

Original Research Article

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## Effect of Fermented Water Hyacinth Leaf Meal on Plankton Productivity and Gut Content Analysis of Common Carp (*Cyprinus carpio*)

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### ABSTRACT

The effect of fermented water hyacinth (FWH) leaf meal on plankton productivity and gut content analysis of common carp (*Cyprinus carpio*) was studied. FWH was incorporated into test diet, as an energy source, at different levels (@ 0 (T1), 40 (T2), 80 (T3), 120 (T4) and 160 (T5) g/kg test diet, as a replacement for equal amount of rice bran. Fish were fed 3-5% of body weight for 120 days. All the water quality parameters were within the range for carp culture. Fermented water hyacinth has enhanced total phytoplankton population and resulted significantly high ( $P \leq 0.05$ ) in T5 compared to control (T1). Green algae (Chlorophyceae) and blue green algae (Cyanophyceae) dominated the phytoplankton population. It also enhanced total zooplankton population in different treatments, T2, T3, T4 and T5 and resulted significantly high ( $P \leq 0.05$ ) in T5 compared to the Non FWH treatment (T1). In the gut content analysis, phytoplankton and zooplankton were observed maximum (37.98 and 13.24% respectively) in T5 and minimum (23.49 and 4.67% respectively) in T1 treatment and the difference among the treatments were significant ( $P \leq 0.05$ ). Diets containing the fermented water hyacinth might have enriched the water, leading to increased plankton population and subsequent consumption by the fish. Fermented water hyacinth leaf meal can partially replace rice bran in the common carp diet to reduce the cost of feed and improving the pond productivity.

#### Keywords

Fermented water hyacinth, Feed, Plankton, Gut content, *Cyprinus carpio*

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### Introduction

Aquaculture is one of the fastest food producing sectors of the world (average annual growth rate of 8.9 %) and it provides marginally half of all fish for human food (FAO, 2016). The majority of world aquaculture production is comprised of herbivorous/omnivorous fish species that feed low in the food chain and are cultured in semi-intensively managed earthen ponds in the tropics and sub-tropics (Azim and Little,

2006). Fishponds are specific open aquatic systems inhabited by a simple community of living organisms including the main trophic levels (nutrients, phytoplankton, zooplankton and fish). The primary productivity (PP) is a fundamental biological characteristic being on the lowest trophic level of the food chain (Terziyski *et al.*, 2016) and plays an important role in transferring energy from a given trophic level to the next higher, leading to fish, the target energy harvest unit in aquatic systems (Diana, 2009). Planktonic community

structure in a fish pond is regulated by the availability of nutrients and predation. Planktonic organisms are potential bio indicators and their quality and quantity indicate the levels of fish pond ecosystems. Pond fertilization using animal waste is widely practiced in many countries to maintain productivity at low costs (Gupta and Noble, 2007; Majumdar *et al.*, 2002) by supplying soluble organic matter in ponds to stimulate phytoplankton growth. In India, carps contribute more than 85% to total fish production from freshwater aquaculture sector, practiced in semi-intensive system.

As in other fish species, carp larvae feed mainly on zooplankton, starting with small organisms (rotifers) and as they grow then shifting to larger organisms, e.g. copepods and cladocerans. As adults they are commonly benthic feeders, concentrating principally on zoobenthos (mainly chironomid larvae); however, zooplankton is also an important part of the diet, depending on food availability and spatial and temporal variation (Anton- Pardo and Adámek, 2015). Though carps mainly thrive on plankton community, they also need supplementary food to balance the diet to achieve good growth rate.

Supplementary feed is one of the key inputs in aquaculture for elevating production and constitutes more than 60% of the input cost. Considering the ever increasing cost of conventional feed ingredients, it is essential to identify locally available nutrient rich low cost non-conventional feed resources (NCFR). Among various NCFR used in aquaculture, aquatic plants like water hyacinth (*Eichhornia crassipes*) could be good alternate feed resource due to its increased nutritive value and fast growth rate. Its potential benefits as animal fodder, aquatic feed, water decontamination, manure, biogas production etc. have gained much attention in latest years. Several studies have been carried out to

evaluate the incorporation of different non-conventional animal and plant proteins and energy sources for herbivorous fishes for varying results (Buddington, 1980; El-Sayed, 1999; Soliman, 2000). The relatively high fibre content of WH restricts its use in carp feeds as they are not capable of secreting the main cellulose digestive enzyme, cellulase (Buddington, 1980). Wilting can be even beneficial by reducing the development of detrimental microorganisms, promoting fermentation and enhancing livestock intake (García, 1999). In order to endorse fermentation of most tropical plants and to achieve satisfactory silage quality, fermentable carbohydrates are required (Bagnall *et al.*, 1974). Sugarcane molasses is commonly used in silage preparation and has been found to cut down pH and ammonia levels (McDonald *et al.*, 2011). Rice bran, one of the chief by-products of the rice milling industry has been used as an absorbent in silage (Yokota *et al.*, 1998).

Currently, culture of common carp is also facing a serious problem due to its prolific breeding, which has led to over population and stunting in growth of the fish due to its early age maturity within five to six months. Due to over population, it is also difficult to find the required nutritious diet, for which there is immense competition from remaining terrestrial animals also. Since water hyacinth is easily available, in bulk without any cost, through fermentation procedure it can be use in fish diet in aquaculture ponds. This would be an interesting intervention to address related environmental issue as well. Hence, the idea of supplementary food using non-conventional, locally available feed resources has been formulated to tackle the issue. Therefore, the present study was undertaken to evaluate the effect of fermented water hyacinth leaf meal on plankton productivity and gut content of common carp (*Cyprinus carpio*), fingerling.

## Materials and Methods

### Experimental design

The experiment was carried out in FRP pools (1.5x1.0x0.75 m) with 3 replicates for each treatment. Two to three inch thick layer of soil was spread at the bottom of each pool to hasten the decomposition process. The borewell water was used for filling and maintaining the water level in the pools, during the culture period. The experiment consisted of 5 treatments (T1, T2, T3, T4 and T5) with 3 replicates each. T1 (Control) with no fermented water hyacinth (FWH), T2 had 10% of rice bran replaced by fermented water hyacinth, while T3, T4 and T5 had respectively 20%, 30% and 40% of rice bran replaced by fermented water hyacinth (Table 1). Each pool was stocked with fingerlings of Common carp, *C. carpio* (L) @ 10/FRP pool.

At the time of stocking, the average body length and body weight was 11.35-11.64 cm and 15.09-15.54 g respectively. The experiment was carried out for a period of four months (May to September, 2017) with periodical exchange of water in the tanks. Post stocking manuring with cow dung was done at fortnightly intervals @ 625 kg/ha. Adequate aeration and periodic liming was provided in all the tanks at the fish farm of College of Fisheries, Guru AngadDev Veterinary and Animal Sciences University (GADVASU), Ludhiana

### Preparation of fermented water hyacinth (FWH) leaf meal

Water hyacinth was collected from nearby water bodies. All other ingredients were purchased from the local market. Fermented water hyacinth leaf meal was prepared according to (El-Sayed, 2003). Water hyacinth was collected from nearby water bodies and brought at Fish Farm, College of Fisheries,

GADVASU. Initially, leaves and leaf stalks were separated from roots and chopped into small pieces (1–2 cm) and were sun-dried until water content dropped to 50%. Then 5% sugar cane molasses and 2 ml orthophosphoric acid/kg were added to sun-dried water hyacinth with continuous mixing and were stored for 50 days in covered plastic containers at room temperature. Fermented material was oven dried at 60 °C for 24 h and finely grinded and stored in labelled plastic bag.

### Pond productivity

Pond productivity was estimated in terms of phytoplankton and zooplankton production, for that sample was collected during early morning hours at fortnightly intervals. The qualitative and quantitative analysis of plankton was done by drop count method of Vollenweider (1971) and zooplankton by Sedgwick Rafter Cell (S.R.C.) method (APHA, 1991).

### Gut content analysis

For gut content analysis, fish were dissected and gutted at the end of the experiment. Then stomach content was examined and the individual food organisms were sorted and identified. The number of stomachs in which each item occurred was recorded and expressed as a percentage of the total number of stomachs examined. The qualitative gut content analysis was performed based complete identification of the organisms in the gut, while quantitative analysis was performed based on frequency of occurrence method ( $O_i$ ) (Hynes 1950) with the following formulae:

$$\text{Frequency of occurrence} = J_i/P$$

Where,  $J_i$  is the number of fish containing prey  $i$  and  $P$  is the number of fish with food in their stomach

## Statistical analysis

Statistical analysis of the data was performed with a statistical package (SPSS 16.0, SPSS Inc., and Richmond, CA, USA). Values were presented as means  $\pm$  standard error of the mean. One way ANOVA was applied to work out of effect of fermented water hyacinth leaf meal on pond productivity and gut content analysis of fish ( $P \leq 0.5$ ), followed by Duncan's multiple comparison to determine significant differences among the treatments.

## Results and Discussion

The use of water hyacinth as a feed ingredient has been investigated in different fish to study growth, survival and body composition (El-Sayed, 2003). To our knowledge, the present study represented the first work to investigate the effect of fermented water hyacinth leaf meal on the pond productivity, nutrient status and gut content analysis in fish. In the present study, different levels of fermented water hyacinth leaf meal were used as partial replacement for rice bran. In an aquatic ecosystem, biomass and species composition of plankton gives an insight of the nutrient status. Phytoplankton is the major primary producers in fish pond ecosystems which are grazed by zooplankton. Phytoplankton community includes four major groups (Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae and zooplankton consists five major groups (Cladocera, Copepoda, Ostracoda, Protozoa and Rotifera), (Rao, 1975; Prasad and Srivastava, 1992; Kumari and Pandey, 2018) (Table 2).

### Effect of fermented water hyacinth on plankton productivity

To assess the plankton production trends and sustainability, qualitative and quantitative analysis of phytoplankton and zooplankton

populations in all the treatments was studied at fortnight intervals. The results of total phytoplankton and zooplankton in different treatments are as follows:

### Total phytoplankton population

The total phytoplankton population in T1, T2, T3, T4 and T5 were  $70 \pm 3.13$ ,  $77 \pm 2.90$ ,  $79 \pm 2.99$ ,  $85 \pm 3.25$  and  $92 \pm 4.06$  (no.  $\times 10^6 L^{-1}$ ) respectively. The trend shows significant changes in total phytoplankton population within the treatments during every sampling. There was significant difference among the treatments with respect to mean total phytoplankton population with maximum numbers in T5 and minimum in T1. ( $T5 \geq T4 \geq T2 \geq T1 \geq T3$ ) (Table 2).

It indicates that the FWH has enhanced total phytoplankton population with progressively increase in percentage of fermented water hyacinth leaf meal in T2, T3, T4 and T5 and these populations were significantly higher ( $P \leq 0.05$ ) compared to T1. High nutrient content in T5 lead to the development of significantly high phytoplankton population which is in agreement with the studies of Sharma *et al.*, (2012) that gross primary production was found to have positive correlation with nitrate and phosphates.

### Bacillariophyceae (Diatoms)

Bacillariophytes are called diatoms, which are major group of algae and are among the most common types of phytoplankton. Bacillariophyceae population ranged between 10 to 15 no.  $\times 10^6 L^{-1}$  among all the treatments. During the course of time, significant changes ( $P \leq 0.05$ ) were recorded in the bacillariophyceae population within the treatments, and the differences among the treatments with respect to mean bacillariophyceae population were also significant, being maximum in T5 and

minimum in both T1 and T3. (T5≥T4≥T3=T2≥T1) (Table 2).

### ***Chlorophyceae (Green algae)***

The chlorophyceae are one of the classes of green algae, distinguished mainly on the basis of ultrastructural morphology. They are usually green in colour due to the dominance of chlorophyll-a and chlorophyll-b pigments (Lewis and McCourt, 2004). Chlorophyceae population ranged between 23-40, 26-43, 24-44, 25-48 and 25-52 no. x 10<sup>6</sup>L<sup>-1</sup> in T1, T2, T3, T4 and T5 respectively. Although, during the culture period significant changes (P ≤ 0.05) in chlorophyceae population were recorded within the treatments, and the differences among the treatments with respect to mean chlorophyceae (green algae) population were also significant, being maximum in T5 and minimum in treatment T1 (T5≥T4≥T3≥T2≥T1) (Table 2).

### ***Cyanophyceae (Blue green algae)***

They are the large group of prokaryotic, mostly photosynthetic organisms. Cyanobacteria are organisms with some characteristics of bacteria and some of algae (Hoffmann, 1999). Though classified as blue-green algae or photosynthetic bacteria, they resemble the eukaryotic algae in many ways, including some physical characteristics and ecological niches and were at one time treated as algae. They contain certain pigments, which with their chlorophyll, often give them a blue-green colour, though many species are actually green, brown, yellow, black and red (Mur *et al.*, 1999). Cyanophyceae population showed variation and ranged between 11 and 32, 13-34, 15-31, 15-35 and 14-38 (no. x 10<sup>6</sup>L<sup>-1</sup>) in T1, T2, T3, T4 and T5 respectively. Although, during the culture period significant changes (P ≤ 0.05) in Cyanophyceae population were recorded within the treatments, and the differences among the

treatments with respect to mean Cyanophyceae population were also significant, being maximum T5 and minimum in treatment T1 (T5≥T4≥T3=T2≥T1) (Table 2).

### ***Euglenophyceae (Flagellates)***

Euglenophyceae are one of the best-known groups of flagellates, which are unicellular in nature and are commonly found in freshwater, especially when it is rich in organic materials, with a few marine and endosymbiotic members (Ciugulea and Triemer, 2010; Leander *et al.*, 2001). Euglenophyceae population in the present study fluctuated between 4 and 12 no. x 10<sup>6</sup>L<sup>-1</sup> in all the treatments. With the progression in culture period, significant changes (P≤0.05) in euglenophyceae population were noticed within the treatments, and the differences among the treatments with respect to mean euglenophyceae population was significant, being maximum in T5 (T5≥T4≥T3≥T2≥T1) (Table 2). Fermented water hyacinth leaf meal has enhanced the euglenophyceae population in T5 compared to control treatment T1.

### **Relative abundance of phytoplankton populations in different treatments**

In all the treatments, Chlorophyceae (green algae) and Cyanophyceae (blue green algae) dominated the phytoplankton population compared to Bacillariophyceae (diatoms) and Euglenophyceae (flagellates) (Table 2). The results revealed that Euglenophyceae were least in number, constituting 7.14-8.86%, while Chlorophyceae represented 43.47-45.71%, of the total phytoplankton population. Amongst different phytoplankton groups, Chlorophyceae population was recorded significantly higher in treatment T5, while differences with respect to mean total phytoplankton population were found to be significant (P≤0.05) among treatments. The

results reveal that fermented water hyacinth leaf meal has enhanced the population of chlorophyceae, cyanophyceae, bacillariophyceae and euglenophyceae in all treatment. Although fermented water hyacinth leaf meal incorporation resulted in higher phytoplankton population in T4 and T5, but it did not alter the predominance order of different phytoplankton groups in any of the treatments (Table 3). Earlier reports states that application of water hyacinth compost helps to achieve better planktonic growth and higher productivity (Saha *et al.*, 1974, Murty *et al.*, 1978; Mishra *et al.*, 1987, 1988). Although the process for water hyacinth composting and fermenting are quite different, but either way it meets the demand of feed or manure which is utilize by fish to improve the production and productivity. Diets containing the fermented water hyacinth might have enriched the water, leading to increased plankton population.

### Total zooplankton

During the culture period, total zooplankton population recorded significant changes ( $P \leq 0.05$ ) within the treatments. The differences among the treatments with respect

to mean total zooplankton population was significant ( $P \leq 0.05$ ), being maximum in T5 and minimum in treatment T1 ( $T5 \geq T4 \geq T3 \geq T2 \geq T1$ ) (Table 3). The results of the present study indicates that the fermented water hyacinth leaf meal enhanced total zooplankton population in different treatments and were significantly higher ( $P \leq 0.05$ ) in T5 compared to others treatments.

### Cladocera

Cladocerans, often called as water fleas because of their shape and “hop-sink” type of locomotion, are the third major group of zooplankton found in freshwater ponds. They are small-sized (0.2–6 mm, and up to 18 mm) commonly found in most freshwater habitats, including lakes, ponds, streams and rivers (Forro *et al.*, 2008). During the culture period, they were one of the dominant species of zooplankton and significant changes ( $P \leq 0.05$ ) were observed in cladocerans population within the treatments. The mean cladocerans population among the treatments also showed significant difference, being maximum in T5 and minimum in CM treatment ( $T5 \geq T4 \geq T3 = T2 \geq T1$ ).

**Table.1** Composition percentage (%) of experimental diets

Ingredients	T1 Control	T2 (10% WH)	T3 (20% WH)	T4 (30 % WH)	T5 (40 % WH)
Fermented WH	-	4	8	12	16
Rice bran (RB)	40	36	32	28	24
Soy meal	26	26	26	26	26
Mustard oil cake	30	30	30	30	30
Carboxy methyl cellulose (CMC)	2	2	2	2	2
Mineral mixture	1	1	1	1	1
Vitamin mixture	1	1	1	1	1

**Table.2** Phytoplankton populations (No. x 10<sup>6</sup>/L) of water in different treatments

Parameters	Treatments				
	T1 (Control)	T2	T3	T4	T5
<b>Bacillariophyceae</b>	10 <sup>b</sup> ±0.44 (14.28%)	12 <sup>b</sup> ±0.53 (15.58%)	12 <sup>b</sup> ±0.59 (15.18%)	13 <sup>a</sup> ±0.58 (15.29%)	15 <sup>a</sup> ±0.65 (16.30%)
<b>Chlorophyceae</b>	32 <sup>b</sup> ±1.07 (45.71%)	34 <sup>ab</sup> ±1.03 (44.15%)	35 <sup>c</sup> ±1.34 (44.30%)	38 <sup>a</sup> ±1.41 (44.70%)	40 <sup>a</sup> ±1.73 (43.47%)
<b>Cyanophyceae</b>	23 <sup>b</sup> ±1.44 (32.85%)	25 <sup>b</sup> ±1.22 (32.46%)	25 <sup>a</sup> ±1.01 (31.64%)	27 <sup>a</sup> ±1.09 (31.76%)	29 <sup>a</sup> ±1.40 (31.52%)
<b>Euglenophyceae</b>	5 <sup>d</sup> ±0.43 (7.14%)	6 <sup>c</sup> ±0.39 (7.79%)	7 <sup>b</sup> ±0.40 (8.86%)	7 <sup>a</sup> ±0.45 (8.23%)	8 <sup>a</sup> ±0.56 (8.69%)
<b>Total phytoplankton population</b>	70 <sup>c</sup> ±3.13	77 <sup>b</sup> ±2.90	79 <sup>b</sup> ±2.99	85 <sup>a</sup> ±3.25	92 <sup>a</sup> ±4.06

<sup>a,b</sup> Mean values with different superscript in a row differ significantly (p<0.05); Values in parentheses indicate percentage of individual plankton group in the respective total phytoplankton population

**Table.3** Zooplankton populations (No./L) of water in different treatments

Parameters	Treatments				
	T1 (Control)	T2	T3	T4	T5
<b>Cladocera</b>	63 <sup>d</sup> ±1.43 (25.09%)	66 <sup>c</sup> ±1.07 (24.26%)	66 <sup>c</sup> ±1.60 (23.15%)	72 <sup>b</sup> ±1.79 (23.76%)	77 <sup>a</sup> ±2.28 (23.83%)
<b>Copepoda</b>	68 <sup>e</sup> ±1.59 (27.09%)	77 <sup>d</sup> ±1.50 (28.20%)	82 <sup>c</sup> ±1.62 (28.77%)	89 <sup>b</sup> ±1.76 (29.37%)	97 <sup>a</sup> ±2.10 (30.03%)
<b>Ostracoda</b>	27 <sup>d</sup> ±0.38 (10.75%)	29 <sup>c</sup> ±0.35 (10.62%)	30 <sup>b</sup> ±0.52 (10.52%)	32 <sup>a</sup> ±0.59 (10.56%)	33 <sup>a</sup> ±0.72 (10.21%)
<b>Protozoa</b>	37 <sup>c</sup> ±1.08 (14.74%)	41 <sup>b</sup> ±1.12 (15.01%)	42 <sup>ab</sup> ±1.10 (14.73%)	43 <sup>a</sup> ±0.95 (14.19%)	44 <sup>a</sup> ±0.88 (13.62%)
<b>Rotifera</b>	57 <sup>d</sup> ±1.0 (22.70%)	61 <sup>c</sup> ±1.0 (22.34%)	65 <sup>b</sup> ±1.30 (22.80%)	68 <sup>b</sup> ±1.79 (22.44%)	73 <sup>a</sup> ±2.15 (22.60%)
<b>Total zooplankton population</b>	251 <sup>e</sup> ±4.94	273 <sup>d</sup> ±4.67	285 <sup>c</sup> ±5.67	303 <sup>b</sup> ±6.47	323 <sup>a</sup> ±7.64

<sup>a,b</sup> Mean values with different superscript in a row differ significantly (p<0.05); Values in parentheses indicate percentage of individual plankton group in the respective total zooplankton population

**Table.4** Gut content analysis (%) of fish in different treatments at the end of experiment

Treatments	Gut content (%)			
	Phytoplankton	Zooplankton	Detritus	Unidentified matter
<b>T1 (Control)</b>	23.49 <sup>b</sup> ±0.65	4.67 <sup>d</sup> ±0.53	56.10 <sup>a</sup> ±0.59	13.68 <sup>c</sup> ±0.29
<b>T2</b>	33.42 <sup>b</sup> ±1.02	7.91 <sup>c</sup> ±0.45	39.48 <sup>a</sup> ±1.03	18.57 <sup>c</sup> ±0.12
<b>T3</b>	31.05 <sup>b</sup> ±0.62	8.38 <sup>bc</sup> ±0.68	42.94 <sup>a</sup> ±0.68	17.23 <sup>c</sup> ±0.49
<b>T4</b>	36.60 <sup>b</sup> ±1.14	8.20 <sup>c</sup> ±0.50	38.03 <sup>a</sup> ±0.40	14.75 <sup>c</sup> ±0.68
<b>T5</b>	37.98 <sup>a</sup> ±0.72	13.24 <sup>c</sup> ±0.42	31.37 <sup>b</sup> ±1.20	13.11 <sup>c</sup> ±0.36
<b>Mean value</b>	<b>32.50<sup>a</sup>±0.82</b>	<b>8.48<sup>b</sup>±0.78</b>	<b>40.86<sup>a</sup>±0.78</b>	<b>15.50<sup>b</sup>±0.56</b>

## **Copepoda**

Copepods are one of the most abundant metazoans on Earth (Humes, 1994). During their diversification, these small aquatic crustaceans have colonized almost all benthic and planktonic aquatic ecosystems, from deep-sea oceans (Brodskaia, 1963) to the crevices of the Himalayan glaciers (Kikuchi, 1994). During the present study, copepoda population (no.  $l^{-1}$ ) ranged between 55-84, 61-89, 64-94, 71-103 and 81-116 in T1, T2, T3, T4 and T5 respectively.

Although, during the culture period significant changes ( $P \leq 0.05$ ) in copepoda population were recorded within the treatments, and the differences among the treatments with respect to mean copepods population was significant ( $P \leq 0.05$ ), being maximum in T5 and minimum in treatment T1 ( $T5 \geq T4 \geq T3 \geq T2 \geq T1$ ) (Table 3). In the present study, the result indicating that the fermented water hyacinth leaf meal has enhanced copepoda population in different treatments

## **Ostracoda**

Like the copepods, the ostracods are very much frequent in both freshwater and marine environment. The marine Ostracoda are commonly known as “Mussel shrimps” or “Seed shrimps”, but the freshwater ostracods are usually are smaller than millimeter and resemble tiny bivalve molluscs. They appear similar to conchostracans (clam shrimps) and can be separated from them by the presence of relatively few thoracic appendages. On first appearance have some resemblance to cladocerans. However, ostracods differ in that the body is completely enclosed in a clam-like bivalve shell that is hinged dorsally (Newman, 2005). In the present study, ostracoda population ranged between 23-28, 25-31, 25-33, 27-36 and 25-37 no.  $l^{-1}$  in T1,

T2, T3, T4 and T5 respectively. Although, during the culture period significant changes ( $P \leq 0.05$ ) in ostracoda population were recorded within the treatments, and the differences among the treatments with respect to mean ostracoda population was significant, being maximum in T5 and minimum in treatment T1 ( $T5 \geq T4 \geq T3 \geq T2 \geq T1$ ) (Table 3). In the present study, the result indicating that the fermented water hyacinth leaf meal has enhanced ostracoda population significantly.

## **Protozoa**

Protozoa is an informal term for single-celled eukaryotes, either free-living or parasitic, which feed on organic matter such as other microorganisms or organic tissues and debris (Panno, 2014). They are heterotrophic, deriving nutrients from other organisms, either by ingesting them whole or consuming their organic remains and waste-products (Bertrand, 2015). The ecological role of protozoa in the transfer of bacterial and algal production to successive trophic levels is important. As predators, they prey upon unicellular or filamentous algae, bacteria, and microfungi. Protozoan species include both herbivores and consumers in the decomposer link of the food chain. They also control bacteria populations and biomass to some extent.

The protozoan population during present study ranged varied between 27 and 51 no.  $l^{-1}$  in all the treatments. Although, during the culture period significant changes ( $P \leq 0.05$ ) in protozoa population were recorded within the treatments, and the differences among the treatments with respect to mean protozoa population was significant, being maximum in T5 and minimum in treatment T1 ( $T5 \geq T4 \geq T2 \geq T3 \geq T1$ ) (Table 3). The present study indicates that the fermented water hyacinth leaf meal has helped to enhanced protozoa population.

## **Rotifera**

The wheel animalcules, belonging to minor phylum Rotifera are the most important soft-bodied invertebrate pseudo coelomates, bilaterally symmetrical, metazoan protostomes ranging from 50 to 2,000  $\mu\text{m}$  in size with three regions (corona, trunk and foot) in the body (Shah *et al.*, 2015). Rotifera, are an important group of freshwater zooplankton and an integral link of aquatic food webs (Sharma, 2017), and commonly called as or wheel animalcules. They belong to the subphylum Toxhelminthes, i.e. they are worms, although their bodies share no resemblance with typical worms such as oligochaets (Clement, 1980). Some rotifers are free swimming and truly planktonic, others move by inch worming along a substrate, and some are sessile, living inside tubes or gelatinous holdfasts that are attached to a substrate. During the culture period, rotifera population (no.  $\text{l}^{-1}$ ) ranged between 47-64, 51-69, 52-74, 50-81 and 50-86 in T1, T2, T3, T4 and T5 respectively. Although, during the culture period significant changes ( $P \leq 0.05$ ) in rotifera population were recorded within the treatments, and the differences among the treatments with respect to mean rotifera population was significant, being maximum (86) in T5 and minimum (47) in treatment T1 ( $T5 \geq T4 \geq T3 \geq T2 \geq T1$ ) (Table 3). In the present study, the result indicating that the fermented water hyacinth leaf meal has enhanced rotifera population in different treatments, T2, T3, T4 and T5 and resulted significantly high ( $P \leq 0.05$ ) in T4 and T5 compared to T1.

## **Relative abundance of zooplankton groups in different treatments**

Cladocerans compete with rotifers and calanoid copepods for phytoplankton (Dole-Oliver *et al.*, 2000; Pennak 1978). In all the treatments, copepods dominated the zooplankton population, constituting 27.09,

28.20, 28.77, 29.37 and 30.03 % of the total zooplankton population in T1, T2, T3, T4 and T5, respectively. Among the different zooplankton groups, ostracods were least in number, constituting only 10.75, 10.62, 10.52, 10.56 and 10.21% of the total zooplankton in T1, T2, T3, T4 and T5, respectively. Among different zooplankton groups, significantly higher ( $P \leq 0.05$ ) copepods more recorded in T5 (30.03%). Predominance of different zooplankton groups was in order: Copepod > Cladocera > Rotifera > Protozoa > Ostracoda (Table 3). The results reveal that fermented water hyacinth leaf meal did not alter the predominance order of different zooplankton groups in any of the treatments. Sahu *et al.*, (2002) reported better planktonic growth and higher productivity by the application of water hyacinth fertilizer in ponds. Whereas, Edwards *et al.*, (1985) observed better growth and feed utilization efficiency in tilapia, *Oreochromis niloticus* fed pelleted diets formulated with 75% composted water hyacinth. Diets containing the fermented water hyacinth might have enriched the water, leading to increased zooplankton population.

## **Effect of fermented water hyacinth on Gut content analysis (%)**

Gut content analysis indicate the food and feeding habits of fish. Feeding is one of the most important basic functions of an organism required for growth, development, reproduction etc. Gut content analysis of different fish species has been studied by Mookherjee *et al.*, (1964), Hyslop (1980), Pillay (1952) and Windell and Bowen (1978) classified the feeding habits of some fishes on the basis of the presence of maximum percentage of the type of food in the gut of fish. Das and Moitra (1963) classified fishes into herbivorous, which feed on plant materials and omnivorous, which feed on one or more groups of organism i.e. plankton, detritus etc. Hynes (1950) and Pillay (1952)

have reviewed the various methods employed in the study of the food of the fishes. In the present study, gut content of common carp, *Cyprinus carpio* was studied at the end of the experiment.

In different treatments, gut content (%) of fish were analyzed, phytoplankton and zooplankton were observed maximum (37.98 and 13.24% respectively) in T5 and minimum (23.49 and 4.67% respectively) in T1 treatment. Detritus was maximum in T1 and minimum in T5 treatment, unidentified matter was maximum in T2 and minimum in T5 treatment and the difference among the treatments were significant ( $P \leq 0.05$ ) (Table 4).

In the present study, fermented water hyacinth leaf meal enhanced phyto and zooplankton production and subsequent consumption by fish in treatment T5 compared to control treatment (CM), which was observed in the gut content analysis of the fish. Whereas, in treatment (CM), detritus matter was observed more in gut content of the fish, as compared to other treatments. Kangombe *et al.*, (2006), worked on the effect of using different types of feeds on plankton abundance and on growth and survival of *Tilapia rendalli* in ponds and concluded that the gut contents analysis of the fish were variable, depended on the type of diets used. The un-utilized feed might have liberated nutrients for plankton growth and subsequent consumption by the fish.

Fisheries in India are a very important farming activity and a flourishing sector with varied resources and potentials. Around 80% of fish farmers are either marginal or small scale farmers and are unable to afford expensive fish feed and chemical fertilizers, for them feed prepared by unconventional source like water hyacinth leaf meal is an alternative to conventional source to improve

pond production and productivity. In the present study, fermented water hyacinth supplementation in common carp feed had significant impact on the pond productivity and gut content analysis of fish, as it helped to enhance the phytoplankton and zooplankton production and its subsequent consumption by the fish. Fermented water hyacinth leaf meal can partially replace rice bran in the common carp diet to reduce the cost of feed and improving the pond productivity.

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