912, p≤0. 05), total alkalinity (F Value=18. 46581, p≤0. 01), Ammonia-Nitrogen, (F Value=0. 987988, p≥0. 05). Total dissolved solids (FValue=9. 443247, p≤0. 01), total hardness (F Value =6. 007916, p≤ 0. 01), seasonally (Table3) significant variation at p≤0. 01 observed in water temperature, total alkanity, total soluble salt and total hardness whereas p value at ≥ 0. 05 noted in dissolved oxygen.

Table 1: seasonal variations of different water parameters (mean±SE)

Parameter	Unit	Spring (Feb-Mar)	Summer (Apr-Jun)	Rain (Jul. -Sept.)	Autumn (Oct.)	Winter (Nov. -Jan.)
Water temperature	0°C	26. 0±0. 21^b	30. 5±0. 8^a	27. 5±0. 31^b	24. 0±0. 15^b	20. 5±0. 16^c
pH		7. 8±0. 08^a	7. 6±0. 11^a	6. 8±0. 21^a	7. 2±0. 09^a	7. 4±0. 06^a
Dissolved oxygen	mg l^{-1}	6. 7±0. 12^{ab}	5. 8±0. 15^c	6. 1±0. 09^{bc}	7. 0±0. 10^{ab}	7. 6±. 07^a
Total Alkalinity	mgl^{-1}	132. 5±6. 2^b	148. 7±7. 5^a	111. 3±6. 5^d	116. 5±7. 1^{cd}	120. 8±7^{bc}
Ammonical Nitrogen	mg l^{-1}	0. 18±0. 005^a	0. 14±0. 02^a	0. 13±0. 01^a	0. 11±0. 01^a	0. 12±0. 015^a
Total soluble salt	mg l^{-1}	254. 3±8. 1^b	268. 2±10. 2^a	175. 4±6. 7^c	193. 4±8. 3^{bc}	235. 7±9. 3^b
Total hardness	mg l^{-1}	132. 3±8. 5^b	121. 7±8. 0^b	128. 4±9. 5^b	119. 6±7. 2^b	145. 5±6. 8^a

SE: Standard error of mean; Means having different superscript (s) in a column by DMRT differed significantly (p≤0. 05)

Table 2: Analysis of variance table of various water parameters

Parameter	Unit	DF	SS	MS	ANOVA F-Value	P-Value
Water temperature	0°C	4	323. 724	74. 091	13. 64807**	p≤0. 01
pH		4	3. 964	0. 607	1. 371094^{NS}	P≥0. 05
Dissolved oxygen	mg l^{-1}	4	7. 677333	1. 55334	4. 53912*	p≤0. 05
Total Alkalinity	mg l^{-1}	4	6830. 933	1608. 93367	18. 46581**	p≤0. 01
Ammonical Nitrogen	mg l^{-1}	4	206. 3786	29. 40651	0. 987988 ^{NS}	P≥0. 05
Total soluble salt	mg l^{-1}	4	32071. 6	7010. 9003	9. 443247**	p≤0. 01
Total hardness	mg l^{-1}	4	2579. 6	531. 2	6. 007916**	p≤0. 01

*: P≤0. 05, **: P≤0. 01

Table 3: Seasonal Comparison of water parameters

Parameter	Spring	Summer	Rain	Autumn	Winter
Water temperature (WT)	P≤0. 01	P≤0. 01	P≤0. 01	P≤0. 01	P≤0. 01
pH	p≥0. 05	p≥0. 05	p≥0. 05	p≥0. 05	p≥0. 05
Dissolved oxygen (DO)	P≤0. 05	P≤0. 05	P≤0. 05	P≤0. 05	P≤0. 05
Total Alkalinity (TAL)	P≤0. 01	P≤0. 01	P≤0. 01	P≤0. 01	P≤0. 01
Ammonical Nitrogen (AMN)	p≥0. 05	p≥0. 05	p≥0. 05	p≥0. 05	p≥0. 05
Total soluble salt (TSS)	P≤0. 01	P≤0. 01	P≤0. 01	P≤0. 01	P≤0. 01
Total hardness (TH)	P≤0. 01	P≤0. 01	P≤0. 01	P≤0. 01	P≤0. 01

Biological indices

Mean values of the biological indices (Table 4) found to vary in relation to season and sex. The condition factor (k) calculated for male and female fishes were varied from1. 35 per cent (rain) to 1. 63 per cent (spring) and 1. 30 per cent (rain) to 1. 69 per cent (spring) respectively. The seasonal variations in the gastro somatic index (Table 4) values were ranged from1. 56 per cent (rain) to 2. 03 per cent (summer) and 1. 35 per cent (rain) to 2. 14 per cent (summer) in male and female respectively. The increase value was found in the summer and the reduced value was in the rainy season in both the sexes. The highest values of HSI were recorded during winter in both the sexes. The range of variations in the male and female fishes was 0. 74 per cent (rain) to 1. 22 per cent (winter) and 0. 70 per cent (rain) to 1. 27 per cent (winter) respectively. The gonad development as reflected by changes in GnSI values **(Table 4)** in case of male fish was ranged from 0. 07 per cent (autumn) to 0. 39 per cent (rain). The GnSI values of female had been increased from autumn (1. 90 per cent) to summer (5. 8 per cent) and reaching maximum in rain (12. 60 per cent).

Correlation matrix **(**Table 5**)** showed that condition factor (K) had a positive correlation with gastro somatic index (r=0. 554 at p≤0. 01) and hepatosomatic index (r=0. 367 at p≤0. 01) but negatively correlated with gonadosomatic index of male (r=-0. 130 at p≥0. 05) and female (r=-0. 314 at p≤0. 01). It was found that gastro somatic index had positive correlation with hepato somatic index (r=0. 593 at p≤0. 01). A negative correlation was observed between hepatosomatic index and gonado somatic index of male (r= -0. 348 at p≤0. 01) and female (r=-0. 543 at p≤0. 01). Analysis of variance (Table 6**)** showed significant differences in conditional factor (F Value=15. 24803, p≤0. 01), gastro somatic index (F Value=1. 371094, p≥0. 05), hepatosomatic index (F Value=4. 53912, p≤0. 05), gonado somatic index (F Value=23. 42713, p≤0. 01). Seasonally (Table 7) significant variation at p≤0. 01 observed in conditional factor, gastro somatic index and hepatosomatic index whereas p value at ≥ 0. 05 noted in gonadosomatic index.

Table 4: Seasonal variations in the biological indices of *Cirrhinus mrigala*

Season	sex		Conditional factor (k)	Gastro somatic index (GSI)	Hepato somatic index (HSI)	Gonad somatic index (GnSI)
Spring	Male	Mean	1. 63	1. 87	1. 11	0. 11
		S. E. of Mean	0. 03^{ab}	0. 04^{a}	0. 04^{b}	0. 004^{b}
	Female	Mean	1. 69	1. 91	1. 08	3. 30
		S. E. of Mean	0. 02^{ab}	0. 08^{a}	0. 02^{b}	0. 10^{b}
Summer	Male	Mean	1. 60	2. 03	0. 92	0. 23
		S. E. of Mean	0. 02^{a}	0. 05^{c}	0. 05^{b}	0. 005^{ab}
	Female	Mean	1. 58	2. 14	0. 86	5. 80
		S. E. of Mean	0. 06^{a}	0. 09^{c}	0. 03^{b}	0. 11^{ab}
Rainy	Male	Mean	1. 34	1. 56	0. 81	0. 39
		S. E. of Mean	0. 04^{c}	0. 05^{c}	0. 06^{c}	0. 02^{a}
	Female	Mean	1. 30	1. 35	0. 75	12. 60
		S. E. of Mean	0. 05^{c}	0. 02^{c}	0. 02^{c}	0. 30^{a}
Autumn	Male	Mean	1. 48	1. 59	0. 92	0. 07
		S. E. of Mean	0. 03^{c}	0. 02^{d}	0. 07^{b}	0. 005^{b}
	Female	Mean	1. 41	1. 53	0. 95	1. 50
		S. E. of Mean	0. 06^{c}	0. 02^{d}	0. 05^{b}	0. 08^{b}
Winter	Male	Mean	1. 50	1. 75	1. 22	0. 08
		S. E. of Mean	0. 03^{bc}	0. 07^{b}	0. 07^{a}	0. 004^{b}
	Female	Mean	1. 54	1. 79	1. 27	2. 18
		S. E. of Mean	0. 04^{bc}	0. 04^{b}	0. 04^{a}	0. 07^{b}

Means having different superscript (s) in a column by DMRT differed significantly (p≤0. 05)

Table 5: Correlationcoefficient (r) matrix among biological indices of *Cirrhinus mrigala*

Bio-indices	Condition Factor	GastroSomatic Index	Hepato Somatic Index	Gonado somatic Index (male)	Gonado somatic Index (female)
Condition Factor	1. 000				
GastroSomatic Index	0. 554**	1. 000			
Hepato Somatic Index	0. 367**	0. 593**	1. 000		
Gonado somatic Index (male)	-0. 130	-0. 552**	-0. 206*	1. 000	
Gonado somatic Index (female)	-0. 314**	-0. 545**	-0. 543**	0. 930**	1. 000

*= p ≤ 0. 05. ** = p ≤0. 01

Table 6: Analysis of variance (ANOVA) table of various Bio indices *Cirrhinus mrigala*

Parameter	Unit	DF	SS	MS	ANOVA F-Value	P-VALUE
Conditional factor (K)	Per cent	29	0. 56052	1. 06173	15. 41512**	p≤0. 01
Gastro-somatic index (GSI)	Per cent	29	4. 98468	1, 21958	210. 2995**	P≤0. 01
Hepato-somatic index (HSI	Per cent	29	1. 986587	0. 451098	50. 99374**	p≤0. 01
Gonado somatic index (GnSI)	Per cent	29	532. 4973	54. 54304	2. 642713*	p≤0. 05

*=P≤0. 05, **= P≤0. 01

Table 7: Seasonal Comparison of means of bio-indices of *Cirrhinus mrigala*

Parameters	Spring	Summer	Rain	Autumn	Winter
Conditional Factor (K)	P≤0. 01	P≤0. 01	P≤0. 01	P≤0. 01	P≤0. 01
Gastrosomatic index (GSI)	P≤0. 01	P≤0. 01	P≤0. 01	P≤0. 01	P≤0. 01
Hepato somatic index (HSI)	P≤0. 01	P≤0. 01	P≤0. 01	P≤0. 01	P≤0. 01
Gonado somatic index (GnSI)	p≥0. 05	p≥0. 05	p≥0. 05	p≥0. 05	p≥0. 05

Table 8: Gut content analysis and grading of various food items of *Cirrhinus mrigala*

Seasons	Food Items	% composition of items		V_1O_1	Preponderance Index
		Volume (V_1)	Occurance (O_1)		
Spring	Detritus	16. 24	17. 43	283. 06	20. 68
	Bacillariophyceae	23. 52	19. 17	450. 87	32. 94
	Chlorophyceae	17. 18	10. 25	165. 84	12. 11
	Myxophyceae	9. 54	6. 58	56. 19	4. 10
	Aquatic insect	5. 21	6. 34	33. 03	2. 41
	Rotifer	8. 63	19. 85	171. 30	12. 51
	Crustacea	7. 33	6. 21	33. 09	2. 42
	Sand and mud	12. 35	14. 17	175. 00	12. 78
Summer	Detritus	16. 81	18. 23	306. 44	20. 2
	Bacillariophyceae	22. 07	20. 52	474. 94	31. 32
	Chlorophyceae	10. 34	13. 85	143. 20	9. 44
	Myxophyceae	11. 63	6. 48	75. 36	4. 96
	Aquatic insect	7. 18	5. 33	38. 26	2. 52
	Rotifer	15. 72	19. 64	308. 74	20. 36
	Crustacea	2. 80	4. 24	11. 87	0. 78
	Sand and mud	13. 45	11. 71	157. 49	10. 38
Rain	Detritus	15. 78	19. 32	304. 86	22. 24
	Bacillariophyceae	16. 52	22. 67	374. 50	27. 32
	Chlorophyceae	14. 25	9. 05	128. 96	9. 40
	Myxophyceae	10. 43	7. 11	74. 15	5. 41
	Aquatic insect	8. 51	6. 02	51. 23	3. 73
	Rotifer	11. 37	16. 43	186. 80	13. 62
	Crustacea	9. 64	3. 17	30. 55	2. 22
	Sand and mud	13. 50	16. 23	219. 05	15. 98
Autumn	Detritus	14. 53	14. 72	213. 88	15. 62
	Bacillariophyceae	21. 37	18. 54	396. 19	28. 94
	Chlorophyceae	10. 79	11. 59	125. 05	9. 13
	Myxophyceae	9. 48	5. 54	52. 51	3. 83
	Aquatic insect	6. 11	7. 12	43. 50	3. 17
	Rotifer	14. 52	18. 74	272. 10	19. 87
	Crustacea	7. 61	12. 62	96. 03	7. 01
	Sand and mud	15. 23	11. 13	169. 50	12. 38
Winter	Detritus	17. 21	15. 38	264. 68	18. 77
	Bacillariophyceae	19. 47	20. 12	391. 73	27. 78
	Chlorophyceae	14. 35	13. 27	190. 42	13. 20
	Myxophyceae	8. 72	8. 15	71. 06	5. 04
	Aquatic insect	8. 03	7. 53	60. 46	4. 28
	Rotifer	13. 28	17. 08	226. 82	16. 08
	Crustacea	7. 75	3. 82	29. 60	2. 09
	Sand and mud	11. 19	14. 65	175. 12	12. 42

Gut content analysis

Food values (Table 8) indicated that the important food item was bacillariophyceae which was ranged from 16. 52 (rain) to 23. 52 (spring) per cent by volume and 18. 54 (autumn) to 22. 67 (rain) per cent by occurrence with index of preponderance 27. 32 (rain) to 32. 94 (spring) per cent. The index of preponderance for food items, bacillariophyceae, detritus, sand and mud, rotifer, chlorophyceae, myxophyceae, crustacean and aquatic insect in spring were 32. 94, 20. 68, 12. 78, 12**.** 12. 11, 4. 10, 2. 42 and 2. 41per cent. In the summer**,** these food compositions were 31. 32, 20. 36, 20. 2, 10. 38, 9. 444. 96, 2. 52and 0. 78per cent. The relative importance of these food items in the rainy season were 27. 32, 22. 24, 15. 98, 13. 62, 9. 4, 5. 41, 3. 73 and 2. 22per cent. Food analysis in the autumn showed preference level of these food items were 28. 94, 19. 87, 15. 62, 12. 38, 9. 13 7. 01, 3. 83and 3. 17per cent respectively. In the winter**,** the percentage compositions of above food were 27. 78, 18. 77, 16. 08, 13. 20, 12. 42, 5. 04, 4. 28and 2. 09per cent respectively. Statistical differences ($p \leq 0.05$) in diet composition with respect to season, were assessed by a chi-square test (Table 9). Significant differences among seasons were found for detritus **(**$\chi 2 = 4.36$, $p \leq 0.05$), crustacea ($\chi 2= 6.04$, $p \leq 0.05$), sand and mud ($\chi 2= 4.48$, $p \leq 0.05$).

Table 9: seasonal comparision of gut content of *Cirrhinus mrigala* by Chi-square test

Food Item	Spring	Summer	Rain	Autumn	Winter	Chi square	Significance
Detritus	16. 68	20. 2	22. 24	14. 62	16. 77	4. 36	p≤0. 05
Bacillariophyceae	32. 94	31. 32	27. 32	28. 94	28. 78	0. 26	p≥0. 05
Chlorophyceae	18. 11	9. 44	9. 40	9. 53	12. 20	1. 40	p≥0. 05
Myxophyceae	4. 10	4. 96	5. 49	3. 83	5. 42	0. 70	p≥0. 05
Aquatic insect	2. 41	2. 56	3. 73	3. 82	4. 28	1. 09	p≥0. 05
Rotifer	14. 51	20. 36	13. 62	19. 87	16. 08	1. 49	p≥0. 05
Crustacea	2. 47	0. 78	2. 22	7. 01	2. 09	6. 04	p≤0. 05
Sand and mud	8. 78	10. 38	15. 98	12. 38	12. 42	4. 48	p≤0. 05

Chi-square value 3. 84 and above, significant at p≤0. 05, 6. 63 and above, significant at p≤0. 01

Discussion

During study period, no abrupt changes in climatic conditions were observed except total rainfall. The variations in the temperature were influenced by air temperature, humidity, wind and solar energy, shallowness of the ponds and influx of the channel water. Ambient temperature range of 26-32°C in tropical waters (Jhingran, 1968) is congenial for optimal growth of fish. The recorded average pH values were within the range of 6. 5 -9. 0 documented by Swingle (1961) and Boyd and Lichtkoppler

(1985) as these values are suitable for fish production for maximum productivity. Recorded dissolved oxygen is in the range recommended for aquatic life in the tropical environment by Laponite and Clark (1992). Dissolved oxygen is inversely proportional to temperature indicating that the higher temperature of water decreased the solubility of oxygen in the pond water and lower dissolved oxygen noted in the summer. Deshmukh and Ambore (2006) also noted a strong negative correlation between DO and temperature. The mean value of recorded alkalinity and the variation range agreed with the range values documented by Boyd (1981) and Mohanty (2003) for natural waters. Higher values of hardness were observed during winter months which may be due to low water level and high rate of decomposition thus, concentrating the salts. These ranges compared well with the ranges reported for other tropical waters as expressed by Chatterjee and Raziuddin (2007).

Gut content indicated increase gastro somatic index in spring and summer season. According to Lin (1951) who documented temperature range of 27 and 32°C will allow tropical fish to eat more and grow faster. This investigation also reported good condition factor in the above season with higher GSI value. Water transparency is inversely proportional to the abundance of most plankton, hence an increase in plankton will reduce transparency of water and ample food availability to fish lead to higher productivity as indicated by Dhawan and Kaur (2002).

The gonadal development was almost follow similar seasonal pattern in both the sexes and GnSI increased gradually from spring to rain and decreased in the autumn. GnSI value indicated, the rainy season is the spawning period of the specimen. Khan (1959) observed that sudden rise of water level during monsoon caused spontaneous spawning in the natural water bodies. A positive relationship between increasing temperature and day length with gonadal development during preparatory and pre spawning phases and fall of temperature due to rainfall associated with upsurge in gonadotropin level during spawning phase has been reported for the Indian major carp (Singh and Sihgh, 1984). Bhatnagar (1972) reported that GnSI value indicated the maturity status and breeding period of Indian major carps. This remark further confirmed by the present finding with the highest GnSI value in the rainy season. In the summer season, rising GnSI value, higher temperature and low dissolved oxygen may act as stimulator for ripening of gonad and spawning in rainy season. Present study is reported the increase liver size corresponding to the decrease in the size of the gonad, suggesting that material might be transported from the digestive gland to the gonad. The correlation coefficient (r) showed a significant inverse relationship between them ($r=-0.543$ at $p \leq 0.01$). Such transfer of nutrients from storage or digestive sites to the gonad has been inferred in a number of other groups of fishes, prawn, mollusks and other species (Ansell, 1974; Gabbott and Bayne, 1973; Le Pennec *et al.,* 1991). Litaay and De Silva (2003) reported that the digestive gland of the *H. rubra* acts a nutrient store, as maturation proceeds nutrients are drawn from the digestive gland, resulting in the lowering of the value of HSI.

Condition factors (k) were comparable to values reported for *Lactarius lactarius* (Neelakantan and Pai, 1985) and for the *Labeo dussumieri* (Kurup, 1990). The study also revealed, though the condition of fish is more related to gonado-somatic index, there exists some relationship between relative condition factor and gastrosomatic index ($r=0.554$, $p \leq 0.01$), environmental and biological factors. This work also observed the relationship among food intake, GSI value, oxygen saturation, temperature and gonad developmental pattern of fish. Increased gut content in spring and summer may be due to impact of favorable temperature and availability of plankton. Randolph and Clemens (1976) found that feeding patterns of channel catfish varied with temperature and oxygen availability. Rainbow trout (*Oncorhynchus mykiss*) reduced its appetite when oxygen saturation fell below approximately 60% (Jobling, 1995). It is nevertheless important to compare fish captured during the same season, as reproduction and other seasonal factors such as environmental have the potential to alter GSI, k, and other biological parameters in different ways at different times of the year (Encina and Granado-Lorencio, 1997a; Encina and Granado-Lorencio, 1997b).

This fish is subsisting mainly on bacillariophyceae and detritus. It is in the line with observation earlier made by Mookherjee and Ganguly (1945) and Das and Moitra (1955). Similar feeding habits also noted by Kumar and Roy (2009) on their analysis of feeding habits of fishes vividly explained the omnivore nature of Indian major carp. Presence of detritus in the dietary component may be due to the omnivorous nature and availability of food during different season as a result the fish use this dead organic matter as food which was according to Wetzel **(1983)** detritus contains functional carbon and energy. The relative occurrence of different food organisms varied from season to season which may be due to varied production of the supply of food items in the environment. The intensity of feeding of these fishes like other tropical fishes have been affected by the maturation of their gonads. Feeding intensity is observed to be low during monsoon that can be associated with the stabilized condition of the environment when more food becomes available then gsi increases as in spring. The spent fish consume more food to recover from the spawning exhaustion. Chaterjee *et al.,* (1992) also reported that fluctuation in feeding intensity in the fishes took place due to maturation of their gonads.

The seasonal variations in the physicochemical parameters of the pond water were as a result of the effects of hydrological regime of the water body and the prevailing weather conditions of the site of the environment. The relationship between seasonal variations of different water parameters and biological indices of *Cirrhinus mrigala* showed that no single parameter can be singled out in relation to fish growth and health. However all these parameters at their optimal level can allow tropical fish to eat more and grow faster and the pond water was suitable for fish production; Statistical analysis confirmed that there were significant differences among parameters in different seasons.

Acknowledgement

Authors are grateful to Head, Utkal University, Bhubaneswar, India, providing necessary facilities to carry out this research work.

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CITE THIS ARTICLE AS:
Sunil Chandra Pradhan and Ajaya Kumar Patra, Seasonal Climate Change of Water Quality Indices and Impact On Feeding Habits and Bioindices Of Cirrhinus Mrigala, *International Journal of Bioassays* 4.9 (2015): 4254-4261.

Source of support: Nil
Conflict of interest: None Declared