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Raj Priyanka Rathor
Department of Aquaculture, College of Fisheries, MPUAT-Udaipur, Rajasthan, India

ML Ojha
Department of Aquaculture, College of Fisheries, MPUAT-Udaipur, Rajasthan, India

VP Saini
Aquaculture Research & Seed Unit, Directorate of Research, MPUAT-Udaipur, Rajasthan, India

NR Keer
Division of Aquaculture, ICAR - Central Institute of Fisheries Education, Versova, Mumbai, Maharashtra, India

Correspondence
NR Keer
Division of Aquaculture, ICAR - Central Institute of Fisheries Education, Versova, Mumbai, Maharashtra, India

Growth performance of Indian major carps in selected micro-watersheds of Banswara district of Southern Rajasthan

Raj Priyanka Rathor, ML Ojha, VP Saini and NR Keer

Abstract
A five micro-water sheds of Banswara district of Southern Rajasthan were chosen to evaluate the biotic conditions and growth performance of Indian major carps. Water quality parameters *viz.*, water temperature (30.4-32.7 °C), pH (8.2-9.3), dissolved oxygen (7.05-10.10mg/l), free CO_2(0-0.45mg/l), total dissolved solids (145.7-212mg/l), electrical conductivity (303-339mS/cm), total hardness (114-175mg/l), total alkalinity (98-141mg/l), Nitrate-Nitrogen (0.122-0.247mg/l), Gross primary productivity (0.138-0.528gC/m^3/h), Net primary productivity (0.034-0.166gC/m^3/h) and Community respiration (0.044-0.248gC/m^3/h) were observed throughout the study period and indicate that the water of the selected micro-watersheds remained congenial for growth of fish except very high pH in a few water bodies. The phytoplankton counts in different micro-watersheds were ranged between 145 to 225 nos/l. Whereas, the counts of total zooplankton in different water bodies were very less, as such the zooplankton counts varied between 3 to 6Nos/l. On comparing different groups it was observed that rotifer dominated the zoo-planktonic counts followed by Copepoda, nauplii and cladocera. The relationship between zooplankton, primary productivity and physico-chemical parameter were also calculated statistically. The present investigation also finds out the fish growth parameters like net weight gain Catla (857.71-950.95gm), Rohu (669.66-830.24gm) and Mrigal (461.82-752.01gm), net length gain Catla (20.82-24.92cm), Rohu (17.00-25.42cm) and Mrigal (15.98-24.64cm) and specific growth rate Catla (2.057-2.100%), Rohu (2.016-2.105%) and Mrigal (1.902-2.104%) and indicates the moderate productivity of the selected micro-watersheds. Further study is recommended to have better supplementary feeding and scientifically culture base fisheries for good results for fish production in micro-watersheds.

Keywords: Watersheds, Copepoda, Cladocera, Nauplii, Catla, Rohu, Mrigal

1. Introduction
Indian major carps viz., *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* dominate the fishery wealth of north Indian reservoirs especially in Rajasthan. Carps belongs to the category of second level in food chain as they feed on plankton, detritus and benthic organisms such as worms, insect and molluscus and hence are particularly suitable for culture in ponds [1]. Indian major carps are the most cultivated fish species in India contributing about 87% of the total freshwater aquaculture [4]. Natural productivity of the ponds with the supplementary feeding is necessary for supporting higher level of fish biomass production. The primary productivity of different water bodies has been widely investigated to assess the fish production potentiality of water bodies and formulate fishery management policies. Natural levels of primary productivity are usually inadequate to support high aquaculture yields. The knowledge of phytoplankton, variations in primary production, nutrient concentration and community structure are fundamental to the understanding of ecosystem dynamics. Larval fish growth rates and biotic variables relationship is more species specific, such as zooplankton and larval fish densities, were. They were also able to generate an understanding of the complex interactions between abiotic and biotic variables that influence larval fish growth rates. A comparative study of Jalmahal and Ramgarh Lake of Jaipur with special reference to plankton diversity was studied by [9] and they found that high nitrate content of these waters can be correlated with high density of phytoplankton and high rate of organic decomposition. A number of studies have been carried out on the ecology of freshwater bodies in various parts of India [17]. Zooplankton diversity is one of the most important ecological parameters in water quality assessment. Environmental factors and innate characteristics of water have great importance upon the growth and abundance of zooplankton [21].

The purpose of the present investigation is to assess the planktonic biomass and fish growth in selected micro-water shed of Banswara, 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 to assess the zooplanktonic biomass in micro- watersheds and 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 Banswara, Southern Rajasthan, Rajasthan (India). The relationship of biotic factors with fish growth and primary productivity was also investigated.

2.1 Climate of Study Area

The study area "Banswara" experiences a subtropical climate with normal average rainfall from 922.4 mm 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 45 -46 ºC and minimum between 10-20 ºC.

2.2 Study Area

The proposed study was conducted in selected micro water sheds of Banswara 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. N.	Name of Water Body	Area(ha)	Lon.	Att.	MSL
1.	NalaPada	10	23˚29.595'	73˚09.529'	189
2.	Jithula	10	23˚36.228'	74˚13.317'	170
3.	Kohala	10	23˚37.010'	74˚18.892'	183
4.	BhamriTandi	26	23˚18.503'	74˚19.600'	228
5.	Gopalpura	4	23˚13.355'	74˚31.508'	402

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.

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 [3].

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 stopperd 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 [2]. The zooplankton species have been identified with the help of standard keys of [8]. 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 [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. 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 Figures 1 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 30.4 ºC in Gopalpura and maximum of 32.7 ºC in Kohala (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 8.25 in NalaPada and a maximum of 9.3 in Jithula (Table 2). The average DO was found to be lowest (7.05mg/l) in BhamriTandi and highest (10.10mg/l) in Kohala. The free carbon-dioxide fluctuated from 0.0mg/l to 0.45mg/l. The lowest average value of total dissolved solid (145.7mg/l) was found in

Gopalpura but highest (212mg/l) in Kohala. Electrical conductivity was found to be lowest (303mS/cm) in Gopalpura and highest (384mS/cm) in BhamriTandi. Mean values of total hardness fluctuated between 114 and 175 mg/l with lowest in Gopalpura and highest in NalaPada. The lowest average value of total alkalinity (98mg/l) was found in Jithula but highest (141mg/l) was in Kohala. The respective highest (0.247 mg/l) and lowest (0.122mg/l) average values of nitrate-nitrogen were observed in Jithula and Gopalpura. The orthophosphate concentration in micro-water shed average varied between 0.00 to 0.11mg/l (Table 2) with lowest in Jithula and highest in Bhamri Tandi.

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 ($0.528 m^3/h^{-1}$) and lowest ($0.138 gC/m^3/h^{-1}$) values of GPP both were observed in Jithula. The mean value of GPP varied between 0.252 and $0.361 gC/m^3/h^{-1}$ with minimum in Kohala and maximum of in NalaPada. The maximum ($0.166 gC/m^3/h^{-1}$) value of NPP was observed in Jithula, while the minimum of $0.034 gC/m^3/h^{-1}$ was noticed in Gopalpura (Table 3). The average NPP value was highest ($0.130 gC/m^3/h^{-1}$) in Jithula and lowest ($0.053 gC/m^3/h^{-1}$) in Gopalpura). The highest ($0.366 gC/m^3/h^{-1}$) and lowest ($0.044 gC/m^3/h^{-1}$) values of RQ were observed in BhamriTandi and Jithula respectively.

3.3 Plankton production

In general, the phytoplankton densities ranged between 110Nos/l and 240Nos/l with lowest in BhamriTandi and highest in NalaPada. The highest mean (225Nos/l) and lowest (145Nos/l) were noticed in NalaPada and BhamriTandi respectively (Fig.2). The counts of total zooplankton in different water bodies were very less. As such the zooplankton count varied between 3 to 6Nos/l. The minimum zooplankton (3Nos/l) was found in Kohala. Whereas the maximum zooplankton (6Nos/l) was found in both Jithula and Gopalpura (Table 4). On comparing different zooplankton groups it was observed that Copepoda dominated the zooplanktonic count followed by Rotifera, nauplii and cladocera.

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 5. The net weight gain of Catla was lowest (856.67 gm) in Jithula and highest (950.95gm) in NalaPada. The net weight gain of Rohu 669.66gm-830.24 gm observed in Kohala and NalaPada respectively. The net weight gain of Mrigala varied between 461.82 to 752.01gm, respectively with minimum in Kohala and maximum of in NalaPada. The highest length gain of Catla (24.92), Rohu (25.42) and Mrigal (24.64cm) and lowest of Catla (20.82cm), Rohu (17.00cm) and Mrigal (12.54cm) were observed in NalaPada and Kohala. The specific growth rate of catla, rohu and mrigal was observed lowest (2.057, 2.016 and 1.902%) in Kohala and highest (2.100, 2.105 and 2.104%) in NalaPada. During the present study, highest productive water shed was NalaPada and lowest productive water shed was Kohala recorded.

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

Watershed name	Temperature (^oC)	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)
NalaPada	30.3 – 34.9 (32.6)	7 – 9.5 (8.25)	6.58-8.87 (7.725)	0-0.9 (0.45)	165.3-190.3 (177.8)	343-394 (368.5)	170-180 (175)	82-136 (109)	0.1-0.1 (0.1)	0.139-0.192 (0.166)	0.02-0.06 (0.04)
Jithula	30.7 – 33.6 (32.15)	8.7 – 9.9 (9.3)	9.25-9.78 (9.515)	0-0 (0)	204-215 (209.5)	423-445 (434)	118-136 (127)	90-106 (98)	0.1-0.1 (0.1)	0.234-0.260 (0.247)	0.04-0.06 (0.0)
Kohala	30.3 – 35.1 (32.7)	7.5 – 9.3 (8.4)	9.51-10.7 (10.10)	0-0 (0)	211-213 (212)	437-441 (439)	112-130 (121)	132-150 (141)	0.2-0.1 (0.15)	0.116-0.153 (0.135)	0.02-0.02 (0.02)
Bhamri Tandi	30.9 – 31.4 (31.15)	8.3 – 8.8 (8.55)	6.87-7.23 (7.05)	0-0 (0)	177.7-192.5 (185.1)	369-399 (384)	108-124 (116)	106-120 (113)	0.1-0.1 (0.1)	0.101-0.198 (0.150)	0.09-0.14 (0.115)
Gopalpura	30.3 – 30.5 (30.4)	8.5 – 8.6 (8.55)	7.53-8.62 (8.075)	0-0 (0)	135.2-156.2 (145.7)	281-325 (303)	100-128 (114)	114-114 (114)	0.1-0.1 (0.1)	0.173-0.171 (0.122)	0.05-0.06 (0.055)

Table 3: Ranges and mean values for primary production of selected micro-water sheds in Southern Rajasthan (Figure in parenthesis gives mean value)

SN.	Water-shed name	GPP ($gC\ m^{-3}h^{-1}$)	NPP ($gC\ m^{-3}h^{-1}$)	RQ ($gC\ m^{-3}h^{-1}$)
1.	NalaPada	0.334-0.388 (0.361)	0.047-0.103 (0.075)	0.231-0.341 (0.286)
2.	Jithula	0.138-0.528 (0.333)	0.094-0.166 (0.130)	0.044-0.363 (0.203)
3.	Kohala	0.197-0.306 (0.252)	0.050-0.063 (0.056)	0.147-0.244 (0.195)
4.	BhamriTandi	0.197-0.459 (0.328)	0.094-0.144 (0.119)	0.053-0.366 (0.209)
5.	Gopalpura	0.250-0.269 (0.259)	0.034-0.072 (0.053)	0.178-0.234 (0.206)

Table 4: Ranges and mean value of phytoplankton and zooplankton densities in selected micro-watersheds in Southern Rajasthan

S. No.	Watersheds name	Phytoplankton (Nos/l)	Zooplankton (Nos/l)				
			Rotifers	Cladocerans	Copepods	Nauplii	Mean total
1.	NalaPada	210-240 (225)	1-2 (2)	1-1 (1)	1-3 (2)	0-1 (0)	5
2.	Jithula	130-220 (175)	1-3 (2)	1-1 (1)	2-3 (2)	1-1 (1)	6
3.	Kohala	130-190 (160)	1-1 (1)	1-1 (1)	0-1 (1)	0-1 (0)	3
4.	BhamriTandi	110-180 (145)	1-2 (1)	1-0 (0)	2-3 (2)	1-2 (1)	4
5.	Gopalpura	130-190 (160)	1-2 (2)	1-0 (0)	2-3 (2)	2-3 (2)	6

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

S. No.	Water sheds	Catla			Rohu			Mrigala		
		NWG(gm)	NLG(cm)	SGR (%)	NWG(gm)	NLG(cm)	SGR (%)	NWG(gm)	NLG(cm)	SGR (%)
1.	NalaPada	950.95	24.92	2.1004	830.24	25.42	2.1054	752.01	24.64	2.1043
2.	Jithula	856.67	21.75	2.0572	770.62	23.04	2.0745	555.93	16.47	1.9793
3.	Kohala	857.71	20.82	2.0577	669.66	17.00	2.0165	461.82	12.54	1.9028
4.	BhamriTandi	935.71	24.41	2.0937	718.70	20.96	2.0457	644.17	20.14	2.0402
5.	Gopalpura	919.52	23.86	2.0865	729.28	21.38	2.0517	544.17	15.98	1.9705

NWG – Net weight gain: NLG – Net length gain; SGR – Specific growth rate

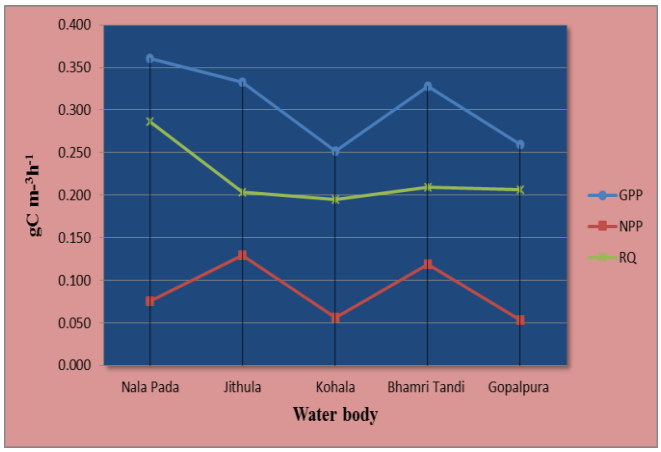

Fig 1: Average value of NPP, GPP and RQ in selected micro- water sheds

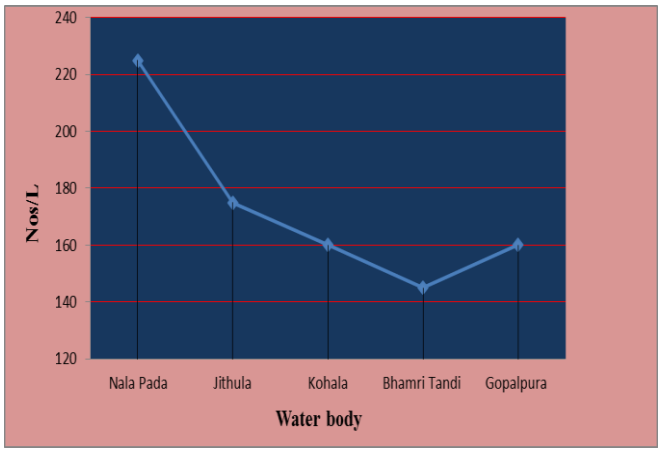

Fig 3: Average density of phytoplankton in selected micro-water sheds

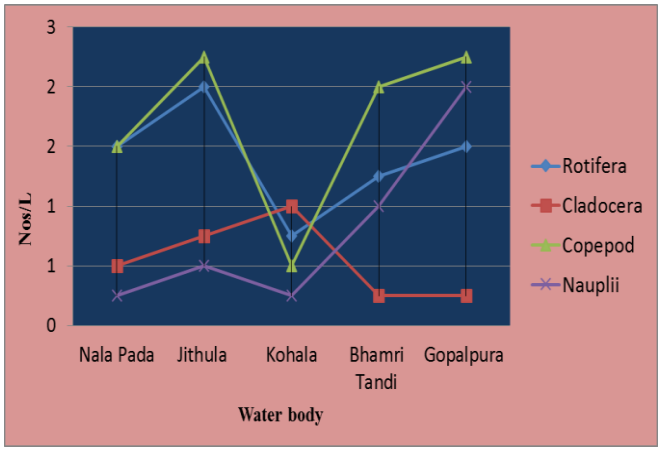

Fig 2: Average Density of Rotifera, Cladocera, Copepod and Nauplii in selected micro- water sheds

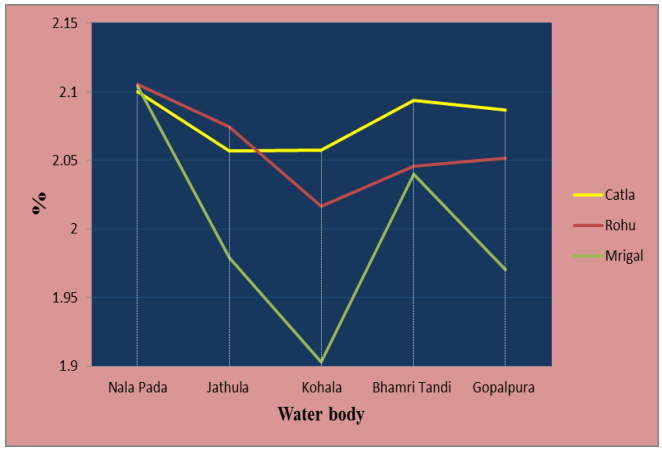

Fig 4: Average SGR of Catla, Rohu and Mrigal in selected micro-water sheds.

4. Discussion

Physico-chemical parameters (Table 2 to 5) of selected micro-water sheds were found to be congenial for fish growth except very high pH in water bodies. However, no single satisfactory index can determine the micro-water sheds productivity according to Welch [23]. Reid [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 30.4 ºC to 32.7 ºC in selected micro-water sheds. Similar range of water temperature was observed in water bodies of arid and semi-arid regions of Rajasthan [15, 10]. A good synchronization between temperature and dissolved oxygen was seen. In the present study, average pH ranged between 8.2 and 9.3 in different micro-water sheds. The pH of the 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 [20]. Similarly high pH range was observed in water bodies of Dungarpur district of Rajasthan [12]. The pH range of 7.7 to 8.7 and 7.4 to 9.2 in Lake Pichhola and Fateh sagar respectively noted [16]. According to the study, selected micro-water sheds was characterized by low level of dissolved oxygen with average of 7.055 mg/l in Bhamritandi. The highest oxygen value of 10.10 mg/l was observed in kohala water bodies. The dissolved oxygen (DO) concentrations were always above 5 mg/l, hence based on the study of Banerjea [6] these water bodies are suitable for fish culture. The absence of free CO_2 in different water bodies of Southern Rajasthan has been found [5, 10]. Exceptionally high values of EC designate pollution status of the reservoirs. Author [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 [15, 13] from waters of Southern Rajasthan. In the present study, total alkalinity ranged from 90 to 141mg/l (Table 2). Author [22] has observed total alkalinity of 65 to 199 mg/l in three water bodies of southern Rajasthan. Similar range of total alkalinity observed in southern Rajasthan [12]. In the present study the average values of NO_3-N varied from 0.122 to 0.247mg/l. These values are fairly comparable to those reported by [19] from different lentic waters. In the case of selected micro-watersheds, the orthophosphate concentrations ranged between 0.00 to 0.11mg/l. Authors [11, 12] has recorded similar range of orthophosphate in different water bodies of Southern Rajasthan. Mean value of Gross primary productivity (GPP) in micro-water sheds ranged between 0.252 to 0.361gC/m^3/hr. NPP value of the surface water of Daya reservoir was reported 0.31 gC/m^3/hr [10]. The average RQ competed in the present study (0.044gC/m^3/h^{-1} to 0.248gC/m^3/h^{-1}) is also comparable with that of Daya reservoir Udaipur (0.14gC/m^3/hr) [10]. The average phytoplankton density observed in different micro-water shads range between 145 to 225Nos/l. Average phytoplankton counts reported in Goverdhan Sagar was 36.71 Nos/ml by [7]. The observed scenario of zooplankton at sampling four of all micro-watersheds are ranking in order of Copepoda>Rotifera>Cladocera>nauplii. Author [7] has 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 [18]. The variation in different physico-chemical water quality parameters affects the production of that system.

5. Conclusion

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

6. Acknowledgement

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