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Growth performance of Indian major carps in selected micro-water sheds of Dungarpur district of southern Rajasthan

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Abstract
A total 10 micro-water sheds of Dungarpur districts of Rajasthan were chosen to evaluate the biotic conditions and growth performance of Indian major carps. Water quality parameters *viz*., temperature (26.2-32.7 ^{o}C), pH (7.3-10.05), dissolved oxygen (6.71-10.21mg/l), free CO_2 (0-0.45mg/l), total dissolved solids (76.55-473mg/l), electrical conductivity (160.4-965mS/cm), total hardness (61-200mg/l), Gross primary productivity (0.119-0.350gC/m^3/h), Net primary productivity (0.028-0.306gC/m^3/h) and Community respiration (0.017-0.286gC/m^3/h) were recorded in present study. All the water quality parameters were found congenial for fish growth except very high pH in a few water bodies. The phytoplankton counts in different micro-water sheds were ranged between 125 to 310 Nos/l. whereas; the count of total zooplankton in different water bodies were very less. As such the zooplankton number varied between 3 to 12 Nos/l. The net weight gain of catla, rohu and mrigal was (762.38-1103.33gm), (628.31-932.16gm) and 395.15-838.29gm respectively. Whereas, the specific growth rate of catla (2.009-2.162%), rohu (1.990-2.153%) and mrigal (1.839-2.149%) were recorded, which indicated the moderate productivity of the selected micro-water sheds. Further study is recommended to have better supplementary feeding and scientifically culture base fisheries for good results for fish production in micro-water sheds.

Keywords: Carps, micro-water sheds, supplementary feeding

1. Introduction
India has a vast freshwater resources in the form of both lentic and lotic ecosystems. Southern Rajasthan which is also known as "Mewar" and "Vagad" region is especially famous for its water bodies. In spite of favorable conditions for high fish growth rate in the state of Rajasthan, fish culture has yet not attained a required popularity. Fish production in any aquatic ecosystem is mainly dependent on the abiotic and biotic factors in their environment.
Carps belongs to the category of lower level in food chain as they feed on plankton, detritus and benthic organisms such as worms, insect and molluscus in the natural conditions Adamek, *et al*., (2004) [1] and hence are particularly suitable for culture in ponds. Indian major carps are the most cultivable fish species in India contributing about 87% of the total freshwater aquaculture production of the country Ayyappan and Jena (2003) [4]. However, natural productivity of the ponds is required for the higher level of fish biomass production. Taylor, *et al*. (1988) [20] have studied abiotic factors (i.e. physical and chemical parameters) influencing macro invertebrates in aquatic systems. Gupta and Gupta (2006) [7] have studied the quality of water in terms of physico-chemical and biological characteristics in fish ponds. The most favorable conditions for the existence of fish as well as other biota which constitute essential components of the food chain were noticed. Korai, *et al*. (2008) [8] have studied the loss in productivity, changes in growth, loss of primary productivity, altered diversity or community structure, changes in aquatic ecosystem process (such as nutrient cycling) and losses. The purpose of the present investigation is to assess the planktonic biomass and fish growth in selected micro-water shed of Dungarpur, Southern Rajasthan. Keeping in view the importance of biotic factors in primary production and second and tertiary productivity of natural aquatic ecosystems the present research work was carried out with the following objectives:
1. To assess the zooplanktonic biomass in micro- watersheds,
2. To correlate planktonic biomass with fish growth.

2. Materials and methods

The present study was carried out during January 2016 to June 2016. The aim of this study was to assess the dynamics of selected biotic factors in selected micro-water sheds of Dungarpur, Southern Rajasthan, Rajasthan (India). Geographical location and area of the selected micro-watersheds is presented in Table 1.

The relationship of biotic factors with fish growth and primary productivity was also investigated.

2.1 Climate of Study Area: The study area "Dungarpur" experiences a subtropical climate with average rainfall ranging from 47 to 76 cm. and relative humidity of 75-95% during monsoon period. The summers are hot and winters are cool having an average range of maximum temperature between 25 ºC and minimum between 9 ºC.

2.2 Study Area: The proposed study was conducted in selected micro water sheds of Dungarpur southern Rajasthan, Rajasthan (India). Geographical location and area of the selected micro-water sheds is presented in Table 1.

Table 1: List of selected water bodies and their geographical location.

S. No.	Name of Water Body	Area(ha)	Lon.	Att.	MSL
1	Advert Samand	8	23˚47.179'	73˚40.350'	312
2	Loar Godhi	10	23˚56.487'	73˚39.334'	289
3	Kanhar Vala	10	23˚42.629'	73˚47.079'	272
4	Pani Dara	10	23˚48.038'	73˚50.856'	272
5	Banjariya	12	23˚52.436'	73˚57.048	254
6	Bassi	10	23˚54.176'	73˚43.236'	284
7	Makodi	6	23˚44.919'	73˚55.557'	188
8	Kalu Dara	8	23˚44.215'	73˚36.761'	354
9	Jhalawadi Talai	4	23˚33.251'	73˚31.355'	244
10	Khanmal	10	23˚54.350'	73˚30.812'	345

2.3 Collection of Water Sample: To monitor the status of water quality (physico-chemical and biological) in selected micro-water sheds (Table.1). The surface water samples were collected during January 2016 to June 2016 at on interval of 45 days. The surface water samples were collected using wide mouth sterile transparent plastic bucket. The water samples were secured in one liter plastic bottles with air tight cap. A total of 11 physico-chemical (Temperature, pH, dissolved oxygen, free carbon-dioxide, total dissolved solid, conductivity, hardness, total alkalinity, salinity, nitrate-nitrogen and orthophosphate) and 3 biological (primary productivity, plankton production and fish growth) parameters were studied. The techniques for the analysis of selected water quality parameter described below.

2.4 Water quality Analysis: Some parameters like, temperature, pH, DO, TDS, EC, and Salinity were determined on the spot by using electric meters HACH and HACH HQ-30. Other parameter like free carbon di-oxide, total alkalinity, total hardness, nitrate-nitrogen and orthophosphate were determined in laboratory by using standard methods of APHA (1989).

2.5 Primary productivity: Primary productivity was measured on site at all the water bodies following light and dark bottles method. For this purpose, glass stoppered black and colorless BOD bottles of 250 ml were used. The bottles were suspended about 1 m below the waterline. The incubation period was kept three hours. Oxygen (O_2) estimations in the BOD bottles were made using HACH (HQ-30) DO meter.

2.6 Plankton analysis: Sample for phyto and zooplankton were also collected along with water sample. The samples were collected by filtering 50 l of water through plankton net of bolting silk No. 30 micron mesh size and concentrated up to 50 ml. The concentrated sample was preserved immediately with the help of 4% formalin solution and adds two drops of glycerin. The samples were observed under the microscope and qualitative and quantitative analysis was done as per the standard keys procedures (Adoni, 1985) [2]. The zooplankton species have been identified with the help of a standard keys of Needham and Needham, (1962). The quantitative estimation was done by using Sedge wick - Rafter Cell and expressed as numbers per liter. The quantitative analysis of phytoplankton was done using a hemocytometer. The standard procedure for the enumeration of phytoplankton count was followed (Adoni, 1985) [2].

2.7 Fish growth studies: All the selected micro-water sheds were stocked with Indian major carp's fingerlings.The selected water bodies were stocked with IMC fingerling @ 2500 nos/ha in the ratio of 3:4:3 of Catla, Rohu and Mrigala. The initial respective size of catla, rohu and mrigal fingerling was 7.2 $\pm$0.05 cm/ $\pm$0.01g, 8.0$\pm$0.03 cm/$\pm$0.03g and 6.9$\pm$0.09 cm/$\pm$0.02g. The seed was stocked during 4th October to 19th October 2015. On the basis of initial size of seed stocked and size (length and weight) of sampled fish growth performance was estimated using following formula:

Weight gain (gm) = Final weight – Initial weight

Length gain (cm) = Final length – Initial length

Specific Growth Rate (%/day) = [Ln (Final Weight) – Ln (Initial Weight)] / Culture Period (Day)*100.

3. Results

The results pertaining to physico-chemical water quality parameters, primary productivity, and plankton counts and fish growth are presented in Table 2 to 4 and Figures1 to 4. In micro-watersheds the quality of water, productivity levels and fish growth performance were markedly different. As such the results reported as described category wise as detailed below:

3.1 Physico-chemical parameters

The average water temperature varied between minimum of 28.1 ºC in Kaludara and maximum of 32.15 ºC in Advert samand (Table 2). In general, the water of all the micro watersheds remained alkaline throughout the study period. The mean values of pH varied between a minimum of 7.6 in Advert samand and a maximum of 10.05 in Banjariya (Table 2). The average DO was found to be lowest (7.19mg/l) in

Kalu dara and highest (10.21mg/l) in Banjariya. The free carbon-dioxide fluctuated from 0.0mg/l to 0.7mg/l. The lowest average value of total dissolved solid (76.55mg/l) was found in Kaludara but highest (473mg/l) in Khanmal. Electrical conductivity was found to be lowest (160.4mS/cm) in Kaludara and highest (965mS/cm) in Khanmal. Mean values of total hardness fluctuated between 42 and 200 mg/l with lowest in Kaludara and highest in Khanmal. The lowest average value of total alkalinity (34mg/l) was found in Kaludara but highest (132mg/l) was in Loar godhi. The respective highest (0.988 mg/l) and lowest (0.05mg/l) average values of nitrate-nitrogen were observed in Loar godhi and Kaludara. The orthophosphate concentration in micro-water shed average varied between 0.00 to 0.33mg/l (Table 2) with lowest in Jithula and highest in Makodi.

3.2 Primary Productivity

The range and mean values of primary productivity (GPP, NPP and RQ) in selected micro-water sheds are depicted in Table 3.The highest ($0.538gC/m^3/h^{-1}$) and lowest ($0.063gC/m^3/h^{-1}$) values of GPP were observed in Bassi and Jhalawadi talai respectively. The mean value of GPP varied between 0.120 and 0.350 $gC/m^3/h$ with minimum in Advert samand and maximum of in Bassi. The maximum ($0.488gC/m^3/h^{-1}$) value of NPP was observed in Bassi, while the minimum of $0.013gC/m^3/h^{-1}$ was noticed in Jhalawaditalai (Table 3). The average NPP value was highest ($0.306gC/m^3/h^{-1}$) in Bassi and lowest ($0.028gC/m^3/h^{-1}$) in Jhalawaditalai (Fig.1). The highest ($0.291gC/m^3/h^{-1}$) and lowest ($0.021gC/m^3/h^{-1}$) values of RQ were observed in Pani Dara and Advert samand respectively. The highest and lowest mean values of 0.248 Pani Dara and $0.044gC/m^3/h^{-1}$ were found in Bassi respectively.

3.3 Plankton production

In general, the phytoplankton densities ranged between 80Nos/l and 470Nos/l with lowest in both Bassi and Kaludara and highest in Makodi. The highest mean (310Nos/l) and lowest (125Nos/l) were noticed in Kanharvala and Kaludara respectively (Fig. 2). The counts of total zooplankton in different water bodies were very less. As such the zooplankton count varied between 4 to 12Nos/l. The minimum (4 Nos/l) was in Advert samand, Loar godhi and Makodi. Whereas the maximum (12 Nos/l) was in both Kanharvala and Pani Dara (Table 4). On comparing different zooplankton groups it was observed that Copepoda dominated the zooplanktonic count followed by Rotifera, cledocera and nauplii.

3.4 Fish Growth

The results of fish growth parameters (Net weight gain, net length gain and specific growth rate) from selected micro-watersheds are presented in Table 6. The net weight gain of Catla, Rohu and Mrigala varied between 762.38 to 1103.33gm, 633.31 to 932.16gm and 395.15 to 838.29gm respectively with minimum in Banjariya and maximum of in Jhalawadi talai. The highest of 30.03(Catla), 29.50(Rohu) and 28.23cm (Mrigal) and lowest of 20.25(Catla), 17.35(Rohu) and 9.77cm (Mrigal) length gain for Catla, Rohu and Mrigal were observed in Jhalawadi talai and both Biyata and Banjariya respectively. The respective lowest (2.009, 1.990 and 1.839%) and highest (2.162, 2.153 and 2.149%) specific growth rate of catla, rohu and mrigal was noticed in Banjariya and Jhalawadi talai. During the present study, highest productive water shed was Jhalawadi talai and lowest productive water shed was Banjariya recorded.

Table 2: Range and mean values of water quality parameters of selected micro-watersheds

Watershed name	Temperature (°C)	pH	D.O. (mg/l)	Free CO_2 (mg/l)	T.D.S. (mg/l)	Conductivity (µs/cm)	Hardness (mg/l)	Total alkalinity (mg/l)	Salinity (mg/l)	Nitrate – nitrogen (mg/l)	Ortho-phosphate (mg/l)
Advert Samand	31.2 – 33.1 (32.15)	6.9 – 8.3 (7.6)	7.31-7.33 (7.32)	0-0 (0)	244-263 (253.5)	244-542 (393)	156-168 (162)	58-84 (71)	0.2-0.2 (0.2)	0.147-0.156 (0.152)	0.001-0.04 (0.0205)
Loar Godhi	30.4 – 30.7 (30.55)	9.8 – 9.9 (9.85)	6.93-9.34 (8.14)	0-0 (0)	315-340 (327.5)	315-698 (506.5)	168-182 (175)	112-152 (132)	0.3-0.3 (0.3)	0.127-0.988 (0.558)	0.03-0.06 (0.045)
Kanhar Vala	26.3 – 32.1 (29.2)	9.5 – 10 (9.75)	6.31-12.62 (9.46)	0-0 (0)	117.1-125.8 (121.45)	125.8-244 (184.9)	86-90 (88)	78-90 (84)	0-0.1 (0.5)	0.119-0.173 (0.146)	0.01-0.02 (0.015)
Pani Dara	29 – 31.2 (31.7)	8 – 10.5 (9.25)	7.41-7.95 (7.68)	0-0 (0)	246-257 (251.5)	509-571 (540)	134-152 (143)	98-118 (108)	0.2-0.2 (0.2)	0.10-0.272 (0.186)	0.001-0.05 (0.0255)
Banjariya	28.7 – 31.6 (30.15)	9.2 – 10.9 (10.05)	9.71-10.71 (10.21)	0-0 (0)	236-249 (242.5)	488-514 (501)	100-130 (115)	110-152 (131)	0.2-0.2 (0.2)	0.273-0.307 (0.290)	0.03-0.04 (0.035)
Bassi	29.6 – 31.3 (30.45)	7.8 – 10 (8.9)	7.92-9.24 (8.58)	0-0 (0)	205-248 (226.5)	425-512 (468.5)	86-100 (93)	120-134 (127)	0.1-0.2 (0.15)	0.110-0.650 (0.380)	0.03-0.11 (0.07)
Makodi	29.6 – 33.8 (31.7)	8.3 – 8.5 (8.4)	7.52-9.09 (8.31)	0-0 (0)	264-282 (273)	545-582 (563.5)	114-144 (129)	96-112 (104)	0.2-0.2 (0.2)	0.140-0.539 (0.340)	0.05-0.33 (0.19)
Kalu Dara	27.7 – 28.5 (28.1)	7.3 – 8 (7.65)	5.75-8.64 (7.195)	0-0 (0)	72.6-80.5 (76.55)	152.3-168.5 (160.4)	42-80 (61)	32-36 (34)	0-0 (0)	0.057-0.120 (0.089)	0.07-0.1 (0.085)
JhalawadiTalai	28.3 – 29.5 (28.9)	7.3 – 8.1 (7.7)	5.26-9.97 (7.615)	0-0.7 (0.35)	69.5-93.7 (81.6)	145.7-196 (170.85)	62-66 (64)	34-50 (42)	0-0.1 (0.5)	0.14-0.218 (0.179)	0.06-0.14 (0.1)
Khanmal	27.7 – 29.4 (28.55)	8.2 – 9.6 (8.9)	7.81-8.33 (8.07)	0-0 (0)	457-489 (473)	933-997 (965)	200-200 (200)	96-130 (113)	0.4-0.5 (0.45)	0.102-0.128 (0.115)	0.001-0.04 (0.0205)

Table 2: Range and mean values for primary production of selected micro-water sheds in Dungarpur

S. N.	Water-shed name	GPP ($gC\ m^{-3}h^{-1}$)	NPP ($gC\ m^{-3}h^{-1}$)	RQ ($gC\ m^{-3}h^{-1}$)
1.	Advert Samand	0.103-0.138 (0.120)	0.044-0.103 (0.073)	0.021-0.094 (0.047)
2.	LoarGodhi	0.159-0.269 (0.214)	0.125-0.203 (0.164)	0.034-0.066 (0.050)
3.	KanharVala	0.144-0.275 (0.209)	0.053-0.078 (0.066)	0.091-0.197 (0.144)
4	Pani Dara	0.256-0.416 (0.336)	0.050-0.125 (0.088)	0.206-0.291 (0.248)
5.	Banjariya	0.169-0.194 (0.181)	0.081-0.172 (0.127)	0.022-0.088 (0.055)
6.	Bassi	0.163-0.538 (0.350)	0.125-0.488 (0.306)	0.038-0.050 (0.044)
7.	Makodi	0.106-0.300 (0.203)	0.022-0.188 (0.105)	0.084-0.113 (0.098)
8.	Kalu Dara	0.131-0.356 (0.244)	0.059-0.156 (0.108)	0.072-0.200 (0.136)
9.	JhalawadiTalai	0.063-0.216 (0.139)	0.013-0.044 (0.028)	0.050-0.172 (0.111)
10.	Khanmal	0.128-0.159 (0.144)	0.028-0.056 (0.042)	0.072-0.131 (0.102)

Table 4: Range and mean value of phytoplankton and zooplankton densities in selected micro-watersheds in Dungarpur

Water-sheds name	Phytoplankton (Nos/l)	Zooplankton (Nos/l)				
		Rotifera	Cledocera	Copepoda	Nauplii	Mean total
Advert Samand	180-220 (200)	2-1 (1)	0-1 (1)	1-1 (1)	1-1 (1)	4
Loar Godhi	210-220 (215)	2-1 (1)	1-1 (1)	1-2 (1)	0-1 (1)	4
Kanhar Vala	210-410 (310)	3-3 (3)	2-4 (3)	4-4 (4)	2-2 (2)	12
Pani Dara	130-350 (240)	4-4 (4)	2-4 (3)	2-5 (4)	1-2 (1)	12
Banjariya	170-220 (195)	1-1 (1)	1-3 (2)	1-1 (1)	1-1 (1)	5
Bassi	80-210 (145)	1-1 (1)	1-1 (1)	2-3 (2)	1-1 (1)	5
Makodi	120-470 (295)	1-2 (1)	2-2 (2)	1-1 (1)	1-1 (1)	4
Kalu Dara	80-170 (125)	1-1 (1)	1-1 (1)	3-4 (3)	1-1 (1)	6
Jhalawadi Talai	150-380 (265)	0-0 (0)	1-2 (1)	2-3 (2)	1-2 (1)	5
Khanmal	140-180 (160)	1-1 (1)	0-0 (0)	2-4 (3)	1-1 (1)	5

Table 5: Growth parameters of IMC in selected micro-water sheds in Southern Rajasthan

Water sheds	Catla			Rohu			Mrigala		
	NWG	NLG	SGR	NWG	NLG	SGR	NWG	NLG	SGR
Advert Samand	950.95	24.92	2.100	920.62	29.04	2.148	739.27	24.10	2.097
Loar Godhi	872.86	22.30	2.065	665.81	18.85	2.014	449.07	12.01	1.891
Kanhar Vala	848.10	21.47	2.053	671.58	19.08	2.018	505.93	14.38	1.940
Pani Dara	914.76	23.70	2.084	675.43	19.23	2.020	537.31	15.69	1.965
Banjariya	762.38	18.59	2.009	628.31	17.35	1.990	395.15	9.77	1.839
Bassi	811.91	20.25	2.035	633.12	17.54	1.993	494.17	13.89	1.931
Makodi	935.71	24.41	2.094	718.70	20.96	2.046	644.17	20.14	2.040
Kalu Dara	976.67	25.78	2.111	908.12	28.54	2.143	640.25	19.98	2.038
Jhalawadi Talai	1103.3	30.03	2.162	932.16	29.50	2.153	838.29	28.23	2.149
Khanmal	855.71	21.72	2.057	669.66	19.00	2.016	461.82	12.54	1.903

NWG – Net weight gain, NLG – Net length gain & SGR – Specific growth rate

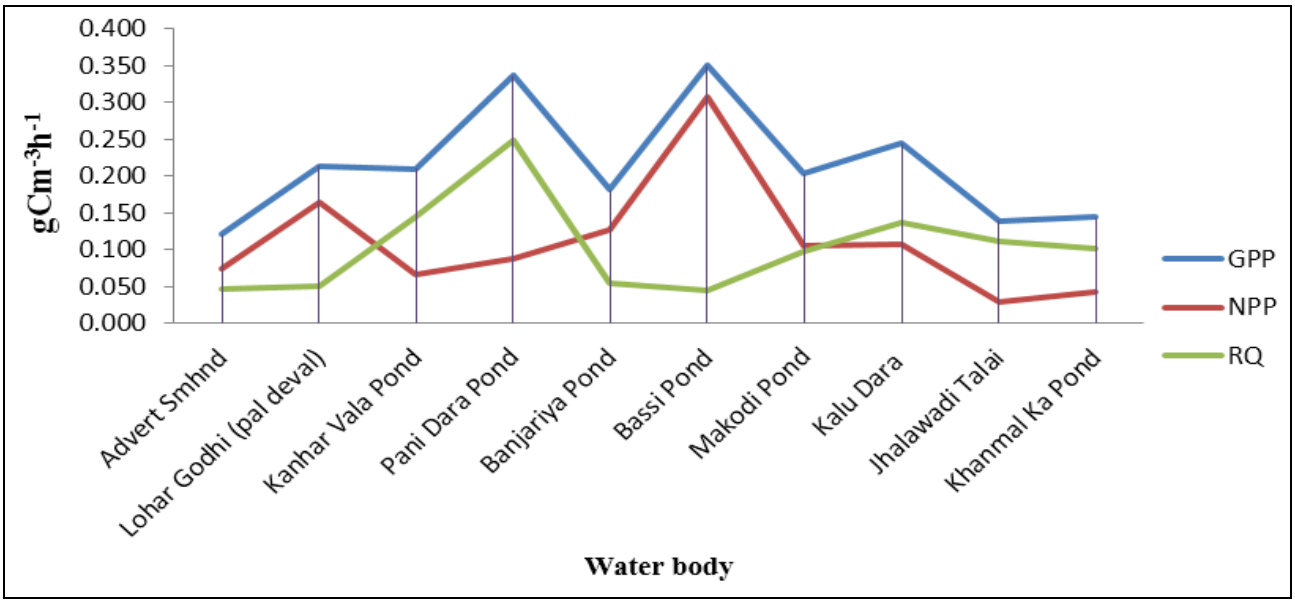

Fig 1: Average value of NPP, GPP and RQ in selected micro- water sheds

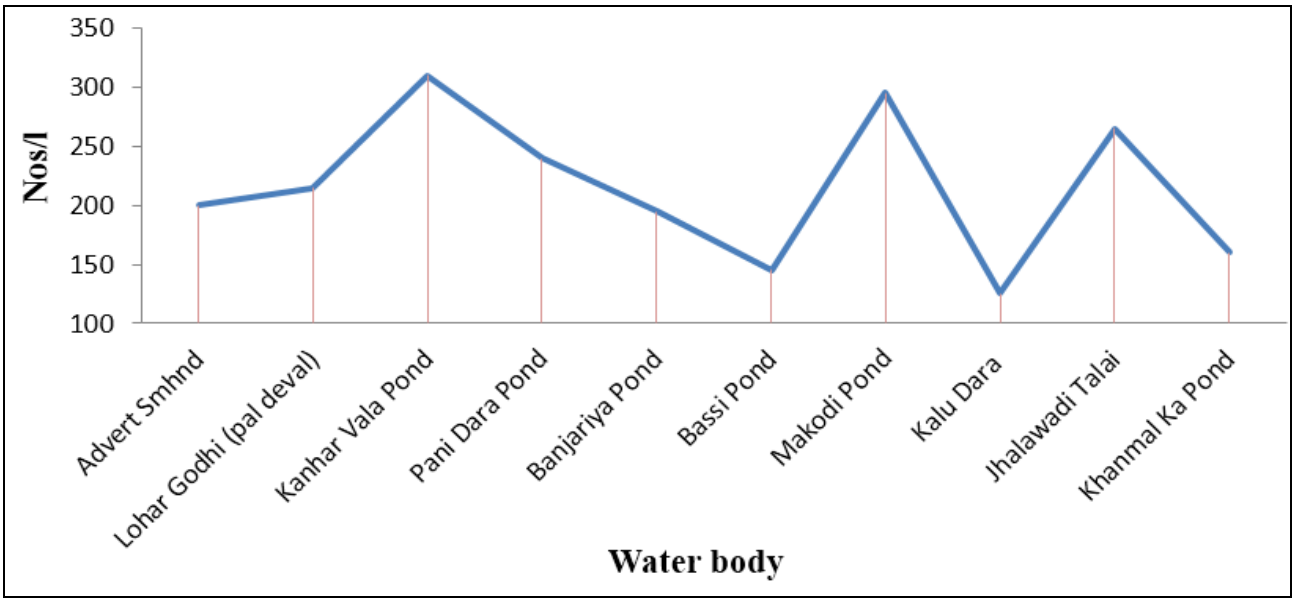

Fig 2: Average density of phytoplankton in selected micro-water sheds.

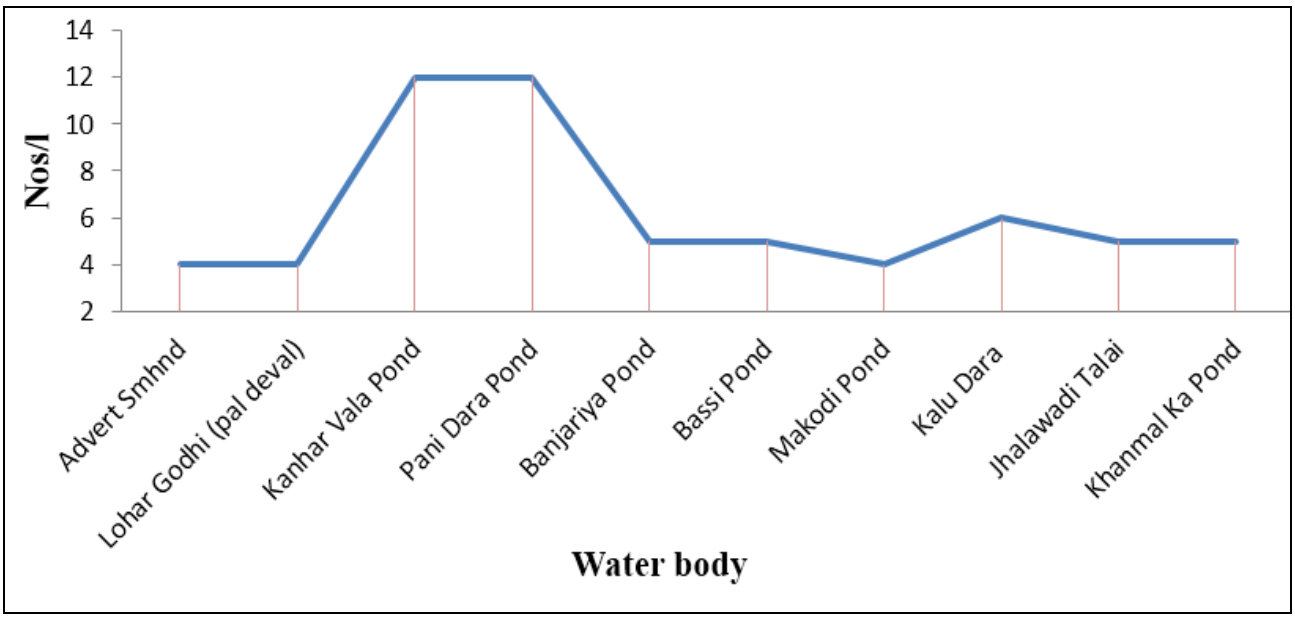

Fig 3: Average density of zooplankton in selected micro-water sheds.

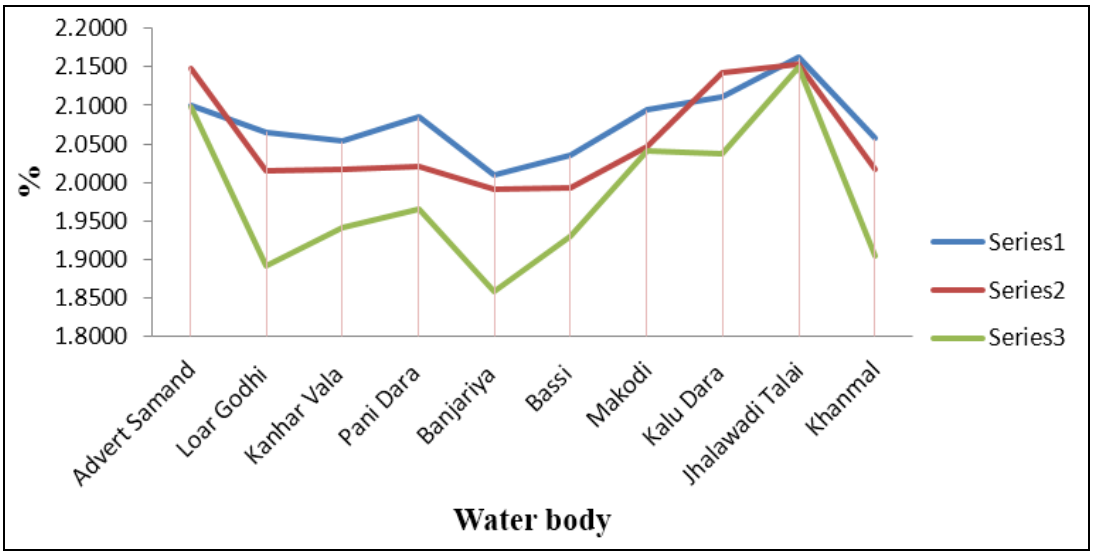

Fig 4: Average SGR of Catla, Rohu and Mrigal in selected micro-water sheds.

4. Discussion

The result of present study are depicted in (Tables 2 to 6) regarding the water quality status, primary productivity and plankton density of selected micro-water sheds in Southern Rajasthan in relation growth performance of Indian major carps. Physico-chemical parameters of selected micro-water sheds were found to be congenial for fish growth except very high pH in a few water bodies (Banjaria, Loar godhi, Pani dara and Kanhar vala). However, no single satisfactory index can determined the micro-water sheds productivity according to Welch (1952) [22]. Reid (1967) [14] has pointed out that whole of the aquatic life in aquatic ecosystem is governed by the interaction of a number of physical and chemical conditions. During the study period the water temperature was ranged between 28.1 ºC to 32.15 ºC in selected micro-water sheds. Similar range of water temperature was observed in water bodies of arid and semi-arid regions of Rajasthan (Sarang, 2001 and Rajkumar, 2005) [15, 11]. In the present study, average pH ranged between 7.6 and 10.05 in different micro-water sheds. The pH of selected micro-water sheds was found to be alkaline. The moderate to slightly alkaline pH has been considered as most suitable for fish culture while pH above 9 is unsuitable for higher fish growth (Swingle, 1967) [19]. The dissolved oxygen (DO) concentrations were always above 5 mg/l, these water bodies are suitable for fish culture. Balai (2007) [5] and Rajkumar (2005) [11] also found the absence of free CO_2 in different water bodies of Southern Rajasthan. Exceptionally high values of EC designate pollution status of the reservoirs. Sharma (1980) [16] has recorded average conductance of 426.6 from Fateh Sagar Lake. In selected micro-water sheds the waters are soft to slightly hard. Such hard water has also been reported earlier by Sarang (2001) [15], Rawat and Jakhar (2002) from waters of Southern Rajasthan. In the present study, total alkalinity ranged from 42 to 152mg/l (Table 2). Ujjania has observed total alkalinity of 65 to 199 mg/l in three water bodies of southern Rajasthan. In the present study the average values of NO_3-N varied from 0.05 to 0.988mg/l. These values are fairly comparable to those reported by Sultan, *et al.* (2003) [18] from different lentic waters. In the case of selected micro-watersheds, the orthophosphate concentrations ranged between 0.00 to 0.33mg/l. Rao (1987) [12] has recorded orthophosphate variations between 0.06 to 0.52 m/l in the Rangsagar Udaipur.

Gross primary productivity (GPP) in micro-water sheds ranged between 0.063 to 0.538 gC/m^3/hr. Sultan, *et al.* (2003) [18]. Rajkumar (2005) [11] has reported an NPP value of 0.31 gC/m^3/hr in the surface water of Daya reservoir. The average RQ competed in the present study (0.291gC/m^3/h^{-1} to 0.021gC/m^3/h^{-1}) is also comparable with that of Daya reservoir Udaipur (0.14 gC/m^3/hr) (Rajkumar, 2005) [11]. The average phytoplankton density observed in different micro-water shads range between 125 to 310 Nos/l. Average phytoplankton counts reported in Goverdhan Sagar was 36.71 Nos/ml by (Mishra, *et al.* 2012) [9]. The observed scenario of zooplankton at sampling four of all micro-watersheds are ranking in order of Copepoda >Rotifera > Cladocera > nauplii. The average density of zooplankton as reported by Shekhawat (1991) was 15 Nos/l. Mishra, *et al.* (2012) [9] have observed 27 species of zooplankton in Goverdhan sagar. The productivity and fish growth trends reported from different micro-water sheds further intensifies the finding of other researches (Sugunan, 1995) [17]. The variation in different physico-chemical water quality parameters affects the production of that system.

From the results of this study it is concluded that the quality of water is fairly good for fish culture. However, the growth performance was found moderate. To get the maximum production potential, there is urgentneed to adopt scientific fish culture technique. Further studies recommended proper fertilization, manuring, feeds and above all the stocking ratio and healthy fish seed supply.

5. References

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