Composition of Plankton in Waters and Digestive of Vanname Shrimp (Litopenaeus vannamei) with Semi-biofloc System of Cultivation

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Abstract

Vaname shrimp is one of the Indonesian fishery commodities which is cultivated by applying a high stocking density of an intensive system. The application of high stocking densities can lead to an increase in artificial feeding and not all feed is eaten. The increase in organic matter and nutrients in the waters also increases the production of plankton, especially phytoplankton. This study aims to determine the composition of plankton in pond waters and the stomach or digestive tract of vannamei shrimp that are cultivated in ponds with a semi biofloc system. This study used a survey method and was statistically analyzed using Ms. Excel and Canonical Correlation Analysis (CCA). Parameters observed were the abundance and composition of phytoplankton and zooplankton in pond waters, the composition of phytoplankton and zooplankton in the stomach or digestive tract of shrimp, Ivlev selection index and water quality parameters. The results showed that the abundance and composition of the phytoplankton found in pond waters were Chlorophyta, Bacillarophyta, Cyanophyta, Charophyta and Dinoflagelata. The abundance and composition of the identified zooplankton consisted of Ciliophora, Rotifera and Arthropods. Meanwhile, in the stomach of the shrimp, the types of phytoplankton and zooplankton identified consisted of Chlorophyta and Cyanophyta and Rotifera. Based on the Ivlev selection index, the type of phytoplankton identified in the water and stomach is $-1<E<0$ and is an unpopular food for vannamei shrimp. While the Ivlev zooplankton selection index $0<E<1$ is a food favored by vannamei shrimp. The results of the Canonical Correlation (CCA) analysis show that all water quality parameters correlate with the abundance and presence of plankton in the waters of vannamei shrimp ponds reared with a semi biofloc system. In particular, the abundance of Chlorophyta and Cyanophyta had a high correlation with DO, TOM and pH, while Bacillarophyta, Ciliophora, Dinoflagelata, Arthropoda and Rotifera had a low to high correlation with all water quality parameters. This shows that the abundance and presence of plankton in pond waters is needed to determine the level of water fertility and can also be used as natural food for shrimp.

Key Words: Litopenaeus vannamei, Zooplankton, Phytoplankton, Semi-biofloc and Ivlev Index

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Introduction

Vaname shrimp (Litopenaeus vannamei) is one of the potential fishery commodities in Indonesia, this is because it has advantages such as disease resistance, relatively fast growth, responsive to feed, can be cultivated in a wide range of salinity and can be maintained with sufficient stocking density. high and relatively short maintenance time (Zainuddin et al., 2019). The advantage possessed by these shrimps is that they allow them to be cultivated by applying high stocking densities, namely using intensive system cultivation. Intensive system shrimp farming is a cultivation system technology

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that applies high stocking densities and the use of additional feed (artificial feed) as the main feed (Romadhona et al., 2016).

The application of high stocking densities can also trigger an increase in the amount of artificial feeding. However, not all of the feed given will be consumed by the shrimp, so that the remaining feed can cause a decrease in pond water quality such as an increase in the content of organic matter and other nutrients (Torun et al., 2022). The decrease in pond water quality causes a decrease in shrimp survival and ultimately a decrease in shrimp production. In addition, an increase in organic matter and nutrients in these waters also increases the production of plankton, especially phytoplankton (Arifin et al., 2017).

Increased plankton production in intensive ponds is usually marked by a decrease in the brightness of pond waters and plankton blooms also occur. If the plankton density is excessive in the pond, it will also disrupt the life of the shrimp being cultivated because there will be excessive O2 production during the photosynthesis process. Excessive O2 concentrations will interfere with shrimp respiration, where if O2 reaches a saturation level it will cause gas embolism in the shrimp gill tissue (Katmoko et al., 2021).

The presence of plankton in intensive ponds is also useful as natural food, it can make ponds shaded during the day, suppresses the growth of glistening, helps absorb harmful compounds such as nitrites, nitrates and ammonia, especially by phytoplankton (Kamilia et al., 2021). Although the presence of plankton has benefits for pond ecosystems, plankton production must also be managed properly so that plankton blooms do not occur, especially phytoplankton. Therefore, this study aims to determine the composition of plankton in pond waters and the stomach or digestive tract of vannamei shrimp that are cultivated in ponds with a semi-biofloc system.

Methods

Location and Time of Research

This research was conducted using a survey method at the Shrimp Cultivation Intensive Pond, Laboratory of Brackish and Marine Water Fisheries, Faculty of Fisheries and Marine Sciences, Universitas Brawijaya (Figure 1) located in Probolinggo City, East Java Province (7o44'32.0''N 113o13'58,3' 'BT). While the sample observations were carried out at the Laboratory of Technical Implementation Unit for Freshwater Fisheries, Sumberpasir, Faculty of Fisheries and Marine Sciences, Universitas Brawijaya. Water and shrimp samples were taken in 3 ponds and water samples for plankton were taken once a week during one cycle of shrimp farming. This research lasted for 5 months, namely January – May 2022

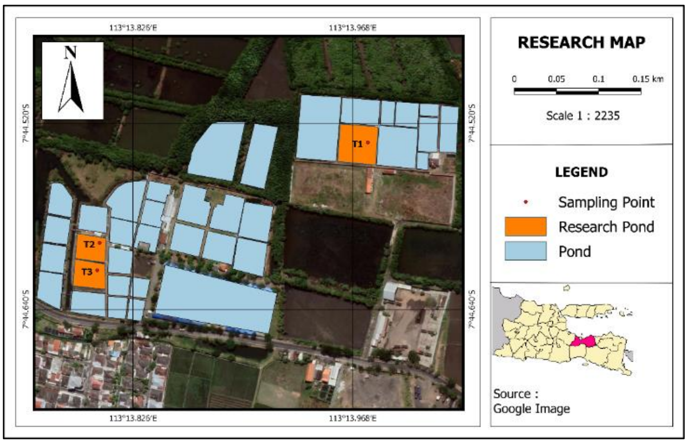

Figure 1. Map of Research Locations

Collection and Observation of Plankton in Water

Sampling of pond water to identify the type of plankton is taken at a depth of 0 – 0.5 m below the surface of the water and is carried out once a week during one cycle of shrimp farming. The water sample was filtered using a plankton net (net size 25 μm) and collected in a plastic bottle with a volume of 60 ml. Then preserved with 1% Lugol's solution and 2% formalin (Saraceni and Ruggiu, 1974). Identification of plankton species was carried out using an Olympus cx 33 microscope with 40x magnification (Hartley, 1996).

Sampling and Observation of Shrimp Digestive Tract or Stomach

Vaname shrimp were taken as many as 3-5 shrimp from each pond plot and then their stomachs were taken (Chan, 1998; Holthuis, 1980). Then measure the total body length of the shrimp with a ruler and weigh the weight of the shrimp using a digital scale. Next, the vannamei shrimp will be observed for their stomach and digestive tract. Then put the shrimp in a plastic that has been given a 4% formalin solution and labeled on each plastic and put into a cool box to be taken to the Sumberpasir Freshwater Fisheries Technical Implementation Unit Laboratory, Faculty of Fisheries and Marine Sciences for observation.

The shrimp sample was removed from the plastic bag and immersed in the petridish with enough water to reduce the formalin content. Furthermore, the shrimp is cut so that the stomach or digestive tract of the shrimp is not broken. Then remove the contents of the stomach or digestive tract of the shrimp and take the contents of the stomach, place it on the petridish and dilute it sufficiently with distilled water. Then the gastric contents were observed using an Olympus type CX-33 microscope with a magnification of 10X to 400x and the observed gastric contents were in the form of plankton. Determination of the type of plankton from the stomach using the help of the Algaebase website, Marine species.org and a plankton identification book.

Water Quality Measurement

Water quality measurements were carried out at each station together with a water sampler for plankton. The water quality parameters measured included temperature, brightness, pH, dissolved oxygen, salinity, carbon dioxide (CO2), total organic matter, nitrate (NO3), phosphate (PO4-) and ammonia (NH3).

Data analysis

The abundance and composition of aquatic plankton is calculated using the modified formula "Lackey Drop" (Herawati, et al., 2019). The abundance of plankton is calculated according to the formula:

$$N = \frac{T \times V}{L \times v \times P \times W} \times n$$

Information :

N : Abundance (eng/l)

n : Number of plankton in the field of view

T : Cover glass area

V : The volume of the plankton sample in the collection bottle

L: field of view

v : Volume of plankton sample under cover glass

P : Number of visual fields (5)

W : Volume of filtered water

Based on research (Herawati et al., 2019), calculating the plankton composition in the shrimp stomach can use the gravimetric method with the following formula:

$$\text{Fitoplankton } (a): \%Xa = \frac{a}{a+b} \times 100\%$$

$$\text{Zooplankton } (b): \%Xb = \frac{b}{a+b} \times 100\%$$

Information:

Xa : Composition of Phytoplankton

Xb : Composition of Zooplankton

a : Phytoplankton

b : Zooplankton

a + b : Number of plankton found

The diversity of plankton in the stomach or digestive tract of shrimp can indicate the eating habits of these shrimp. Shrimp food, especially plankton found in the waters, is not necessarily the type of food that is preferred by shrimp. Comparison between plankton in the waters and the stomach can be seen from the selection index. The preferred index for determining the eating habits of the shrimp is with the following Ivlev (Effendie, 1979) preferred index:

$$E = \frac{ri - pi}{ri + pi}$$

Information:

E : Preferred Index

ri : The relative number of types of organisms eaten

pi : Relative number of kinds of organisms in the waters

All data were statistically analyzed using Ms. Excel 2019 and the types of plankton identified were analyzed descriptively. Furthermore, it was also analyzed using Canonical Correlation Analysis (CCA) to describe the relationship between water quality parameters and the abundance of plankton identified in intensive pond waters with a semi biofloc system.

Results and Discussion

Phytoplankton Abundance and Composition

Phytoplankton found in semi biofloc ponds consists of 5 phyla, namely Chlorophyta, Bacillarophyta, Cyanophyta, Charophyta and Dinoflagelata. Phylum Chlorophyta consists of 6 genera found namely Chlamidomonas, Chlorella, Dunalliela, Dictyosphaerium, Golenkinia and Oocystis. The phylum Bacillarophyta consists of 16 genera found namely Achnanthidium, Chaetoceros, Coscinodicus, Cyclotella, Cylindrotheca, Cymbella, Entomoneis, Gyrosigma, Isthmia, Navicula, Nitzschia, Skeletonema, Synedra, Synura, Thalasiosira, Lithodesmium. Phylum Cyanophyta consists of 6 genera found, namely Anabaena, Chroococcus, Gloeothace, Phormidium, Pseudanabaena and Spirulina. Phylum Charophyta only consists of 1 genus, namely Cosmarium. While the Dinoflagellate Phylum consists of 2 genera found, namely Gymnodinium, Preperidinium and Protoperidinium.

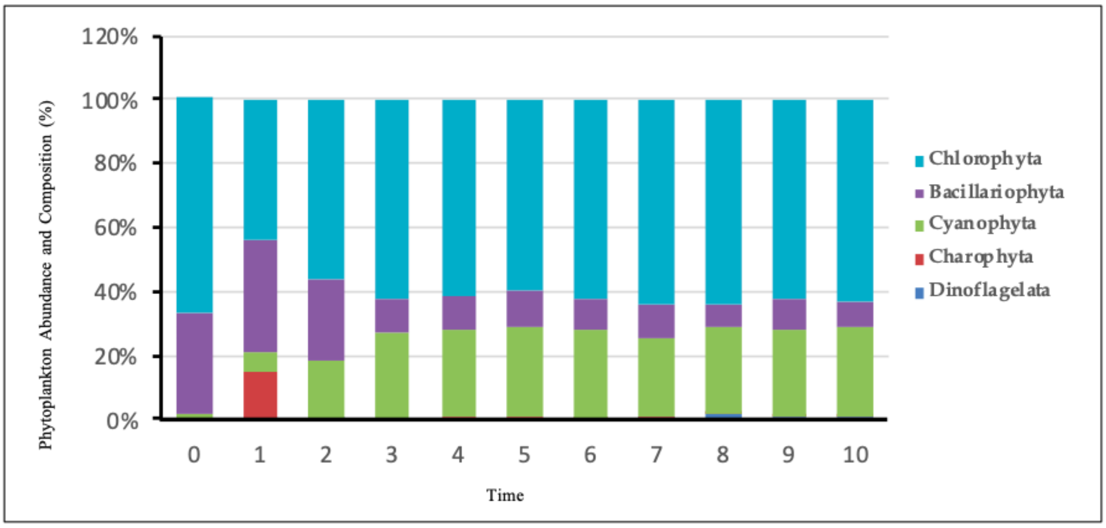

Figure 2. Graph of Phytoplankton Abundance and Composition in Pond Waters

Based on Fig. 2, the composition of the phytoplankton found during observations in the ponds of the semi biofloc system showed that the Chlorophyta phylum showed the highest percentage of abundance, ranging from 44% - 67% during one cycle of shrimp cultivation. The highest percentage was at the time before stocking, namely 67% and only in the 1st week, the lowest percentage was 44%, but then during the rearing of phylum Chlorophyta shrimp it was still the highest until harvest. The most common species from the Chlorophyta phylum is Chlorella. The Chlorophyta phylum that is commonly found in these ponds can be affected by brightness because Chlorophyta is the largest phylum of the type of phytoplankton or algal vegetation in the waters, the fast metabolic rate is due to the fact that most have chlorophyll a and b for photosynthesis (Fauziah and Laily, 2015). One of the species from the Chlorophyta phylum which has a cosmopolitan nature, namely Chlorella, means that it can grow in any waters except waters that are critical for its life (Yuni and Mustaqim, 2020). Renitasari and Musa (2020) state that cultivation water that is suitable for cultivation is green in color and because it is dominated by Chlorella.

Abundance and Composition of Zooplankton

The zooplankton identified in this semi biofloc pond system consist of 3 phyla, namely Ciliophora, Rotifera and Arthropoda. Phylum Ciliophora consists of 7 identified genera, namely Strombidium, Acineta, Euplotes, Cymatocylis, Mesodinium, Vorticella and Zoothamnium. Phylum Rotifera consists of 5 genera found namely Branchionus, Euchlanis, Asplachna, Mytillina, Notommata. Phylum Arthropoda also found 1 genus, namely Copepoda.

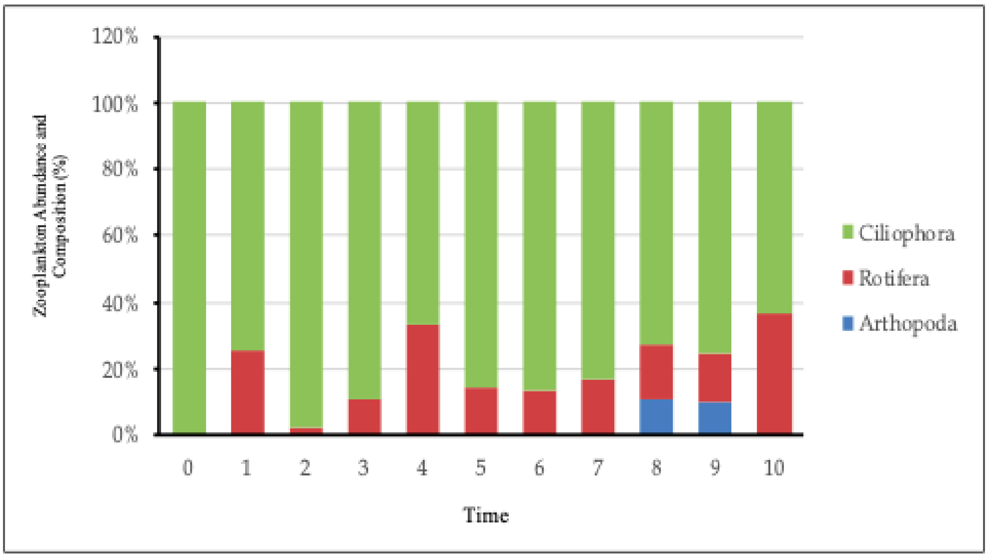

Figure 3. Graph of Zooplankton Abundance and Composition in Pond Waters

Based on Fig. 3, the highest percentage of zooplankton abundance and composition is Ciliophora, which ranges from 64% - 100%. The most common species from the Ciliophora phylum is Euplotes. The high percentage of the composition of the Ciliophora phylum is thought to be due to its ability to survive in poor aquatic environmental conditions and utilize organic matter for food, short reproduction and the ability to live attached to other biota (Warindra et al., 2020).

The phylum with the highest percentage of composition was found, namely the Rotifera phylum, which was the highest at 36% and the branchious genus that dominated. Phylum Rotifera is one of the natural foods needed by fish and shrimp larvae to grow to the adult phase and can live in temperature changes such as changes in dry and rainy seasons (Badjoeri and Yustiawati, 2021). In addition, Rotifers are also able to live in conditions of high density and grow faster (Letsoin et al., 2013). Meanwhile, the phylum with the least percentage of composition was found, namely the Arthropoda phylum with 11%, namely the Copepoda genus.

Composition of Plankton in Shrimp Stomach

Shrimp stomachs were taken to identify the type of plankton consumed by vannamei shrimp reared in this semi biofloc pond. The shrimp stomach contents were taken and identification of the type of plankton found, both phytoplankton and zooplankton. Stomach identification of vannamei shrimp is to determine the eating habits consumed by shrimp reared in ponds. Based on Fig 4, the percentage of phytoplankton composition found in the hull of vannamei shrimp is 78% consisting of 2 phyla, namely Chlorophyta and Cyanophyta. Phylum Chlorophyta consists of 2 genera, namely the genus Chlorella. and the Dictyophaerium. While the phylum Cyanophyta found 1 genus, namely the genus Chrococcus. While the percentage of zooplankton composition is 22% consisting of 1 Rotifera phylum, namely the Branchionus genus. Vannamei shrimp are omnivore scavenger animals or eat everything in the form of animals and plants and vannamei shrimp also tend to swim in all water columns so that they can utilize natural food such as plankton and detritus in pond waters (Supono, 2017).

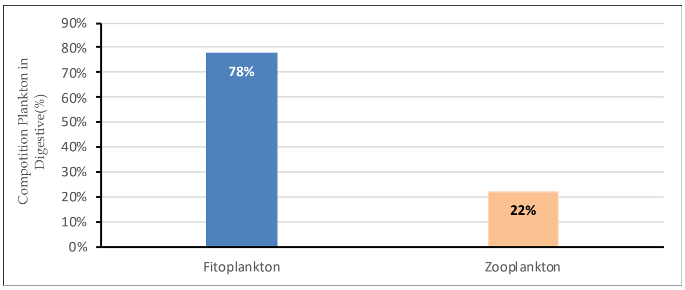

Figure 4. Graph of Plankton Composition in Shrimp Hulls

Ivlev Options Index

Based on previous results, vannamei shrimp tend to eat most of the plankton found in the waters, but it is not yet known which food is the preferred food. Ivlev choice index is used to determine the tendency of shrimp to eat what is consumed and what is not consumed. The value of the food choice index can be seen if the value ranges from 0<E<1, it means the food is liked and if the value is -1<E<0 it means the food is not liked (Tresna et al., 2012). The types of phytoplankton found in pond waters are Bacillariophyta, Cyanophyta, Chlorophyta, Charophyta and Dinoflagelata. However, in the stomach only found Cyanophyta and Chlorophyta.

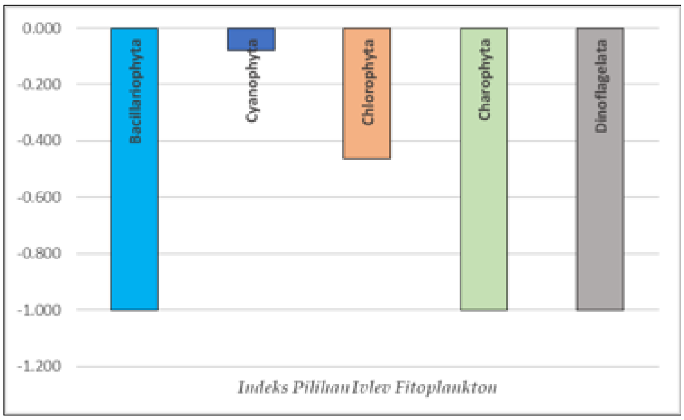

Figure 5. Graph of Phytoplankton Choice Index

Based on Figure 5, that there is no plankton phylum favored by vannamei shrimp cultivated with a semi biofloc system. It can be seen that the choice index value, namely -1<E<0, is a phytoplankton found in waters that is not favored by vannamei shrimp. Shrimp have a preference for feed determined by various factors both in terms of distribution and availability of the feed, choice of feed and water quality parameter factors (Effendie, 2002).

Ivlev's preferred index for zooplankton can be seen in Fig. 6 that the zooplankton found in the waters are the phyla Rotifera, Ciliophora and Arhropoda. While the zooplankton found in the stomach of the shrimp is Rotifera and the index value is 0<E<1 which means that the type of rotifer is the preferred food for vannamei shrimp which are cultivated in ponds with a semi biofloc system. This is presumably due to the presence of flocs in the ponds of this semi biofloc system which contain organic matter containing nutrients originating from rotifers, protozoa, bacteria, nematodes and flagellates (Rivera et al., 2014).

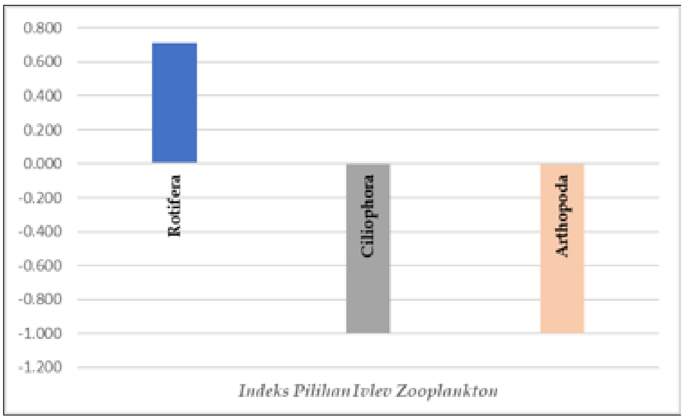

Figure 6. Graph of Zooplankton Selection Index

Water quality

Observation of water quality is intended to determine changes in water conditions which will affect the growth conditions of shrimp and plankton. The results of water quality measurements during the study are presented in Table 1 below:

Table 1. Observed water quality parameters

Chemical Physics Parameters	Water Chemistry Physics Range Values	Optimum Range
Temperature	28.1 – 30.0 °C	26 – 32 °C (Edy *et al.*, 2010)
Brightness	31.4 – 84.0 cm	30 – 40 cm (Edy *et al.*, 2010)
Dissolved Oxygen (DO)	6.4 – 7.9 mg/L	> 4 mg/l (Edy *et al.*, 2010)
Salinity	18.4 – 21.9 ppt	5 – 35 ppt (Edy *et al.*, 2010)
Ph	7 – 8	7 – 8 (Hernandez *et al.*, 2011)
Carbon dioxide (CO_2)	0 mg/l	< 5 mg/l (Furtado *et al.*, 2017)
Total Organic Matter (TOM)	8.43 – 50.03 mg/L	< 90 mg/l (Edy *et al.*, 2010)
Nitrate	0.02 – 0.14 mg/L	< 10 mg/l (Edy *et al.*, 2010)
Phosphate	0.02 – 0.014 mg/L	< 0.2 mg/l (Edy *et al.*, 2010)
Ammonia	0.01 – 0.09 mg/L	< 0.1 mg/l (Castaneda *et al.*, 2018)

Based on the results of water quality analysis showed that the concentration of water quality parameters during the rearing period was in the optimum range for shrimp culture and plankton growth. However, the brightness parameter is in a high range for the growth of shrimp and other organisms in semi-biofloc pond waters such as phytoplankton and zooplankton. The range of optimal brightness values for shrimp and plankton growth is 30 – 40 cm (Edy et al., 2010). Brightness is the intensity level of the sun entering the waters, because the sun plays a very important role in the process of photosynthesis which affects the growth of phytoplankton as primary producers in the food chain. The availability of nutrients also greatly influences the growth of plankton in the waters, especially nitrate and phosphate which support the development of phytoplankton (Simanjuntak et al., 2022).

Data Analysis

Based on the results of the Canonical Correspondence Analysis (CCA) analysis, it shows that the abundance and presence of plankton in pond waters is influenced by water quality parameters as can be seen in Fig.7.

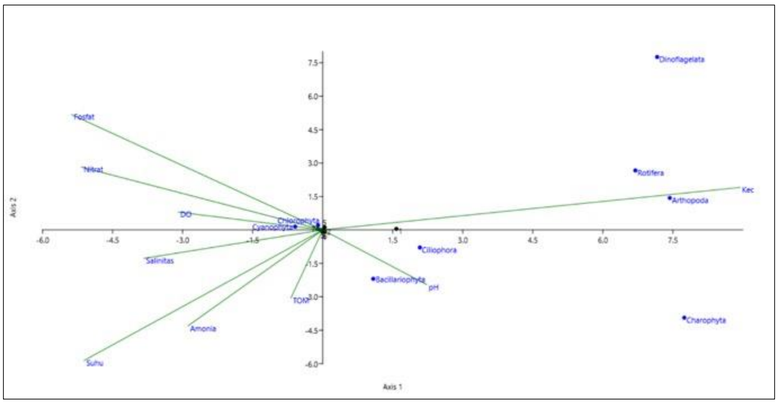

Figure 7. Effect of Water Quality on the Presence of Plankton in Ponds

The presence of phytoplankton from the Chlorophyta and Cyanophyta phyla has a high correlation with DO, TOM and pH. while phosphate, nitrate, salinity, ammonia and temperature are moderately correlated. But it correlates low with brightness. The high correlation of DO, pH and TOM with the presence of Chlorophyta and Cyanophyta is suspected because DO, pH and TOM levels support the growth and metabolic activity of Chlorophyta and Cyanophyta. Chlorophyta species can be found abundant in good conditions of DO, temperature, PH, salinity, phosphate and water quality parameters because chlorophyta is a species of phytoplankton that has a wide range of water quality parameters (Thakur et al., 2013; Mohebbi et al., 2016) . Likewise, the presence of Bacillarophyta has a high correlation with pH and a low to moderate correlation with phosphate and nitrate and brightness. The presence of arthropods has a high correlation with brightness and low correlation with other water quality parameters such as pH, TOM, ammonia, temperature, salinity, DO, nitrate and phosphate. Ciliophora has moderate correlation with pH and low correlation with phosphate, nitrate and DO. However, the abundance of Rotifera was highly associated with brightness and moderate with salinity. The presence of Charophyta and Dinoflagelata correlated low with all parameters of pond water quality in this semi biofloc system. The abundance and presence of plankton in a water is influenced by water quality parameters and nutrient levels such as phosphate and nitrate (Wilson et al., 2018).

Conclusion

It can be concluded that the abundance and composition of plankton found in the pond waters of the semi biofloc system are Chlorophyta, Bacillarophyta, Cyanophyta, Charophyta, Dinoflagelata, Ciliophora, Rotifera and Arthropods. Meanwhile, in the shrimp stomach, Chlorophyta and Cyanophyta and Rotifera were identified. The Ivlev selection index for phytoplankton is an unpopular food for vannamei shrimp. Meanwhile, zooplankton is the food favored by vannamei shrimp, namely rotifers. The results of the Canonical Correspondence Analysis (CCA) show that the presence and abundance of identified plankton in vaname shrimp ponds with a semi-biofloc system are influenced by water quality parameters, especially DO, TOM and pH and brightness.

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