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EFFECT OF WATER PROPERTIES AND DOMINANT GENERA OF PHYTO-PLANKTON ON THE ABUNDANCE OF AVAILABLE GENERA OF ZOOPLANKTON

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The combined effect of physico-chemical properties of water of nursery ponds was significant ($P < 0.05$) on the growth of *Volvox* ($R = 0.852$), *Ulothrix* ($R = 0.765$), *Anabaena* ($R = 0.769$) and *Microcystis* ($R = 0.759$) which covered 72.63, 57.15, 59.61 % of the total analyses, respectively. The combined effect of available genera of phytoplankton on the growth of the genera of zooplankton was not significant ($P > 0.05$). The growth of *Catla catla* and *Labeo rohita* juveniles were higher in pond 5 than other ponds. But the growth of *Cirrhina mrigala* fry was relatively higher in pond and than other nursery ponds. The significant ($P < 0.05$) correlation coefficient values of *Volvox, Ulothrix, Anabaena* and *Microcystis* with most of the physico-chemical properties were positive in nature. All the genera of phytoplankton were inversely correlated only with free CO_2. Again, *Filinia* and *Cyclops* had strong ($P < 0.001$) direct and inverse correlations with *Anabaena* ($r = 0.690$) and *Microcystis* ($r = 0.639$), respectively.

Key words: Productivity; Water properties; Combined effect.

INTRODUCTION

The successful fish fry rearing is often partly dependant on the greater abundance of both phytoplankton and zooplankton in nursery ponds, the basic natural food items of fish fry and juveniles [1-2, 15, 17-18].

Within the aquatic ecosystem, the growth and abundance of phytoplankton almost completely depend upon some environmental factors, such as, meteorological factors as well as physico-chemical factors of water [1-3]. Again, the abundance of phytoplankton and zooplankton is interlinked to one another and generally the abundant genera of zooplankton almost depends upon the available genera of phytoplankton [3-5]. Thus, to ensure the nursery ponds productive enough, it is very much essential to know the nature of combined effects of physico-chemical factors of water on the growth of phytoplankton and also the combined effects of phytoplankton on the growth and abundance of zooplankton and linear correlations among them. Again, at the same time, it is essential to record the growth of fish fry. But, as because the statistically satisfied information regarding this fact is very rare, the present work is undertaken aiming to determine the combined effects of some physico-chemical factors of water on the growth of available genera of phytoplankton and also to find out the combined effects of these genera of phytoplankton on the growth of abundant genera of zooplankton and their correlationships, and to study the growth of major carp fry.

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MATERIALS AND METHODS

Six nursery ponds, having an area of 0.10 acre each, of the Freshwater Aquaculture Research Station, Mymensingh, Bangladesh, were selected as six sampling spots of the whole area to conduct the present study during the period of 1st May to 30 September, 1982. All the ponds were dried, cleaned, and treated with lime (100 kg/acre) and cow-dung (3700 kg/acre) at the mid April. The oxygenated underground water was supplied on 1st May and N:P:K fertilizers (2:2:1) were applied in the subsequent days. The major carp fry, such as, *Catla catla* (0.11 g ± 0.04), *Labeo rohita* (0.07 g ± 0.01) and *Cirrhina mrigala* (0.06 g ± 0.01) of length 1.1 cm ± 0.20, 0.90 cm ± 0.13 and 0.8 cm ± 0.12, respectively were released in ponds.

Collection of samples. Sampling of water, plankton and carp juveniles were done once a month on the 12th day between 0900 hrs. to 1200 noon from every pond. Water samples were collected by using Kemmerer type of water sampler and stored in black bottles of 500 ml capacity by adding 2 to 3 drops of toluene and carried to the laboratory for analyses.

Analysis of water samples. A centigrade thermometer was used to determine the water temperature in ponds. Digital pH meter for pH, azide modification of iodometric method for dissolved O_2, titrimetric method for free CO_2, phenol-disulphonic acid method for NO_3-N by colorimeter, ascorbic acid method for PO_4-P by colorimeter and ammonia acetate extract method by Flame Photometer for exchangeable K and Ca were followed. All the analyses were critically done by following the standard methods for the examination of water and wastewater [6].

Fish juveniles. The length (cm) and weight (g) of major carp juveniles such as *Catla catla, Labeo rohita* and *Cirrhina mrigala* were recorded.

Identification and counting of plankton. To make the sample of plankton a good representative, 10 litres of water from different zones of each pond were collected by using water sampler and after filtering through a No. 40 bolting silk plankton net, the plankton was preserved in 10 ml of 4 % formaldehyde solution. The quantitative estimation of phytoplankton and zooplankton was done by haemacytometer counting [7] and by drop method [3]. The estimated number of plankters was expressed as unit/litre. Both the phytoplankton and zooplankton was identified upto the generic level under an illuminating compound microscope in the laboratory [8-15].

Data analyses. The multiple and linear correlation were done through statistical analysis following key given by Gomez and Gomez [16] by IBM pc. computer.

RESULTS AND DISCUSSION

The mean values and standard errors of physico-chemical properties of water (Table 1), available genera of phytoplankton and zooplankton (Table 2) are shown in Figures 1, 2 and 3, respectively. Again, the mean values and standard errors of length and weight of juveniles of three species of major carp are shown in Table 3. It has been recorded that temperature, NO_3-N, PO_4-P and exchangeable Ca of water were higher in pond 1 but lower pH, dissolved O_2, exchangeable K and exchangeable Ca were recorded in pond 4. The similar trend of fluctuations of dissolved O_2 and NO_3-N of water were observed in ponds. Again, pH and exchangeable Ca had similarity in the trend of their fluctuations in ponds. Almost similar trend recorded in the fluctuations of free CO_2 and PO_4-P of water in ponds (Table 1, Fig. 1). In the case of plankton abundance, *Anabaena, Ankistrodesmus, Branchiura* and *Cyclops* in pond 4 whereas, *Aphanocapsa, Diaphanosoma* and *Diaptomus* in pond 1 were dominant. Again, *Volvox, Ulothrix* and *Daphnia* were abundant in pond 3 but *Keratella* and *Filinia* were dominant in pond 5. There were some similarities in the trend of fluctuations of *Anabaena, Microcystis, Ulothrix, Volvox, Aphanocapsa, Ankistrodesmus, Bosmina, Diaphanosoma* and *Daphnia* (Figs. 2, 3). During the study, the growth of major carp juveniles such as, *Catla catla* and *Labeo rohita* were higher in pond 5 where *Aphanocapsa, Volvox, Ulothrix, Ankistrodesmus, Microcystis, Diaphanosoma, Brachionus* and *Bosmina* were almost less abundant (Fig. 2 and 3). It indicates that *Catla catla* feeds on phytoplankton which ultimately decreased the phytoplankton population. The abundance of various genera of zooplankton was comparatively lower in ponds where the growth of *Labeo rohita* and *Cirrhina mrigala* juveniles were

Table 1. Mean values and standard errors of physico-chemical properties of water of six nursery ponds.

Water properties	Pond No. 1	2	3	4	5	6
Water temp. (°C)	28.55 ± 0.49	28.20 ± 0.40	28.30 ± 0.60	28.17 ± 0.74	28.20 ± 0.56	28.17 ± 0.35
pH	7.13 ± 0.11	7.20 ± 0.14	7.00 ± 0.07	7.08 ± 0.15	7.12 ± 0.13	7.23 ± 0.20
Dissolved O_2 (ppm)	4.55 ± 0.31	4.68 ± 0.46	4.46 ± 0.28	4.41 ± 0.30	4.60 ± 0.45	4.45 ± 0.33
Free CO_2 (ppm)	1.20 ± 0.85	1.55 ± 0.75	1.95 ± 0.65	2.10 ± 0.32	2.50 ± 0.49	2.25 ± 0.29
Available N (ppm)	0.92 ± 0.16	0.83 ± 0.21	0.75 ± 0.12	0.93 ± 0.22	0.91 ± 0.13	0.82 ± 0.08
Available P (ppm)	0.22 ± 0.04	0.91 ± 0.03	0.20 ± 0.02	0.22 ± 0.02	0.20 ± 0.04	0.18 ± 0.02
Exchangeable K (ppm)	8.90 ± 0.89	8.30 ± 0.90	9.15 ± 0.51	8.21 ± 0.89	8.82 ± 0.82	8.20 ± 0.81
Exchangeable Ca (ppm)	12.21 ± 0.75	12.02 ± 0.80	11.45 ± 0.35	11.30 ± 0.55	11.72 ± 0.95	12.25 ± 0.74

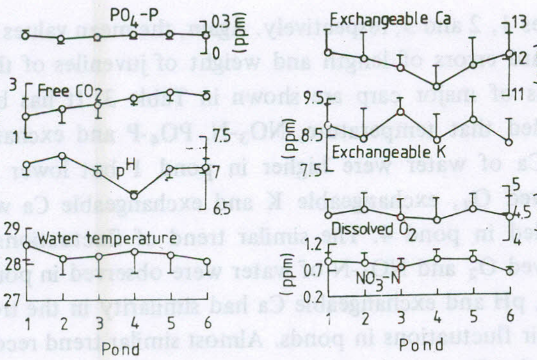

Fig. 1. The fluctuations of physico-chemical properties (mean values) of water in six ponds (vertical bar represents standard error).

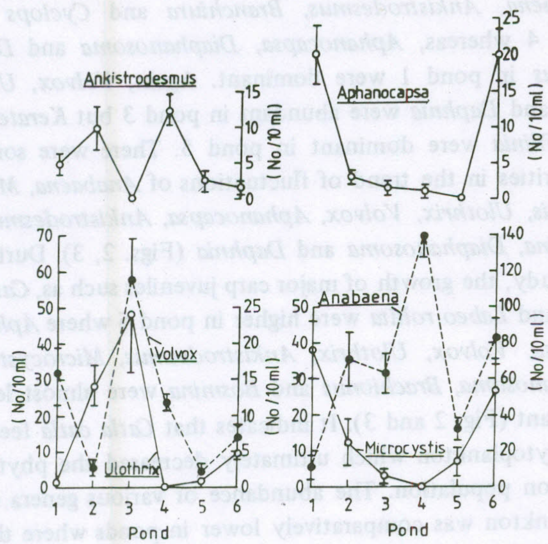

Fig. 2. The fluctuations of available genera of phytoplankton (mean values) in six ponds (vertical bar represents standard error).

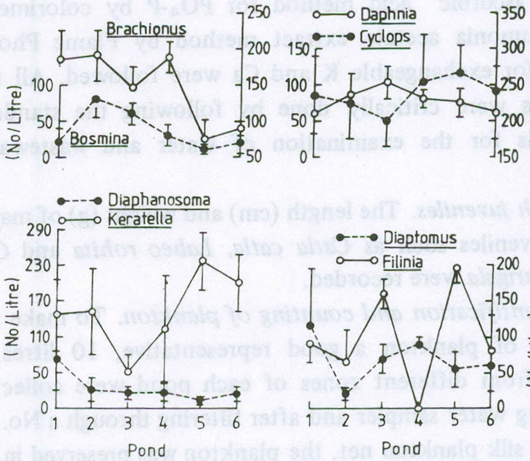

Fig. 3. The fluctuations of available genera of zooplankton (mean values) in six ponds (vertical bar represents standard error).

higher. Lower zooplankton populations prove that both *L.rohita* and *C.mrigala* depend on them for food. Again, *C.mrigala* is known as bottom feeder but it fees on both the zooplankton and benthic fauna. Dewan *et al.* [18] and Banu *et al.* [19] reported that the juveniles of *Labeo rohita* mostly depend on zooplankton but they feed a little amount of phytoplankton which almost agrees with the present findings. Phytoplankton is more suitable food for surface feeder like *Catla catla* and zooplankton is more appreciated feed for column feeder, *Labeo rohita* and bottom feeder, *Cirrhina mrigala* [1-3, 15].

From the Table 1, it is observed that the range of temperature, dissolved O_2, free CO_2 and other nutrients were

Table 2. Mean values and standard errors of available genera of plankton of six nursery ponds.

Plankton	Pond No. 1	2	3	4	5	6
Anabaena	1200 ± 550	7400 ± 1700	6400 ± 1100	14000 ± 1500	3200 ± 450	8150 ± 1100
Microcystis	3800 ± 800	1250 ± 600	450 ± 200	10 ± 3	800 ± 450	2600 ± 600
Volvox	3200 ± 700	550 ± 200	5800 ± 1000	2400 ± 250	500 ± 250	1300 ± 300
Ulothrix	150 ± 30	1350 ± 390	2350 ± 800	50 ± 10	180 b 40	480 ± 120
Aphanocapsa	2050 ± 420	240 ± 70	150 ± 65	100 ± 60	25 ± 6	2000 ± 380
Ankistrodesmus	500 ± 150	1070 ± 350	40 ± 12	1200 ± 260	350 ± 120	270 ± 100
Keratella	150 ± 40	160 ± 75	55 ± 35	130 ± 85	255 ± 50	225 ± 56
Brachionus	180 ± 40	190 ± 30	145 ± 28	185 ± 18	78 ± 15	83 ± 13
Filinia	62 ± 30	63 ± 42	160 ± 28	6 ± 2	195 ± 30	82 ± 38
Daphnia	60 ± 25	86 ± 35	103 ± 21	76 ± 12	72 ± 25	62 ± 32
Bosmina	22 ± 16	80 ± 25	65 ± 19	35 ± 13	12 ± 8	24 ± 15
Diaphanosoma	75 ± 15	30 ± 20	25 ± 10	25 ± 15	18 ± 6	25 ± 12
Cyclops	235 ± 52	226 ± 51	200 ± 35	256 ± 67	265 ± 42	242 ± 35
Diaptomus	107 ± 80	20 ± 7	72 ± 25	86 ± 12	53 ± 25	62 ± 37

Table 3. Length (cm) and weight (g) of cultured species of fishes in six nursery ponds.

Fish species		Pond No. 1	2	3	4	5	6
Catla catla	L	15.5 ± 8.3	12.5 ± 7.4	13.5 ± 6.3	11.5 ± 5.3	16.5 ± 7.3	12.6 ± 5.4
	W	55.7 ± 6.5	39.5 ± 18.6	40.5 ± 17.5	35.6 ± 15.8	59.8 ± 17.5	33.6 ± 14.8
Labeo rohita	L	13.6 ± 6.6	12.6 ± 5.7	12.2 ± 5.3	12.9 ± 6.3	14.2 ± 5.8	13.0 ± 6.2
	W	49.6 ± 18.7	46.8 ± 16.9	44.5 ± 15.8	46.5 ± 18.5	52.8 ± 17.3	47.5 ± 17.8
Cirrhina mrigala	L	16.5 ± 8.6	14.8 ± 7.9	15.2 ± 8.2	15.9 ± 7.0	14.4 ± 6.2	15.8 ± 7.3
	W	56.4 ± 16.6	49.7 ± 17.6	52.3 ± 17.4	53.3 ± 19.2	46.8 ± 17.3	52.9 ± 18.3

L = Length, W = Weight.

Table 4. Multiple correlation coefficient (R), F-values, MR^2 and estimated y-values ($\hat{y}$) of dominant genera of phytoplankton with the growth influencing physico-chemical factors of water in nursery ponds.

Genera of Phytoplankton	F	R	MR^2	Estimated values of y ($\hat{y}$)
Volvox	5.30	0.852^{**}	72.63	$2117.764 + 1580.495^{****}x_1 - 15748.057^{****}x_2 - 2016.152^{****}x_3 - 1092.421^{****}x_4 + 14671.644^{****}x_5 + 2314.565^{****}x_6 + 2885.004^{****}x_7 + 880.710^{****}x_8$
Ulothrix	3.07	0.756^{*}	57.15	$1403.777 - 3812.589^{****}x_1 - 5149.294^{****}x_2 + 1918.507^{****}x_3 - 491.456^{****}x_4 - 3835.986^{****}x_5 + 6981.759^{****}x_6 - 603.560^{****}x_7 - 359.342^{****}x_8$
Ankistrodesmus	2.51	0.651	42.38	$-511.329 + 1295.453^{****}x_1 + 2545.658^{****}x_2 - 831.172^{****}x_3 + 157.173^{****}x_4 + 2586.981^{****}x_5 - 22125.235^{****}x_6 + 44.648^{****}x_7 + 102.273^{****}x_8$
Anabaena	3.98	0.769^{*}	59.14	$-580.364 + 188.391^{****}x_1 + 188.863^{****}x_2 + 157.351.351^{****}x_3 + 13.61^{****}x_4 + 161.998^{****}x_5 - 152.384^{****}x_6 - 122.772^{****}x_7 + 148.483^{****}x_8$
Microcystis	3.54	0.759^{*}	57.61	$594.033 - 84.327^{****}x_1 + 128.913^{****}x_2 + 72.561^{****}x_3 - 7.378^{****}x_4 - 5.330^{****}x_5 + 101.651^{****}x_6 + 70.115^{****}x_7 - 34.728^{****}x_8$
Aphanocapsa	0.91	0.293	08.58	$22.263 - 96.875^{****}x_1 + 11.679^{****}x_2 + 3.827x_3 + 1.924^{****}x_4 + 1.087x_5 + 15.382^{****}x_6 + 1.729x_7 - 15.123^{****}x_8$

$^{*}P_{0.05\,(15,\,8)} = 2.64$, $^{**}P_{0.01\,(15,\,8)} = 4.00$, df. = 22, **** $P \leqslant 0.001$, MR^2 = % contribution of independent factors upon the growth of dependent factors.

suitable for the growth of phytoplankton and zooplankton during the study [1,4]. The physico-chemical properties of water had combined effect on the growth of phytoplankton (Table 4) and also it had been observed that the available genera of phytoplankton had combined effect as feed on the dominant genera of zooplankton (Table 5). During the study, the combined effect of physico-chemical properties of water was highly ($P < 0.01$) significant in case of *Volvox* ($R = 0.852$) and simply ($P < 0.05$) significant in case of *Ulothrix* ($R = 0.756$), *Anabaena* ($R = 0.769$) and *Microcystis* ($R = 0.759$) which covered 72.63 %, 57.15 %, 59.14 % and 57.61 % of total analyses, respectively (Table 4). Habib *et al.* [3] stated that the combined effect of physico-chemical properties of water was highly

Table 5. Multiple correlation coefficient (R). F-values, MR^2 and estimated y-values ($\hat{y}$) of available genera of zooplankton with their growth influencing dominant genera of phytoplankton in nursery ponds.

Genus of Zooplankton	F	R	MR^2	Estimated values of y ($\hat{y}$)
Keratella	0.937	0.488	23.79	$203.428 - 0.004x_1 - 0.0.18x_2 - 0.015x_3 - 0.002x_4 - 0.230x_6$
Brachionus	0.778	0.454	20.59	$140.050 + 0.0002x_1 - 0.004x_2 + 0.035x_3 + 0.001x_4 + 0.005x_5 - 0.002x_6$
Filinia	1.846	0.617	38.10	$99.952 + 0.002x_1 + 0.003x_2 + 0.022x_3 + 0.003x_4 + 0.018x_5 - 0.029x_6$
Daphnia	1.960	0.629	39.54	$90.723 + 0.001x_1 + 0.001x_2 + 0.01x_3 + 0.002x_4 + 0.003x_5 - 0.010x_6$
Bosmina	0.643	0.420	17.65	$47.028 - 0.0003x_1 + 0.004x_2 + 0.015x_3 - 0.001x_4 - 0.007x_5 - 0.003x_6$
Diaphanosoma	1.245	0.545	29.65	$29.406 + 0.001x_1 - 0.006x_2 + 0.005x_3 - 0.001x_4 - 0.001x_5 + + 0.010x_6$
Cyclops	1.937	0.626	39.24	$298.350 - 0.006x_1 - 0.020x_2 - 0.015x_3 - 0.003x_4 + 0.007x_5 - 0.037x_6$
Diaptomus	0.203	0.252	6.33	$85.589 - 0.001x_1 - 0.003x_2 - 0.013x_3 - 0.001x_4 + 0.003x_5 - 0.015x_6$

$P_{0.05\ (17,\ 6)} = 2.10$, MR^2 = Contribution of independent factors upon the growth of dependent factors.

Table 6. Linear correlation coefficient (r) of dominant genera of phytonlankton with some physicochemical properties of water.

Genus of Phytoplankton	Water properties: Water Temp.(°C)	pH	Dissolved O_2	Free CO_2	NO_3-N	PO_4-P	Exchangeable K	Exchangeable Ca
Volvox	0.413*	– 0.113	0.452*	– 0.199	0.649****	0.406*	0.622***	0.511***
Ulothrix	0.488**	0.654****	0.312	– 0.155	0.174	0.346	– 0.146	– 0.166
Ankistrodesmus	0.014	0.521**	0.102	– 0.425*	0.421*	0.012	– 0.070	– 0.358
Anabaena	– 0.248	0.630****	0.563***	– 0.222	0.635****	0.621***	0.470**	– 0.334
Microcystis	0.483**	0.42*	0.533***	– 0.213	0.564***	0.639****	– 0.119	0.273
Aphanocapsa	0.480**	– 0.486*	– 0.060	– 0.262	0.609***	0.438*	– 0.153	0.162

df. 22, *$P \leqslant 0.05$, **$P \leqslant 0.02$, *** $P \leqslant 0.01$ and **** $P \leqslant 0.001$.

($P < 0.01$) significant in case of *Microcystis, Anabaena* and *Volvox*. Ali *et al.* [2] stated that the combined effects of meteorological factors as well as some physico-chemical factors of water influence the growth and abundance of all the species of phytoplankton but the effect was significant in case of *Microcystis* spp., *Anabaena* spp. and *Melosira granulata* which agree partially with the present findings. Mollah and Haque [4] and Parameswaran *et al.* [15] reported that the climatic factors and physico-chemical properties of water have some effects on the growth of phytoplankton periodicity but was not statistically supported.

Most of the available genera of phytoplankton had significant correlation with pH and available N (NO_3-N) of water during the study (Table 6) where *Ulothrix* and *Anabaena* were strongly ($P < 0.001$) and directly correlated with pH which partially agrees with the findings of Ali *et al.* [2]. Again, *Volvox* and *Anabaena* had strongly ($P < 0.001$) direct, and *Microcystis* and *Aphanocapsa* had highly ($P < 0.01$) direct correlations with the available N (NO_3-N). It has been observed that all the genera of phytoplankton were inversely correlated with free CO_2 of water which indicates that they absorb free CO_2 during photosynthesis and grow. Again, exchangeable Ca and

Table 7. Linear correlation coefficients (r) of dominant genera of phytoplankton with dominant genera of zooplankton.

Genus of Phytoplankton	Genus of Zooplankton							
	Keratella	*Brachionus*	*Filinia*	*Daphnia*	*Bosmina*	*Diaphanosoma*	*Cyclops*	*Diaptomus*
Volvox	– 0.042	– 0.092	0.150	– 0.008	– 0.164	– 0.064	– 0.347	– 0.091
Ulothrix	– 0.137	– 0.127	0.208	– 0.013	0.146	– 0.227	– 0.167	– 0.173
Ankistrodesmus	– 0.037	0.385	– 0.202	0.157	– 0.183	0.127	0.509***	0.158
Anabaena	0.278	0.158	0.690****	– 0.271	0.048	– 0.083	– 0.237	– 0.129
Microcystis	0.031	0.204	0.049	0.371	0.269	– 0.012	– 0.639****	– 0.204
Aphanocapsa	– 0.050	0.075	– 0.178	– 0.522***	– 0.325	– 0.065	– 0.153	– 0.171

df. - 22, *P ⩽0.05, **P ⩽0.02, ***P ⩽0.01 and ****P ⩽0.001.

exchangeable K had inverse (negative) correlations with some genera of phytoplankton which indicates that they absorb these nutrients during photosynthesis. But most of the genera of phytoplankton had direct (positive) correlations with water temperature, dissolved O_2, pH and available P (PO_4-P) indicate that the quantitative values of both the factors increase which has the partial similarity with the findings of Habib *et al.* [3]. During the study, *Volvox, Ulothrix* and *Ankistrodesmus* were positively correlated with water temperature. Venkateswarlu [17] recorded the similar results. Ali *et al.* [2] stated the partially similar results with the present findings.

The combined effect of available genera of phytoplankton on the growth of dominant genera of zooplankton were recorded but the effect was not significant ($P < 0.05$) during the study (Table 5). Habib and Mohsinuzzaman [5] recorded the significant ($P < 0.05$) combined effect of six available genera of phytoplankton on the gorwth of *Brachionus, Keratella, Notholca, Polyarthra Bosmina* and *Diaptomus*.

Intergeneric correlations of phytoplankton and zooplankton were either direct or inverse in nature where *Diaphanosoma, Cyclops* and *Diaptomus* had inverse correlations with most of the genera of phytoplankton (Table 7). *Cyclops* had strongly ($P < 0.001$) inverse and highly ($P < 0.01$) direct correlations with *Microcystis* ((r = -0.639) and *Ankistrodesmus* (r = 0.509), respectively. *Filinia* and *Daphnia* were strongly ($P < 0.001$) and highly ($P \leq 0.01$) correlated with *Anabaena* (r = 0.690) and *Aphanocapsa* (r = -0.522), respectively. But Habib and Mohsinuzzaman [5] reported that most of the genera of zooplankton were significantly ($P < 0.05$) correlated with *Microcystis* and *Anabaena*.

From the present experiment, it is established that major carp juveniles depend on phytoplankton and zooplankton for their growth in nursery pond. Again, the physicochemical factors of water has combined effects on the growth of phytoplankton and their linear correlation value informed about the nature of direct or inverse relationships among them. The combined effect of some available genera of phytoplankton influence the growth of various genera of zooplankton, and competitions and mutual actions (positive relation) among them has been observed through the negative and positive values of linear correlations, respectively. These findings ultimately help the Fisheries Scientists to culture major carp fry in nursery pond properly.

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