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Impact of Phytoplankton on the Growth of Common Carp *Cyprinus carpio* L. Larvae

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ABSTRACT

The current study was conducted at the Agricultural Research Station-Al-Hartha (Agriculture College, Basrah University) in Al-Hartha District, approximatley 16km to the northeast of Basrah Governorate. The experiment was conducted in four earthen ponds (2500m^2). These ponds were drained for one month; one ton of organic fertilizers (Buffalo dung) was applied in each pond before refilling with water. After one week from refilling, 10000 common carp larvae with an average weight of 0.104± 0.002g were stocked in each pond. No artificial food was supplied to the fish during the experiment. Fish growth recorded a high rate at the beginning of experiment, then decreased or ceased at the end. The total number of phytoplankton was low at the beginning of the experiment, while a gradual increase was detected during the study. A negative correlation was found between the total number of phytoplankton and fish growth in all ponds. In addition, a significant positive correlation was recorded between salinity and fish growth. The investigation of phytoplankton taxa in the four ponds revealed that the first important family was Bacillariophyceae followed by Chlorophyceae.

INTRODUCTION

Common carp, *Cyprinus carpio*, is a very important cultivated species in several Asian countries and also in some European countries **(Rahman, 2015)**. This is the most common cyprinid species that constitutes a significant part of inland freshwater fish production **(Vilizzi *et al*., 2015)**. The highest production of four cultivated fish around the world in 2020 were 5791.5, 4896.6, 4407.2 and 4236.3 thousand tons for grass carp, *Ctenopharyngodon idella*, silver carp, *Hypophthalmichthys molitrix*, the Nile tilapia, *Oreochromis niloticus*, and common carp, respectively **(FAO, 2022)**.

The presence of carp has led to the shift in ecosystems characterized by phytoplankton-dominated turbid waters, few macrophytes, and subsequent decreases in biodiversity **(Zambrano & Hinojosa, 1999; Khan *et al*., 2003; Miller & Crowl, 2006)**. **Hnatiuk (2006)** found that ponds cultivated with carp species tended to be turbid and phytoplankton-dominated, while ponds without theses fish were clear and macrophyte-dominated. The density of common carp cultivated in ponds of some western countries is a critical factor affecting the aquatic ecosystem. An increase in nutrient availability may enhance photosynthesis and plankton production if common carp is not excessive. However, if it is excessive, it can cause dramatic ecological disruption for the community and ecosystem **(Rahman, 2015)**. The sediment can store nutrients up to 100 times more than the water column **(Rahman & Verdegem, 2007)**. **Rahman (2015)** stated that common carp increased the production of phytoplankton by releasing nutrients from the sediment due to its benthivoros habitat. **Rahman *et al.* (2006)** elucidated that rohu, *Labeo rohita* grows better in ponds with common carp than in a monoculture since it is a planktivorous.

Pond fertilization has become a management protocol in most aquaculture activities **(Bhakta *et al*., 2006)**. **Jha *et al*. (2004)** noticed that achieving high fish production relies on the higher abundance of different plankton in the culture system, therefore the purpose of the addition of fertilizers to ponds is to increase fish production through autotrophic and heterotrophic pathways **(Jha *et al.*, 2008)**. **Sevilleja *et al*. (2001)** pointed that stimulation of phytoplankton growth can be applied by supplying soluble organic matter to the ponds. The use of organic and inorganic fertilizers in polyculture ponds provides basic nutrients and elements needed for growth of phytoplankton and zooplankton that serve as a major source of natural fish food **(Javed *et al*., 1990)**. Fish growth is strongly correlated with the increase in phytoplankton and zooplankton production resulting from fertilization **(Abbas & Rehman, 2005)**.

In Iraq, no study has addressed the natural food in earthen ponds, except for the study of **Al-Agidi (2008)**, who investigated the zooplankton population in earthen ponds in Mahaweal District, Babylon Government.

The aim of current experiment was to investigate the role of phytoplankton as natural food for larvae and juvenile common carp cultivated in earthen ponds.

MATERIALS AND METHODS

The current experiment was conducted in Al-Hartha District, approximately 16km northeastern of Basrah Governorate (30°65′64.6″N, 47° 74′79.5″E), using ponds of the Agricultural Research Station belonging to the Aquaculture Unit, College of Agriculture, University of Basrah. The fish farm consisted of four large ponds (2500m^2) and 14 small ponds (600m^2). The water source from Shatt al-Arab River and inlet water was supplied from one branch with an electrical pump, while the outlet was made by gravity. The four large ponds were used for the current experiment and drained for a month, and one ton of organic fertilizers (Buffalo dung) was applied in each pond before refilling with water. After one week from refilling, 10000 common carp larvae of 0.104± 0.002g weight were stocked in each pond.

The larvae of common carp were obtained from the Marine Science Center Fish Hatchery on the 2nd of April 2019 and transported to the station via a small truck. No artificial food was supplied to the fish, and natural food was the only food source. For each pond, temperature, pH and salinity of the water were measured at each sampling period. During the experimental research, the weight of representative fish samples from each pond was measured with a sensitive electronic top loading scale. Throughout this period, five sampling data were collected to calculate the following equations, as outlined by **APHA (2005)**:

Weight increments (WI, g) = FW – IW

Daily growth rate (DGR, g/day) = FW – IW / days

Specific growth rate (SGR, %/day) = 100 * [(ln FW) - (ln IW)] / days

Relative growth rate (RGR, %) = {(FW-IW)/WI} * 100

Where: FW = Final fish weight (g); IW = Initial fish weight (g).

Samples for phytoplankton were collected by filtering water through a 20µ mesh plankton net and immediately preserved in Lugol solution **(APHA, 2005)**. Preserved samples were diagnozed by an Olympus microscope with a magnification of 40x based on the guidelines of **Hadi *et al*. (1984)** and **Al-Handhal *et al*. (1989)**. The phytoplankton quantities were calculated based on the outlines of **Maulood and Boney (1980)**.

RESULTS

Table (1) presents the measurements of average fish weight for different samplings during the experiment in the four ponds in addition to water temperatures, pH, and salinities. The initial weight for the four ponds was 0.104g, while the final weights reached by the fish were 8.35, 6.20, 6.55 and 9.01g for pond 1, 2, 3, and 4, respectively. The range of water temperature was 21- 26^{0}C; range of pH was 6.1- 7.5, while the range of salinity was 3.3-7.3ppt in different ponds during the whole experimental period.

The results of the current experiment revealed higher weight increments achieved by fish in the four ponds during the second period, then decreased or showed negative values throughout the third and fourth period (Table 2). The total weight increments at all experimental periods were 8.25, 6.10, 6.45 and 8.91g for the four ponds, respectively (Fig. 1).

The daily growth rate showed nearly the same pattern of weight increments in different ponds, where a negative growth was recorded in ponds 2 and 3, while the growth rate stopped in pond 4. The average daily growth rates achieved by fish were 0.16, 0.12, 0.12 and 0.17g/ day for the four ponds, respectively (Fig. 2). The specific growth rates were high at the beginning of the experiment and decreased gradually later with a negative growth in ponds 2 & 3. The averages of specific growth rates achieved by fish were 9.30, 8.67, 8.87 and 9.36%/ day for the four ponds, respectively (Fig. 3). The relative growth rates recorded the same pattern of specific growth rate, where averages specific growth rates were 4.93, 4.47, 4.33 and 4.58% for the four ponds, respectively (Fig. 4).

Table (3) shows different species of phytoplankton with their numbers (cell*10^6/ L) in pond 1 during the experiment.

The total phytoplankton density increased from 49.78 cell*10^6/ L in the first sample to 798.24 cell*10^6/ L in the final sample. The first phytoplankton class, Bacillariophyceae, constituted 56.9, 61.2, 39.3, 39.9 and 40.6% of the total five phytoplankton sampled, respectively, during some periods. The second class was Chlorophyceae, with a mean of 25.1%.

The total wide variety of phytoplankton was shown in the second pond. The first pattern elevated from 50.38 to 837.50 cell*10^6 /L in the last sample (Table 4). The first huge phytoplankton class was Bacillariophyceae, with a mean of 42.6% from the whole phytoplankton for five samples, followed by Chlorophyceae class with 27.6% and Cyanophyceae with 25.5%.

Table (5) displays different species of phytoplankton with their density (cell*10^6/L) in pond 3 during the experiment. The total number of phytoplankton was increased from 34.58 cell*10^6/ l in first sample to 785 cell*10^6/ l in the final sample. The first important family of phytoplankton was Bacillariophyceae that consisted 49.8% as an average of total phytoplankton ranging from 72.9% in the first sample to 34.1% in the third sample. Chlorophyceae accounted for an average of 22.6% of the total phytoplankton, while Cyanophyceae comprised 22.1%.

Table (6) refers to different species of phytoplankton with their density (cell*10^6/L) in pond 4 during the experiment.

The total number of phytoplankton was increased from 27.42 cell*10^6/ L in the first sample to 827.23 cell*10^6/ L in the final sample. The first important family of phytoplankton was Bacillariophyceae that comprised 37.2- 52.9% of total phytoplankton, followed by Chlorophyceae that accounted for an average of 33.1% of the total phytoplankton, ranging from 24.4- 49.1%. Cyanophyceae consisted of 18.6% of the total phytoplankton, showing a significant increase from 2.6% in the first sample to 29.6% in the third sample.

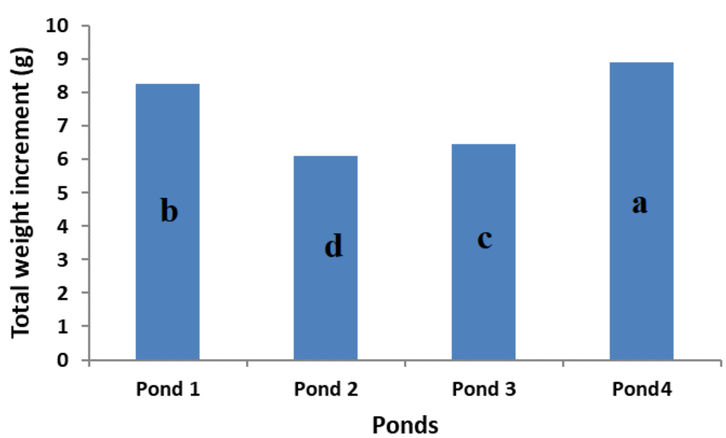

Fig. 1. Total weight increment for fishes in different ponds during experiment, analyzed to determine significant or non-significant differences using statistical letters

Table 1. Measurements of average fish weight during the experiment with water temperatures, pH, and salinities. Values were analyzed to determine significant or non-significant differences using statistical letters

Parameter	Pond	Date				
		2/4/2019	13/4/2019	27/4/2019	9/5/2019	18/5/2019
Average fish weight (g)	Pond1	0.104a	1.82a	7.43a	7.85b	8.35b
	Pond2	0.104a	1.67b	6.40b	5.90d	6.20c
	Pond3	0.104a	1.65b	5.24c	6.78c	6.55c
	Pond4	0.104a	1.61c	7.43a	9.01a	9.01a
Water temperature (ºC)	Pond1	22b	24a	21b	26a	26a
	Pond2	22b	24a	22a	26a	25b
	Pond3	23a	23b	22a	26a	25b
	Pond4	22b	23b	22a	26a	25b
pH	Pond1	6.7b	7.3a	7b	6.4b	7.2b
	Pond2	6.8a	6.5c	7.1a	6.8a	7.5a
	Pond3	6.8a	6.7b	7.1a	6.1c	7.4a
	Pond4	6.5c	6.8b	7.2a	6.7a	7.3b
Salinity (ppt)	Pond1	4.1a	4.5a	5.4a	6.7a	7.3a
	Pond2	3.9a	4.2b	5.2b	6.8a	7.1b
	Pond3	3.3c	3.7c	5.4a	6.8a	7.4a
	Pond4	3.6b	4.4a	5.2b	6.5b	7.3a

Table 2. Growth criteria of common carp in different ponds during experiment analyzed to determine significant or non-significant differences using statistical letters

Period	Pond 1	Pond 2	Pond 3	Pond 4
	Weight increment (g)			
2/4 – 13/4	1.72b	1.57b	1.55b	1.51b
13/4 – 27/4	5.61a	4.73a	3.59a	5.82a
27/4 – 9/5	0.42c	-0.50d	1.54b	1.58b
9/5 – 18/5	0.06d	0.30c	-0.23c	0
Period	Daily growth rate (g/day)			
2/4 – 13/4	0.16b	0.14b	0.14b	0.14b
13/4 – 27/4	0.40a	0.33a	0.26a	0.42a
27/4 – 9/5	0.04c	-0.04d	0.13b	0.13b
9/5 – 18/5	0.06c	0.03c	-0.03c	0
Period	Specific growth rate (%/day)			
2/4 – 13/4	26.02a	25.24a	25.13a	24.91a
13/4 – 27/4	10.05b	9.6b	8.25b	10.92b
27/4 – 9/5	0.46c	-0.70d	2.15c	1.61c
9/5 – 18/5	0.69c	0.55c	-0.04d	0
Period	Relative growth rate (%)			
2/4 – 13/4	16.54a	15.1a	14.9a	14.52a
13/4 – 27/4	3.80b	2.83b	2.18b	3.61b
27/4 – 9/5	0.06c	-0.80d	0.29c	0.21c
9/5 – 18/5	0.06c	0.05c	-0.03d	0

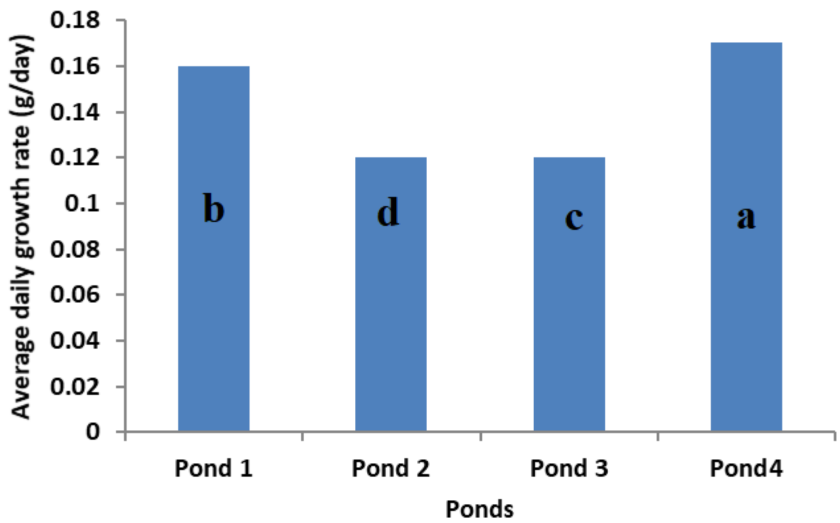

Fig. 2. Average daily growth rate for fishes in different ponds during experiment, were analyzed to determine significant or non-significant differences using statistical letters

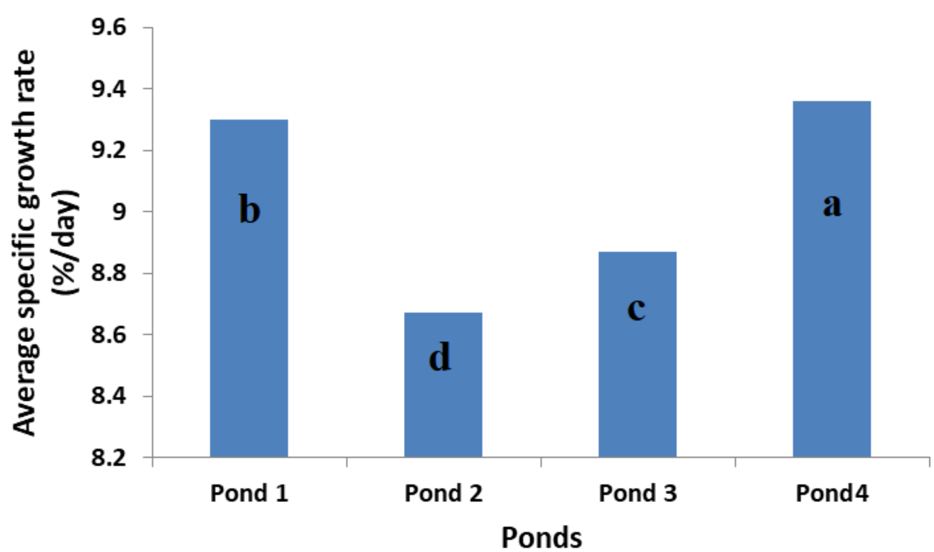

Fig. 3. Average specific growth rate for fishes in different ponds during experiment, analyzed to determine significant or non-significant differences using statistical letters

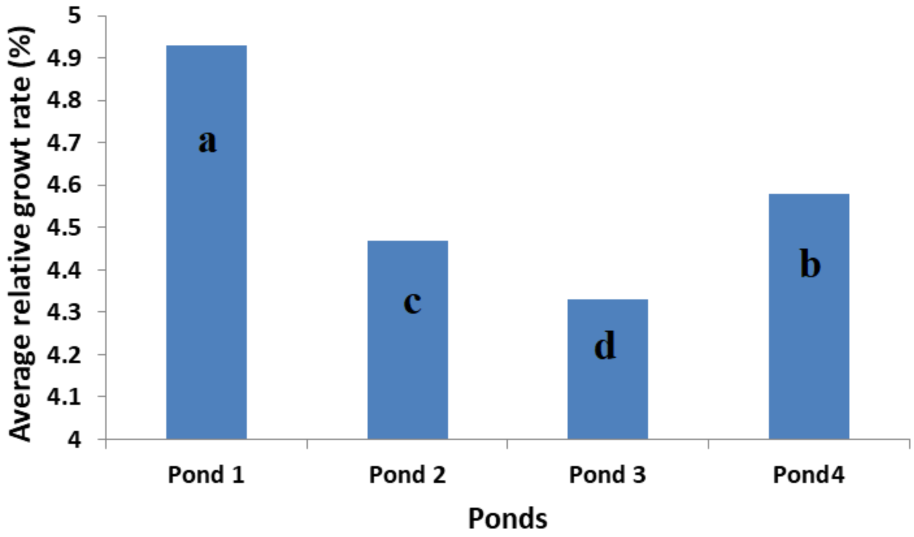

Fig. 4. Average relative growth rate for fishes in different ponds during experiment, analyzed to determine significant or non-significant differences using statistical letters

Table 3. Quality and quantity of phytoplankton in pond 1 during the experiment

Phytoplankton taxa	Phytoplankton density (cell * 10^6/l)				
	2/4/2019	13/4	27/4	9/5	18/5
CYANOPHYCEAE					
Chroococcus turgidus (Kützing) Nägeli	2.6	3.9	13.1	12.3	22.1
Gomphosphaeria lacustris Chodat	0	2	0	0	0
G. aponina Kützing 1836	0	0	13.6	22.1	0
Lyngbya sordida Gomont	0	0	0	22.6	55.9
Merismopedia convolute (Brébisson & Kützing)	3	2	0	0	0
M. punctata Meyen	0	0	0	33	0
Microcystis aeruginosa (Kützning) Kützing 1846	0	0	28.5	0	51.9
Oscillatoria limosa C. Agardh & Gomont	1.9	0	0	0	44.9
Spirulina princeps West & G. S. West	0	0	0	35.6	0
S. major (Kützing & Gomont)	0	3	19.8	0	0
Synechococcus aeruginosus Nägeli	0	0	14.1	43.5	75.9
Total of CYANOPHYCEAE	7.50	10.90	89.12	169.20	250.70
EUGLENOPHYCEAE					
Euglena acus (O.F. Müller) Ehrenberg	1.0	0	5.7	0	23.0
E. convoluta Korshikov	0	3.0	0	32.0	0
Phacus longicauda (Ehrenberg) Dujardin 1841	0	0	0	0	22.0

Phacus sp.	2.0	0	2.5	12.7	0
Total of EUGLENOPHYCEAE	3.00	3.00	8.20	44.7	45.00
CHLOROPHYCEAE					
Chlorella sp.	3.5	13.0	13.9	18.8	15.6
Cosmarium moniliforme Ralfs	0	0	9.4	0	12.6
C. hammeri Reinsch	0	11.8	16.9	0	0
Cosmarium sp.	0	0	0	13.8	27.9
Mougeotia sp.	0	0	0	17.45	0
Oedogonium sp.	0	0	0	0	15.5
Oocystis borgei J.W.Snow	0	0	0	21.9	0
Ophiocytium bicuspidatum (Borge) Lemmermann	0	0	0	0	30
Pandorina morum (O.F.Müller) Bory	0	0	17.0	0	0
Pediastrum duplex Meyen	0	0	0	0	14.0
Scenedesmus armatus (Chodat) Chodat	0	10.8	14.3	0	0
S. arcuatus var. platydiscus G.M. Smith	0	0	0	16.5	23.4
Scenedesmus sp.	7.44	14.6	0	0	13.9
Uronema elongatum Hodgetts	0	0	0	21.7	0
Total of CHLOROPHYCEAE	10.94	0	13.34	18.99	25.8
BACILLARIOPHYCEAE		50.2	84.81	129.18	178.65
Amphora ovalis (Kützing) Kützing 1844	3.8	19.2	10.5	12.2	32.2
Bacillaria paxillifer (O. F. Müller) T. Marsson	0	0	0	0	24.5
Caloneis sp.	4	15.5	0	15.3	0
Chaetoceros sp.	0	0	0	0	23.6
Cocconeis pediculus Ehrenberg	0	10.6	0	15.9	0
Cyclotella meneghiniana Kützing 1844	2.5	0	0	0	0
C. striata (Kützing) Grunow	0	0	0	22.5	25.45
Cymatopleura elliptica F. Meister	0	0	0	0	0
Cymbella aspera (Ehrenberg) Cleve	3.3	0	0	0	22.8
Cymbella cistula (Ehrenberg) Kirchner	0	14.9	0	15.5	0
C. tumida (Brébisson) Van Heurck	1	0	11.5	0	21.5
C. turgida W. Gregory	3.8	0	0	0	0
Diatoma elongata (Lyngbye) C. Agardh	0	11.5	0	9.5	12.9
Epithemia zebra (Ehrenberg) Kützing	0	0	0	0	24
Fragilaria sp.	0	0	8.6	24.5	29.7
Gomphonema montanum (Schumann) Grunow	0	0	12.5	22.5	0
G. olivaceum (Hornemann) Ehrenberg	7.4	14.7	0	12.1	22.6
Gyrosigma attenuatum(Kützing) Rabenhorst	0	2.5	0	0	24.5
G. tenuirostrum (Grunow) A. Cleve	0	0	19.5	15.4	0
Mastogloia elliptica (C. Agardh) Cleve	0	9	11.5	12.5	35.5

M. smithii Thwaites & W. Smith 1856	2.5	0	0	15.8	0
Melosira varians (C. Agardh)	0	0	9.8	18.5	12.5
Navicula cryptocephala (Kützing)	0	3.2	15.4	15.8	0
N. cuspidata (Kützing) Kützing, 1844	0	0	18.5	0	12.1
Total of BACILLARIOPHYCEAE	28.34	101.28	117.96	227.98	323.89
Total of all phytoplankton	49.78	165.38	300.09	571.06	798.24

Table 4. Quality and quantity of phytoplankton in pond 2 during experiment

Phytoplankton taxa	Phytoplankton density (cell*10^6/l)				
	2/4/2019	13/4	27/4	9/5	18/5
CYANOPHYCEAE					
Chroococcus turgidus (Kützing) Nägeli	0	0	0	0	32.0
Gomphosphaeria lacustris (Chodat)	3.3	0	10.0	23.1	0
G. aponina Kützing 1836	0	4	0	23.4	0
Lyngbya sordida Gomont	3.0	4.6	0	0	0
Merismopedia convoluta Brébisson & Kützing	0	0	22.3	0	60.8
M. punctata Meyen	0	0	0	0	60.9
Microcystis aeruginosa (Kützning) Kützing 1846	2.2	5.0	0	34.5	0
Oscillatoria limosa C. Agardh & Gomont	0	0	33.8	0	0
O. tenuis var. *natans* Gomont	2.0	0	0	0	40.7
Spirulina major Kützing & Gomont	1.0	0	15.1	36.7	0
S. princeps W. and West & G. S. West	3.0	6.0	0	0	60.2
Synechococcus aeruginosus Nägeli	0	3.4	0	0	50.0
Total of CYANOPHYCEAE	14.50	23.00	81.21	117.8	304.63
EUGLENOPHYCEAE					
Euglena convoluta Korshikov	0	0	15.2	12.9	22.0
Phacus longicauda (Ehrenberg) Dujardin 1841	2.0	3.6	0	13.6	0
Phacus sp.	0	0	0	0	18.9
Total of EUGLENOPHYCEAE	2.00	3.60	15.22	26.50	40.90
CHLOROPHYCEAE					
Chlorella sp.	0	0	0	0	21.2
Coelastrum microporum Nägeli	0	0	20.0	0	24.5
Cosmarium moniliforme Ralfs	0	0	0	24.0	14.4
C. hammeri Reinsch	0	18.9	0	0	0
Cosmarium sp.	0	0	15.0	9.65	11.8
Mougeotia sp.	6.4	0	0	0	26.0
Oedogonium sp.	0	17.7	0	0	26.4
Oocystis borgei J.W.Snow	0	0	17.9	13.6	0
Ophiocytium bicuspidatum (Borge)	6.2	0	0	0	0

Lemmermann					
Pandorina morum (O.F.Müller) Bory	0	0	0	19.7	14.6
Pediastrum simplex Meyen	0	14.3	0	13.8	19.0
Scenedesmus armatus (Chodat) Chodat	0	8.9	0	0	14.0
S. arcuatus var. *platydiscus* G.M. Smith	0	0	16.9	8.8	0
Uronema elongatum Hodgetts	0	0	16.9	14.9	0
Zygnema chalybeospermum Hansgirg 1888	0	16.7	0	0	12.9
Total of CHLOROPHYCEAE	12.66	76.44	86.65	104.44	184.87
BACILLARIOPHYCEAE					
Achnanthes lanceolata (Brébisson ex Kützing) Grunow, 1880	2.4	0	0	0	25.4
Amphora ovalis (Kützing) Kützing,1844	0	14.5	0	0	35.6
Bacillaria paxillifer (O. F. Müller) T. Marsson	2.8	0	0	12.6	0
Caloneis sp.	0	0	11.5	0	25.5
Chaetoceros sp.	0	0	0	0	0
Cocconeis pediculus Ehrenberg	3.3	11.9	0	0	0
Cyclotella meneghiniana Kützing 1844	5.6	13.9	0	22.5	12.5
Cymatopleura elliptica (Brébisson) W.Smith 1851	0	10.5	0	0	0
Cymbella aspera (Ehrenberg) Cleve	5.8	0	9.5	18.2	24.6
C. tumida(Breb.)Van Heurck.	0	0	0	21.5	0
C. turgida W. Gregory	0	0	0	0	5.5
Diatoma elongata (Lyngbye) C. Agardh	5.3	0	12.6	15.6	0
Epithemia zebra (Ehrenberg) Kützing	0	1.8	0	15.5	12.5
Fragilaria sp.	0	0	0	21.5	0
Gomphonema montanum (Schumann) Grunow	0	0	16.0	11.0	35.6
G. olivaceum (Hornemann) Ehrenberg	0	0	0	0	26.0
Gyrosigma attenuatum (Kützing) Rabenhorst	1.4	0	18.5	12.0	0
G. tenuirostrum (Grunow) A. Cleve	2.5	2.8	0	22.5	32.7
Mastogloia elliptica (C. Agardh) Cleve	0	0	12.0	0	0
M. smithii Thwaites & W. Smith 1856	0	14.6	0	12.5	15.2
Melosira varians C. Agardh	0	0	10.6	0	0
Navicula cryptocephala Kützing	0	0	0	21.5	23.5
N. cuspidata (Kützing) Kützing, 1844	0	12.4	15.5	0	32.4
Total of BACILLARIOPHYCEAE	29.22	82.47	106.12	206.99	307.10
Total of all phytoplankton	58.38	185.51	289.20	455.73	837.50

Table 5. Quality and quantity of phytoplankton in pond 3 during experiment

Phytoplankton taxa	Phytoplankton density (cell*10^6/l)				
	2/4/2019	13/4	27/4	9/5	18/5
CYANOPHYCEAE					
Chroococcus turgidus (Kützing) Nägeli	0	0	0	12.3	0
Gomphosphaeria lacustris(Chodat)	0	0	0	0	33.9
G. aponina Kützing 1836	0	0	23.0	0	0
Lyngbya sordida Gomont	2.0	0	0	29.1	60.9
Merismopedia convolutae Brébisson & Kützing	0	0	24.0		44.9
M. punctata Meyen	0	0	0	35.3	0
Oscillatoria tenuis var.*natans* Gomont	0	3.6	13.1	0	65.7
Spirulina princeps West & G. S. West	0	0	40.0	57.8	0
S. major (Kützing)	0	0	0	0	57.8
Synechococcus aeruginosus Nägeli	0	0	13.6	57.9	0
Total of CYANOPHYCEAE	2.00	3.60	113.72	192.41	263.20
EUGLENOPHYCEAE					
Euglena acus (Ehrenberg 1830)	0	2.0	6.0	15.0	12.0
E. convoluta Korshikov	1.6	3.7	0	0	0
Phacus longicauda (Ehrenberg) Dujardin 1841	0	1.0	16.2	21.0	17.9
Total of EUGLENOPHYCEAE	1.60	6.70	22.20	36.00	29.90
CHLOROPHYCEAE					
Chlorella sp.	0	0	16.7	0	0
Cladophora fracta (O.F.Müller ex Vahl) Kützing 1843	0	0	16.8	7.9	14.6
Cosmarium hammeri Reinsch	0	0	0	0	13.3
C. moniliforme Ralfs	0	0	0	6.5	0
Cosmarium sp.	0	0	0	16.7	0
Mougeotia sp.	0	0	0	0	26.8
Oedogonium sp.	0	0	0	17.8	0
Oocystis borgei J.W.Snow 1903	0	0	11.8	0	13.8
Ophiocytium bicuspidatum (Borge) Lemmermann	0	0	0	15.8	
Pandorina morum (O.F.Müller) Bory	0	13.0	0		19.5
Pediastrum duplex Meyen	0	0	12.8	13.9	0
P. simplex Meyen	5.8	0	0	0	0
Scenedesmus armatus (Chodat) Chodat	0	0	0	26.3	0
S. arcuatus var. *platydiscus* G.M. Smith	0	0	0	0	29.0
Scenedesmus sp.		16.8	17.9	16.7	28.0
Uronema elongatum Hodgetts	0	0	0	0	30
Zygnema chalybeospermum Hansgirg 1888	0	0	0	18.5	0
Total of CHLOROPHYCEAE	5.76	29.74	76.09	140.04	175.04

BACILLARIOPHYCEAE					
Amphora ovalis (Kützing) Kützing, 1844	0	0	0	15.7	25.4
Bacillaria paxillifer (O. F. Müller) T. Marsson	5.1	5.4	0	0	0
Chaetoceros sp.	0	14.6	0	20.6	23.5
Cocconeis pediculus Ehrenberg	0	0	10.5	19.5	0
Cyclotella striata (Kützing) Grunow 1880	4.0	0	0	19.2	0
C. meneghiniana Kützing 1844	4.5	0	0	0	0
Cymatopleura elliptica F. Meister	0	4.5	9.5	15.6	24.6
Cymbella tumida (Brébisson) Van Heurck	4.8	0	8.6	23	52.5
C. cistula (Ehrenberg) Kirchner	0	4.8	0	0	25.1
C. turgida W. Gregory	0	5.4	15.3	0	0
Diatoma elongate (Lyngbye) C. Agardh	0	0	0	0	23.5
Epithemia zebra (Ehrenberg) Kützing	0	0	8.5	14.4	21.4
Fragilaria sp.	0	12.4	0	15.2	23.5
Gomphonema montanum (Schumann) Grunow	4.7	0	18.8	12	0
G. olivaceum (Hornemann) Ehrenberg	0	0	0	14.2	0
Gyrosigma attenuatum (Kützing) Rabenhorst	0	12.5	0	10.2	15.5
G. tenuirostrum (Grunow) A. Cleve	0	0	15.9	0	0
Mastogloia elliptica (C. Agardh) Cleve	0	0	0	15.6	24.5
M. smithii Thwaites ex W.Smith 1856	0	0	10.5	0	22.5
Melosira varians C. Agardh	0	0	12.0	0	0
Navicula cryptocephala Kützing	2	12.4	0	24.5	35.2
Total of BACILLARIOPHYCEAE	25.22	72.23	109.70	219.66	317.53
Total of all phytoplankton	34.58	112.27	321.71	588.11	785.67

Table 6. Quality and quantity of phytoplankton in pond 4 during experiment

Phytoplankton Taxa	Phytoplankton density (cell*10^6/l)				
	2/4/2019	13/4	27/4	9/5	18/5
CYANOPHYCEAE					
Gomphosphaeria aponina (Kützing 1836)	0	0	0	24.7	45.9
Lyngbya sordida Gomont	0	0	14.1	0	0
Merismopedia convoluta Brébisson & Kützing	0	0	0	39.9	0
M. punctata Meyen	0	3.4	0	0	0
Microcystis aeruginosa (Kütznìng) Kützing 1846	0	0	26.0	37.7	46.0
Oscillatoria tenuis var.*natans* Gomont	0	0	22.0	0	0

Spirulina princeps W. & G.S.West	1.6	0	19.1	30.1	59.2
S. major (Kützing)	0	4.0	0	0	0
Synechococcus aeruginosus Nägeli	0	3.1	0	0	60.6
Total of CYANOPHYCEAE	1.60	10.50	81.21	132.35	211.73
EUGLENOPHYCEAE					
Euglena acus (Ehrenberg 1830)	0	0	0	12.1	0
E. convoluta Korshikov	0	3.0	13.9	0	22.0
Phacus longicauda (Ehrenberg) Dujardin 1841	1.8	0	0	0	0
Phacus sp.	0	1.0	3.5	11.8	17.0
Total of EUGLENOPHYCEAE	1.80	4.00	17.40	23.86	38.99
CHLOROPHYCEAE					
Chlorella sp.	0	0	0	19.5	24.0
Cladophora fracta (O.F.Müller ex Vahl) Kützing 1843	0	0	0	0	20.8
Coelastrum microporum (Nägeli)	0	0	0	16.4	0
Cosmarium hammeri Reinsch	0	0	0	15.8	0
C. moniliforme Ralfs	6.3	0	14.8	0	21.9
Cosmarium sp.	0	0	0	0	32.9
Mougeotia sp.	0	17.9	11.8	9.0	22.8
Oocystis borgei J.W.Snow 1903	0	0	0	17.4	0
Ophiocytium bicuspidatum (Borge) Lemmermann	7.4	0	0	0	25.6
Pandorina morum (O.F.Müller) Bory			15.9	0	0
Pediastrum duplex Meyen	7.8	0	0	0	23.8
P. simplex Meyen 1829	0	0	17.2	17.6	0
Scenedesmus arcuatus var. *platydiscus* G. M. Smith	0	18.9	0	0	14.9
S. armatus (Chodat) Chodat 1913	8.3	0	0	0	0
Scenedesmus sp.	0	0	0	0	30.2
Uronema elongatum Hodgetts	0	17.3	0	19.4	12.9
Zygnema chalybeospermum Hansgirg 1888	0	0	13.8	0	0
Total of CHLOROPHYCEAE	29.8	54.07	73.54	115.15	229.87
BACILLARIOPHYCEAE					
Achnanthes lanceolata (Brébisson ex Kützing) Grunow 1880	2.0	0	0	0	0
Amphora ovalis (Kützing) Kützing	5.4	0	0	15.9	0
Bacillaria paxillifer (O. F. Müller) T. Marsson	0	0	0	0	22.4
Caloneis sp.	4.46	0	0	12.5	0
Chaetoceros sp.	0	12.4	0	0	12.5
Cocconeis pediculus Ehrenberg	0	0	9.8	21.5	0
Cyclotella meneghiniana Kützing 1844	0	0	0	0	28.9
Cyclotella striata (Kützing) Grunow	0	12.4	0	0	0

Cymatopleura elliptica (Brébisson) W. Smith	5.4	0	0	0	0
Cymbella aspera (Ehrenberg) Cleve 1894	0	0	8.7	15.9	24.6
C. cistula (Ehrenberg) O. Kirchner	0	12.2	0	0	0
C. tumida Brébisson Van Heurck	0	0	6.6	24.4	25.6
Diatoma elongatum (Lyngbye) C. Agardh	0	0	15.2	15.2	24.5
Epithemia zebra (Ehrenberg) Kützing	0	12.5	0	0	0
Fragilaria sp.	4.1	0	19.6	15.5	0
Gomphonema montanum (Schumann) Grunow	0	15.1	0	19.9	25.5
G. olivaceum (Hornemann) Ehrenberg	0	0	5.0	0	38.2
Gyrosigma attenuatum (Kützing) Rabenhorst	1.5	0	3.0	22.1	0
G. tenuirostrum (Grunow) Cleve-Euler 1952	0	0	0	0	36.9
Mastogloia elliptica (C.Agardh) Cleve, 1893	4.5	0	13.2	0	0
M. smithii Thwaites ex W.Smith 1856	0	0	9.0	24.4	35
Melosira varians C.Agardh 1827	0	0	0	0	13.5
Navicula cryptocephala Kützing, 1844	0	0	12.1	12.2	22
N. cuspidata (Kutzing) Kutzing, 1844	0	12.4	0	0	37.0
Total of BACILLARIOPHYCEAE	27.42	77.13	102.12	199.50	346.64
Total of all phytoplankton	60.62	145.70	274.27	470.86	827.23

Table (7) shows the relationship between the total numbers of phytoplankton and growth criteria of common carp in different ponds. The results showed a negative correlation between the total numbers of phytoplankton and growth of fish, where the average of this correlation in different ponds were -0.59, -0.634, -0.85 and -0.77 for weight increment, daily growth rate, specific growth rate, and relative growth rate, respectively.

Table 7. The correlation coefficient between total numbers of phytoplankton and growth criteria

Pond	Correlation coefficient for different growth criteria			
	WI	DGR	SGR	RGT
Pond 1	-0.59	-0.58	-0.86	-0.80
Pond 2	-0.50	-0.54	-0.80	-0.73
Pond 3	-0.69	-0.76	-0.88	-0.79
Pond 4	-0.56	-0.63	-0.83	-0.78
Average	-0.59	-0.63	-0.85	-0.77

Table (8) displays the relationship of the correlation coefficient between salinity and the total number of phytoplankton, and also the relationship between salinity and fish growth. The results showed weak positive and negative correlations, without exceeding 0.32, and they are not significant between salinity and the total number of phytoplankton. This is also the case for the relationship between salinity and fish growth.

Statistical analysis of the correlation coefficient showed that there was a direct, significant correlation between salinity and fish growth, r = +0.877, while the correlation coefficient was weak and insignificant between salinity and the total number of phytoplankton; r =+ 0.238 at a significant level of $P \leq 0.05$.

DISCUSSION

Phytoplankton are an important source of numerous nutritional components, such as vitamins, mineral elements, and fatty & amino acids for fish larvae **(Napiórkowska-Krzebietke, 2017)**. The manure is a costless fertilizer that increase the growth of phytoplankton and zooplankton as an important natural food for most fish during an early life stage **(Lan *et al*., 2000)**. **Knud-Hansen *et al*. (1993)** stated that the role of organic fertilizers as food source for fish is not well known although these fertilizers are consumed directly or as manure-derived detritus after heterotrophic microbial activity. **Dhawan and Kaur (2002)** postulated that primary (Phytoplankton) and secondary (Zooplankton) productions in manured earthen ponds were significantly higher, and fish growth was significantly more compared with none manured ponds. Many researchers **(Wurts, 2000; Jana *et al*., 2001; Ansa & Jiya, 2002; Kadri & Emmanuel, 2003)** pointed that organic manures contain most of the essential nutrient elements that stimulate the growth of phytoplankton. The results of the current experiment in the four ponds revealed that, at the beginning of experiment, fish growth was high, and then decreased or stopped at the end of experiment, while the total number of phytoplankton was low at the beginning of experiment and high at the end of experiment. This means that common carp juveniles (0.104g and bigger) don’t consume phytoplankton and depend on another source of food. This result is supported by a negative correlation between the total number of phytoplankton in the four ponds with growth criteria (WI, DGR, SGR and RGR) of fish. **Anton-Pardo and Adamek (2015)** stated that the growth of juvenile common carp was high when the total number of zooplankton was also high, and there was a gradual decrease in growth as the number of zooplankton decreased. For this reason, it can be concluded that the growth of juvenile common carp doesn’t depend on viability of phytoplankton but depends on the viability of zooplankton. Moreover, we can relate the gradual increase of phytoplankton numbers to the gradual decrease in the zooplankton numbers. It is well known that the main food item of zooplankton was phytoplankton.

Some researchers **(Osse *et al.*, 1997; Chakrabarti & Sharma, 1998; Dulić *et al.*, 2011)** revealed that zooplankton was the main component in the diet of larvae and fries of crap, and the size of zooplankton ingested increased with increasing the size of the fish. **Anton-Pardo *et al.* (2014)** found that, there were no correlations between pond natural food and that in the common carp gut. They suggested that, any variations in diet likely reflected the microhabitats where individual carp chose to feed. **Jaeger and Aubin (2018)** stated that, in extensive ponds, there were lower growth for common carp and roach. This suggests that they might be too large to effectively feed on phytoplankton and zooplankton present in the water column **(Rahman *et al.*, 2010)**. **Dhawan and Kaur (2002)** pointed that, phytoplankton numbers were significantly higher in fertilized ponds, and also fish growth was significantly higher.

The results of current experiment revealed that the first important family of phytoplankton was Bacillariophyceae, accounting for 46.00% as a percentage of total phytoplankton, followed by Chlorophyceae at 27.10%, Cyanophyceae at 22.20%, and Euglenophyceae at 4.70%. **Kloskowski (2011)** stated that, Chlorophyta and Bacillariophyta consisted 60% of the gut contents of all common carp age classes and in all seasonal samples. The significant positive correlation coefficient between salinity and fish growth, on the one hand, and between salinity and the total number of phytoplankton, may be due to various reasons including the influence of other environmental variables **(Liu *et al.*, 2010)**.

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