# Culture of the zooplankton as fish food: observations on three freshwater species from Assam, India

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**Abstract**. A laboratory trial for the growth and production of the three species of zooplankton was made to highlight their use as fish food. The species *Moina micrura, Scapholeberis kingi* and *Brachionus calyciflorus* were considered against cow dung cake, oil cake and the artificial fish food as resources for growth. Observations over a period of 30 days revealed that the growth of the zooplankton were considerably high with cow dung and oil cake estimated through the instantaneous rate of increase and the proportion of the egg bearing females. While the significant differences in the food type for the growth of the zooplankton were observed, in all instances, the production remained high indicating about the prospective use as fish food. The growth pattern and the population dynamics of the three zooplankton species under the relatively economical food type support cost effective culture for large scale production and use in the aquaculture industry. Further studies including other zooplankton species and using the different food type for the growth can prove helpful in determining the feasibility of the zooplankton in supporting the growth of the juveniles of the freshwater fish species and the shell fishes.
**Key Words**: zooplankton, live fish food, aquaculture, oil cake, cow dung cake.

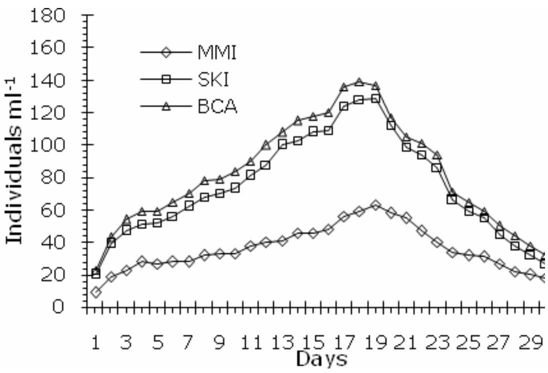
**Introduction**. The sustenance of wide variety of freshwater organisms including fish is dependent on the zooplankton. In commercial aquaculture, the fingerlings of different fish species are nurtured with the live or processed zooplankton to achieve desired growth. In natural habitats, the zooplankton constitutes the bulk of the staple food of different fish species revealed through the gut content analysis. The relevance of the zooplankton in commercial aquaculture prompted the initiation and culture of several species under artificial condition. As a live feed, the zooplankton are preferred resources with high quality protein and lipid contents essential for the growth and survival of the fish larvae (Velasco-Santamaría & Corredor-Santamaría 2011; Shil et al 2013). In many instances, the intensive culture of the fish larvae is made possible through the supply of the cultured zooplankton. Although the zooplankton are considered as rich resources for the growth and survival of commercially cultured fish species, the culture and adequate production requires to be economically feasible. In most instances, the larval fish derives the nutrition in full or at least in major part from the zooplankton food resources and therefore the culture of the zooplankton is being promoted irrespective of the fish species (Silas 1982; Geiger 1983). The rotifers and *Artemia* are mostly used in the rearing of the fish larvae (Stemberger 1981), though the use of the calanoid copepod and cladocerans are also noted in several instances (Stemberger & Gilbert 1985; Tessier & Goulden 1987; Schulze et al 1995; Begum et al 2013). However, prior to promoting the zooplankton species as live food for the fish culture the feasibility of the culture is to be noted.

In recent years the culture methods for different zooplankton have been explored that provides adequate options for continuation of the culture in small as well as large scale. The artificial culture of the cladoderans like *Diaphanosoma celebensis* (Khatoon et al 2013), *Ceriodaphnia* and *Moina* (Pena Aguado et al 2005), the copepods, like *Acrodiaptomus* (Temerova et al 2002), *Acartia tonsa* (Øie et al 2017) and *Centropages hamatus* (Jakobsen et al 2016) and rotifers (Folkvord et al 2016) like *Brachionus* (Pena Aguado et al 2005; Maehre et al 2013) are established to meet the demand of the live food for the fish larvae in commercial aquaculture. The culture of the zooplankton is carried out to increase the nutritional quality with enhanced lipid and protein content that may facilitate the growth of the fish larvae. Owing to the advantage of incorporation of the precursor molecules through the food of the zooplankton, the desired level of nutrient can be manipulated in the concerned species benefiting the growth of the fish species (Velasco-Santamaría & Corredor-Santamaría 2011). The culture of the zooplankton is also accomplished in waste water with little or no accumulation of the pollutants from the ambient environment (Nandini & Sarma 2003; Nandini et al 2004). Keeping in view the advantages of the zooplankton as food and the ease of culture, the present study was carried out to highlight the prospective growth and survival of three zooplankton species *Moina micrura, Scapholeberis kingi* and *Brachionus calyciflorus* under artificial culture in the laboratory. Since the zooplankton are in abundance in the freshwater habitat of the concerned geographical region, as well as in Indian context, the culture method may enable exploitation of the zooplankton as a resource for fish species, thereby adding value as a natural resource. While the multiple ecological role of the zooplankton species qualify them as a valued natural resources, promoting the species as live feed for fish species would enhance the value and bring economic benefit in aquaculture sector. Earlier studies have attempted the culture of the species using different substrate, but in the present instance the cowdung and oil cake will be used as a resource for the growth of the zooplankton, thereby providing an economic means of culturing the zooplankton at large scale.

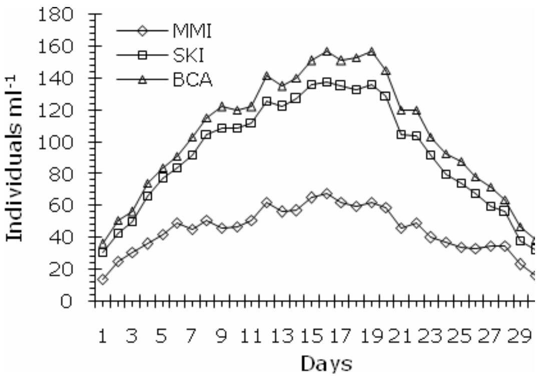
**Material and Method**. In the present study three zooplankton species, viz., two Cladocera, *Moina micrura, Scapholeberis kingi* and a Rotifera*, Brachionus calyciflorus* were considered post segregation from assorted species of the zooplankton collected from the ox-bow lakes. During the summer of 2015, as a part of the laboratory studies, samples of zooplankton collected from the freshwater ox-bow lakes were brought to the laboratory and segregated initially as a genus and finally through several levels of segregation into the species level. The segregated individuals were placed separately in glass jar (1000 mL in volume) using the cowdung cake as food and kept for one week time period to observe the variations in the zooplankton density in the culture containers. Following establishment of the culture medium and the segregation of the plankton into smaller sized individuals, the study was initiated with observations on the number of individuals in unit space in the containers. The data on the number of individuals per unit space was used as a response variable for growth with reference to the different food types as a source of energy for the species level. A total of 27 glass aquaria (each of size 15 cm x 15 cm x 15 cm) with aeration (SoBo, China) of 36 hours were maintained for culture medium. Prior to experimentation, these tanks were washed thoroughly dried and then filled with 2L of filtered water. The water was kept for 3 days. On the $4^{th}$ day, three different kinds of food viz, cowdung cake (2 g + 2 L of water), oil cake (2 g + 2 L of water) and artificial fish food (2 g + 2 L of water) were introduced. For each food type, three replicates were used. The culture was maintained at least for 1 month under standard laboratory conditions, prior to culture, the pH of the tank was calculated to be 6.5. Each replicate were introduced with 10 neonates of each species. Following initiation in growth of the species, the number of individuals was counted daily using Sedgewick – Rafter counting cell (50 mm x 20 mm x 1 mm). The process was carried out until the number of individuals started decreasing in number day by day. The water of the zooplankton culture aquarium were changed every week and supplied with fresh food in each aquarium. Water temperature (°C) of the culture media was recorded by using mercury thermometer.

***Data analysis***. The data on the growth of the zooplankton was assessed employing ANOVA and logistic regression to highlight the differences in the food type and the species on the growth of the respective zooplankton species. In case of the logistic regression (binomial Generalized linear model with logit link), the explanatory variables were the type of the zooplankton and the food source for their growth and the number of individuals (indicator of growth) of the zooplankton as the response variables counted over the time period of one month. The logistic regression was of the form: (y) = $1/(1+\exp(-(a + b_1x_1 + b_2x_2)))$, where, y is the dependent variable (species abundance ) and $x_1$ and $x_2$ are the explanatory variables (species of zooplankton and the type of food for the growth of the zooplankton). The assumption was that the species abundance (individuals of the zooplankton species in culture) follows the binomial distribution (n, p) with n replicates (days of observations) for each zooplankton species and food types (explanatory variables). The probability parameter p represents the linear combination of the zooplankton species and the food types (explanatory variable). A Wald's chisquare was used to justify the significance of the parameters of the model considered in the regression equation (Zar 1999). In addition, the growth of the individual zooplankton species against a particular food type was monitored using the finite rate of increase, $\lambda_t$, which was considered as $N_t/N_0$, $N_t$ the numbers in the containers at the end of the time period t and N0 the numbers in the containers at the beginning of the time period. However, the $\lambda_t$ was estimated for each day for the 30 day time period of the culture. A Kruskal-Wallis ANOVA was applied to justify whether the $\lambda_t$ differed with the species and the type of foods provided in the culture. The analyses were carried out using *XL*STAT software (Addinsoft 2010).

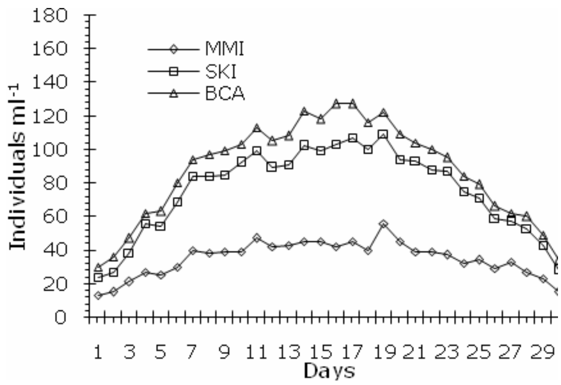
**Results**. All the three different species of the zooplankton namely *M. micrura*, *S. kingi*, *B. calyciflorus* remained in living state in the culture vessels for the whole study period. Increment in the number of the individuals for the three species varied considerably though the trends in growth were similar. The food resource dependent variations were prominent for the three species (Figure 1). The application of the ANOVA revealed significant differences (Table 1) in the growth with reference to the species and the food resources as the source of variations. While the differences between the fish food and the oil cake were not observed, the cow dung cake as food resource appeared to be significantly different from the rest of the two. The bionomial generalized linear model (GLM) indicated that the species and the food resources contributed significantly to the variations in the growth of the zooplankton cultured in the laboratory condition. The logistic regression could be represented as Abundance = 1/(1 + exp(-(-4.72 + 0.17*Species + 0.12*Food - 0.08*Species*Food)), where the parameters of the model were significant at $p < 0.001$ level (Intercept - 4.72 ±; Wald's Chisquare = ; $p < 0.001$; species - 0.17 ±; $p < 0.0001$; food type - 0.12 ±; Wald's chi square = '; $p < 0.001$). The growth pattern of the three species, measured in terms of the $\lambda_t$, shown in Figure 2, did not exhibit significant difference among the species as well as the food type provided in the culture (for species, Kruskal Wallis K = 0.174 p = 0.912 not significant; for food type, Kruskal Wallis K = 0.007; p = 0.996 not significant). For each food type, the number of the egg bearing individuals (Figure 3) was found to differ significantly irrespective of the species concerned (for food type oil cake, $F_{2,\ 87}$ = 35.521; for cow dung cake, F2,87 = 33.494; for artificial fish food, $F_{2,\ 87}$ = 133.427; all values are significant at $p < 0.0001$ level).




(a) Fish food as food resource




(b) Cow dung cake as food resource




(c) Oil cake as food resource

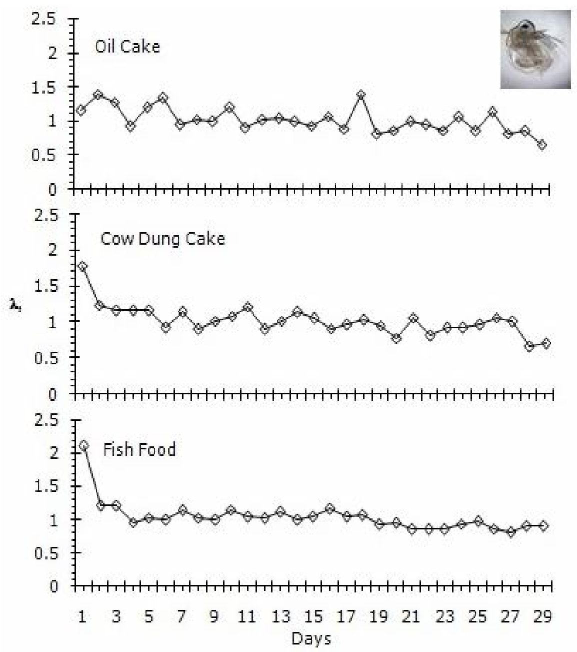
Figure 1. The number of individuals of the three species of zooplankton cultured under three different food sources, (a) artificial food (fish food), (b) cow dung cake and (c) oil cake in restricted amount in the culture containers for a period of 30 days. Data on the number of individuals in the culture containers were taken for a period of 30 days in laboratory condition in Cachar, Assam, India. MMI – *Moina micrura*; SKI – *Scapholeberis kingi*; BCA – *Brachionus calyciflorus*.

Table 1

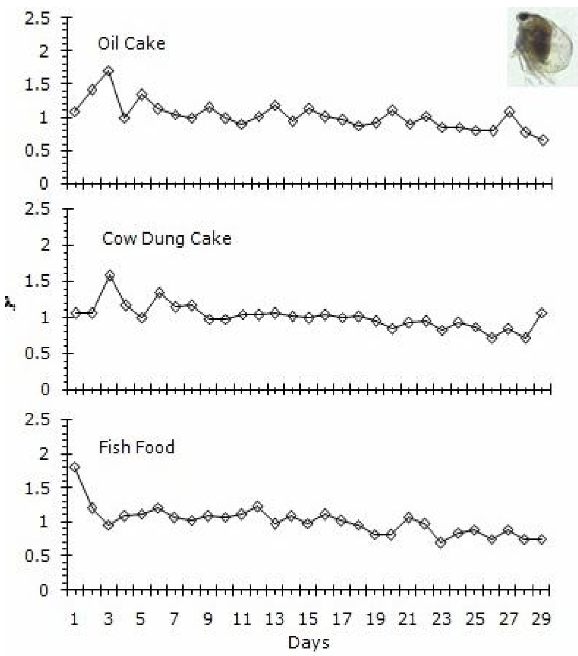
The results of ANOVA followed by the Tukey test on the growth features (numerical changes in population size) of the zooplankton species using the species type and the food resources as explanatory variables

| *Source* | *Sum of squares* | *DF* | *Mean squares* | *F* |
|---|---|---|---|---|
| Species | 53833.1 | 2 | 26916.548 | **155.285** |
| Food | 2776.096 | 2 | 1388.048 | **8.008** |
| Error | 45934.08 | 265 | 173.336 | |
| Total | 102543.3 | 269 | | |
| *Tukey test* | | | | |
| Food type | | | Species | |
| Contrast | Difference | | Contrast | Difference |
| FF vs. CC | **-3.827** | | BCA vs SKI | **-16.101** |
| FF vs OC | -0.9 | | BCA vs MMI | **-14.255** |
| CC vs. OC | **-2.927** | | MMI vs SKI | -1.846 |
| Critical value 2.344 | | | | |

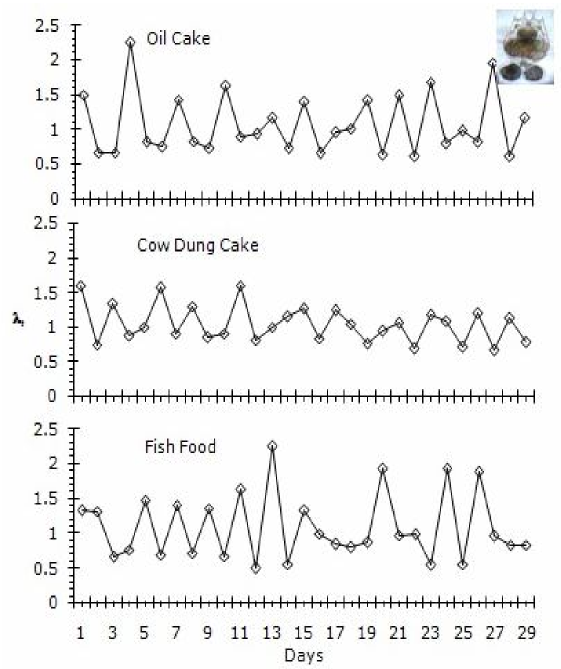
MMI – *Moina micrura*; SKI – *Scapholeberis kingi*; BCA – *Brachionus calyciflorus*; FF - fish food; CC - cowdung cake; OC - oil cake.




(a) *Moina micrura*

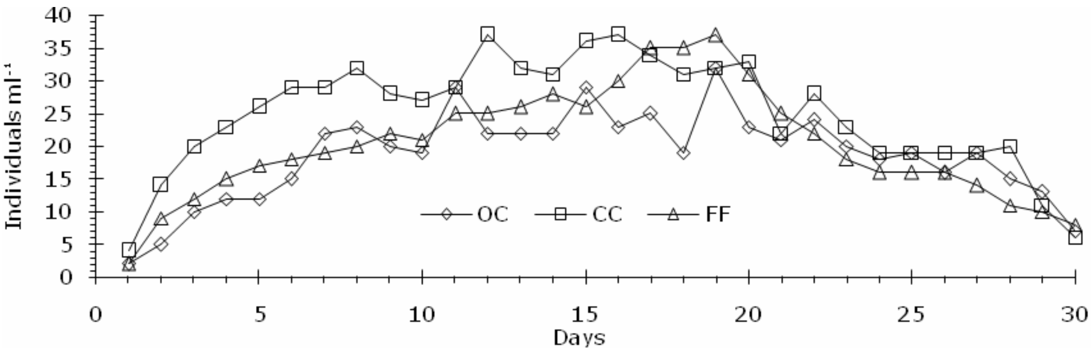



(b) *Scapholeberis kingi*

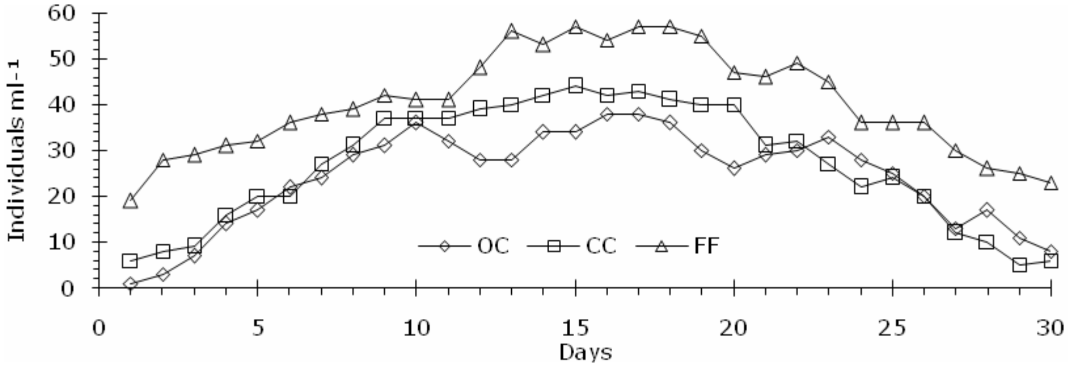



(c) *Brachyionus calyciflorus*

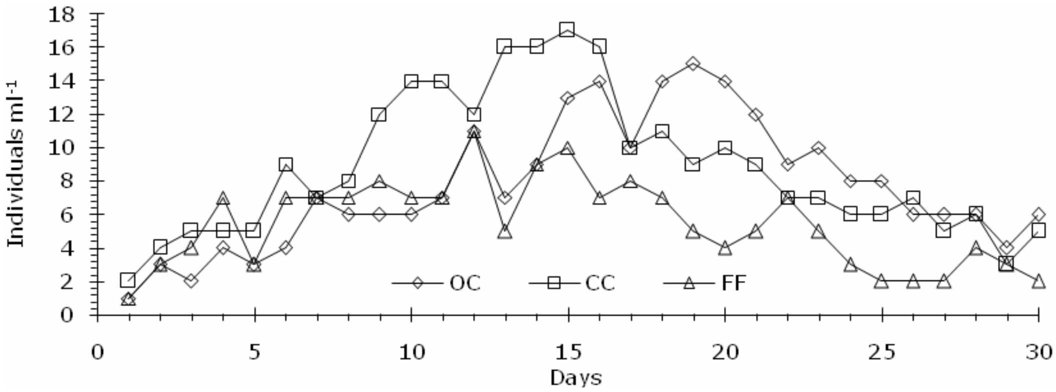
Figure 2. The growth of the three zooplankton under different food regime for a period of 30 days represented through the $\lambda_t$, an indicator of the intrinsic rate of natural increase. MMI – *Moina micrura*; SKI – *Scapholeberis kingi*; (c) – *Brachionus calyciflorus*.



(a) *Moina micrura*



(b) *Scapholeberis kingi*



(c) *Brachyionus calyciflorus*

Figure 3. The number of egg bearing females in the three zooplankton species during the culture period of 30 days allowed to grow in three different food types namely fish food (FF), cow dung cake (CC) and oil cake (OC), separately in three replicates. Data for each day is represented as cumulative of the three replicates.

The egg bearing individuals were found to be an increasing function of the population density of the concerned species of zooplankton (Figure 4), and differed among the zooplankton species as well as the food type provided in the culture (Table 2). The results indicate that the growth pattern and the use of the resources by the zooplankton varied considerably with the food type and the species concerned.

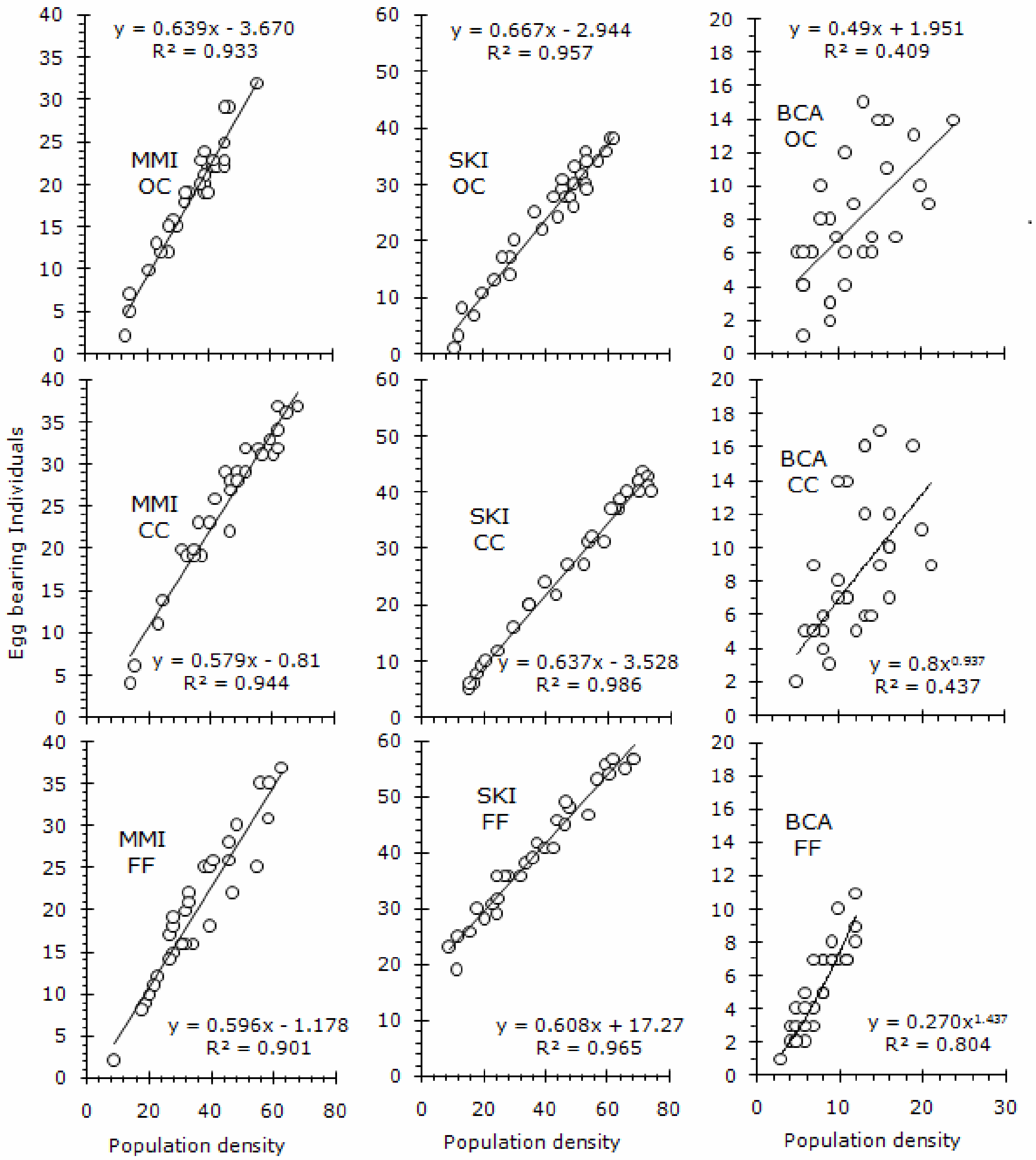



Figure 4. The ratio of the egg bearing females as a function of the density of the zooplankton in the culture containers over a period of 30 days. Each point in the graph represents the mean value of the three replicates considered in the study. MMI – *Moina micrura*; SKI – *Scapholeberis kingi*; (c) – *Brachionus calyciflorus.*

Table 2

The results of ANOVA followed by the Tukey test on the number of egg bearing individuals of the zooplankton species observed in the culture during the 30 day period of the culture

| *Source* | *Sum of squares* | *df* | *Mean squares* | *F* |
|---|---|---|---|---|
| Food (F) | 24,526.45 | 2 | 12,263.23 | **169.41** |
| Species (S) | 1,278.25 | 2 | 639.13 | **8.83** |
| F*S | 4,122.24 | 4 | 1,030.56 | **14.24** |
| Error | 18,893.30 | 261 | 72.39 | |
| Total | 48,820.24 | 269 | | |
| *Tukey test* | | | | |
| Food type | | | Species | |
| Contrast | Difference | | Contrast | Difference |
| FF vs. CC | **-5.244** | | BCA vs SKI | **-23.178** |
| FF vs OC | **-3.444** | | BCA vs MMI | **-14.011** |
| CC vs. OC | -1.800 | | MMI vs SKI | **-9.167** |
| Critical value 3.314 | | | | |

MMI – *Moina micrura*; SKI – *Scapholeberis kingi*; BCA – *Brachionus calyciflorus*; FF - fish food; CC - cowdung cake; OC - oil cake.

**Discussion**. The growth and the sustenance of the fish and shell fish in the culture fisheries are highly dependent on the supply of ample food resources. As a result the culture of the zooplankton species of choice is considered as a feasible option to supplement the necessary food requirement of the fish and shell fish. In Indian context and in several tropical and subtropical countries, the survival of the juvenile fish species and the crustaceans are in part dependent on the supplied food like the zooplankton. Species like *M. micrura and Diaphanosoma birgei* are considered as highly valued food resources for the fish species, with high protein content (Sipaúba-Tavares & Bachion 2002; Ud Din & Altaff 2010). Almost all major groups of the zooplankton are used as a food source in freshwater and marine aquaculture (Walz & Welker 1998; Schipp et al 1999; Payne & Rippingale 2001; Raskoff et al 2003), like the copepods, the cladocerans and the rotifers (Payne & Rippingale 2001). The larvae of the carps feed mainly on the zooplankton in the initial stages followed by other food types with the increase in age (Anton-Pardo & Adamek 2015), which provides one of the many reasons for the culture of the zooplankton for steady supply to the aquaculture. However, the selection of the species and the culture methods vary according to the requirements and the feasibility of the culture methods. As shown in the present instance, the waste materials like the cow dung cake and the oil cake were used as input resources for the growth of the zooplankton, justifying the use of the wastes as a food resource (Jana & Chakrabarti 1993). In carp aquaculture, the use of the waste like the cow dung and the oil cake are common to enhance the productivity of the zooplankton. Following such principle the use of the oil cake and the cow dung cakes as the food resources for the growth of two cladocerans, *M. micrura* and S. *kingi* and a rotifer species *B. calyciflorus* was shown in the present instance. The differences in the growth pattern and the increment in the population of the three species are possible reflection of the species specific adaptations in the concerned environment (Sarma et al 1998). While the differences in the rate of increase was not observed, the variations in the number of the egg bearing individuals in the three species is a reflection of the differential ability of the species to allocate resources for the reproduction and the population growth. The growth and the reproduction of *B. calyciflorus* and *M. micrura* observed in the present instance remained similar to those observed elsewhere (Nandini & Sarma 2000; Sipaúba-Tavares & Bachion 2002; Pena-Aguado et al 2005). These species are proved to be tolerant to a wide range of habitat conditions and fluctuations of the environmental quality (Hardy & Duncan 1994; Nandini et al 2004). In India, particularly in Assam and north eastern region, the species like *M. micrura* and *B. calyciflorus* are common and therefore can be selected as a species for mass culture using the waste food as shown in the present instance. In all the three different food types the growth and the reproduction remained comparable to the extent obtained when cultured using supplementary vitamins and the algae. However, the extent of the reproduction and the growth achieved using the waste foods suggest that mass rearing of the species *M. micrura, S. kingi* and *B. calyciflorus* can be accomplished in a cost effective way.

Among the zooplankton, several species of rotifers and cladocerans serve as food supplements for the larval fish and shell fish, and are thus considered significant for commercial aquaculture. The selection of the zooplankton species, as food resource as well as for artificial culture, depends on the various factors like natural abundance and availability in freshwater, growth and reproduction capability and economically sustainable (Geiger 1983; Schulze et al 1995; Ud Din & Altaff 2010; Maehre et al 2013). In addition, the use of the wastes as non-conventional food source for the culture of the zooplankton like *M. micrura*, *S. kingi* and *B. calyciflorus* provide evidence of enhancing value of the resources as fish food. The growth and the reproduction of these zooplankton species remained similar in many senses to the observations made with algae and yeast being offered as food resources (Jana & Chakrabarti 1993; Nandini & Rao 1997; Nandini & Sarma 2003). Thus the present study was successful in establishing the use of the cow dung cake and oil cake as a source of food for the culture of the zooplankton. While the use of these wastes may appear to be economical and sustainable for the mass culture of the desired species of zooplankton, the nutritional quality needs to be judged further to ascertain the food value. Considering aquaculture in Indian context and the expenditure in commercial aquaculture, the use of the cow dung cake and oil cake based mass rearing of the zooplankton seems to be a feasible alternative to sustain the fingerlings or the larval fish in natural habitats.

**Conclusions**. The laboratory based culture of the three species of the zooplankton namely *M. micrura*, *S. kingi* and *B. calyciflorus* using the wastes like oil cake and the cow dung cake as food resources justified the feasibility of the generating live fish feed at low cost. The growth, reproduction and the available numbers of the egg bearing individuals were different based on the food type used in the culture and the species concerned. However, in all instances, the growth and the reproduction of the three species of zooplankton were satisfactory to sustain the mass culture and the supply as live feed for the growth of the concerned size groups of the species. The economic feasibility for the culture of the species like *M. micrura*, *S. kingi* and *B. calyciflorus* was found to be acceptable though further study are required on the food value of the zooplankton species so as to meet the demand of the fishermen associated with large fish selling.

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## References

Addinsoft SARL, 2010 XLSTAT software, version 9.0. Addinsoft, Paris, France.

Anton-Pardo M., Adámek Z., 2015 The role of zooplankton as food in carp pond farming: a review. Journal of Applied Ichthyology 31:7-14.

Begum M., Noor P., Ahmed K. N., Mohanta L. C., Sultana N., Hasan M. R., Uddin M. N., 2013 Assessment of four different media for the mass culture of *Ceriodaphnia reticulata* (Jurine) as a live fish feed. Journal of the Asiatic Society of Bangladesh, Science 39(2):129-138.

Folkvord A., Koedijk R., Grahl-Nielsen O., Meier S., Rydland Olsen B., Blom G., Otterlei E., Imsland A. K., 2016 You are what you eat? Differences in lipid composition of cod larvae reared on natural zooplankton and enriched rotifers. Aquaculture Nutrition 00:1-12.

Geiger J. G., 1983 A review of pond zooplankton production and fertilization for the culture of larval and fingerling striped bass. Aquaculture 35:353-369.

Hardy E. R., Duncan A., 1994 Food concentration and temperature effects on life cycle characteristics of tropical Cladocera (*Daphnia gessneri* Herbst, *Diaphanosoma sarsi* Richard, *Moina reticulata* (Daday): I. Development time. Acta Amazonica 24(1-2):119-134.
Jana B. B., Chakrabarti R., 1993 Life table responses of zooplankton (*Moina micrura* Kurz and *Daphnia carinata* King) to manure application in a culture system. Aquaculture 117(3-4):273-285.
Jakobsen H. H., Jepsen P. M., Blanda E., Jørgensen N. O. G., Novac A., Engell-Sørensen K., Hansen B. W., 2016 Plankton composition and biomass development: a seasonal study of a semi-intensive outdoor system for rearing of turbot. Aquaculture Nutrition 22:1239-1250.
Khatoon H., Banerjee S., Yusoff F. M., Shariff M., 2013 Use of microalgal-enriched *Diaphanosoma celebensis* Stingelin, 1900 for rearing *Litopenaeus vannamei* (Boone, 1931) post larvae. Aquaculture Nutrition 19:163-171.
Maehre H. K., Hamre K., Elvevoll E. O., 2013 Nutrient evaluation of rotifers and zooplankton: feed for marine fish larvae. Aquaculture Nutrition 19:301-311.
Nandini S., Rao T. R., 1997 Somatic and population growth in selected cladoceran and rotifer species offered the cyanobacterium *Microcystis aeruginosa* as food. Aquatic Ecology 31:283-298.
Nandini S., Sarma S. S. S., 2000 Life table demography of four cladoceran species in relation to algal food (*Chlorella vulgaris*) density. Hydrobiologia 435:117-126.
Nandini S., Sarma S. S. S., 2003 Population growth of some genera of cladocerans (Cladocera) in relation to algal food (*Chlorella vulgaris*) levels. Hydrobiologia 491:211-219.
Nandini S., Aguilera-Lara D., Sarma S. S. S., Ramírez-García P., 2004 The ability of selected cladoceran species to utilize domestic wastewaters in Mexico City. Journal of Environmental Management 71:59-65.
Øie G., Galloway T., Sørøy M., Holmvaag Hansen M., Norheim I. A., Halseth C. K., Almli M., Berg M., Gagnat M. R., Wold P. A, Attramadal K., Hagemann A., Evjemo J. O., Kjørsvik E., 2017 Effect of cultivated copepoda (*Acartia tonsa*) in first-feeding of Atlantic cod (*Gadus morhua*) and ballan wrasse (*Labrus bergylta*) larvae. Aquaculture Nutrition 23:3-17.
Payne M. P., Rippingale R. J., 2001 Intensive cultivation of the calanoid copepod *Gladioferens imparipes*. Aquaculture 201(3-4):329-342.
Peña-Aguado F., Nandini S., Sarma S. S. S., 2005 Differences in population growth of rotifers and cladocerans raised in algal diets supplemented with yeast. Limnologica 35:298-303.
Raskoff K. A., Sommer F. A., Hamner W. H., Cross K. M., 2003 Collection and culture techniques for gelatinous zooplankton. Biological Bulletin 204(1):68-80.
Sarma S. S. S., Stevenson R. A., Nandini Y. S., 1998 Influence of food (*Chlorella vulgaris*) concentration and temperature on the population dynamics of *Brachionus calyciflorus* Pallas (Rotifera) isolated from a subtropical reservoir in Mexico. Ciencias Naturalis 5:77-81.
Schipp G. R., Bosmans J. M. P., Marshall A. J., 1999 A method for hatchery culture of tropical calanoid copepods, *Acartia* spp. Aquaculture 174(1-2):81-88.
Schulze P. C., Zagarese H. C., Williamson C. E., 1995 Competition between crustacean zooplankton in continuous cultures. Limnology and Oceanography 40(1):33-45.
Shil J., Ghosh A. K., Bazlur Rahman S. M., 2013 Abundance and diversity of zooplankton in semi-intensive prawn (*Macrobrachium rosenbergii*) farm. Springer Plus 2:183.
Silas E. G., 1982 Feed formulation methods. In: Manual of research methods for fish and shellfish nutrition. Silas E. G. (ed), CMFRI Special Publication no. 8, Central Marine Fisheries Research Institute, Cochin, India, pp. 95-98.
Sipaúba-Tavares L. H., Bachion M. A., 2002 Population growth and development of two species of cladocera, *Moina micrura* and *Diaphanosoma birgei*, in laboratory. Brazilian Journal of Biology 62(4A):701-711.
Stemberger R. S., 1981 A general approach to the culture of planktonic rotifers. Canadian Journal of Fisheries and Aquatic Sciences 38(6):721-724.

Stemberger R. S., Gilbert J. J., 1985 Body size, food concentration and population growth in planktonic rotifers. Ecology 66(4):1151-1159.
Tessier A. J., Goulden C. E., 1987 Cladoceran juvenile growth. Limnology and Oceanography 32(3):680-686.
Temerova T. A., Tolomeyev A. P., Degermendzhy A. G., 2002 Growth of dominant zooplankton species feeding on plankton microflora in Lake Shira. Aquatic Ecology 36:235-243.
Velasco-Santamaría Y., Corredor-Santamaría W., 2011 Nutritional requirements of freshwater ornamental fish: a review. Revista MVZ Cordoba 16(2):2458-2469.
Walz N., Welker M., 1998 Plankton development in a rapidly flushed lake in the river Spree system (Neuendorfer See, Northeast Germany). Journal of Plankton Research 20(11):2071-2087.
Ud Din M. W., Altaff K., 2010 Culture of zooplankton for rearing fish larvae. Pollution Research 29(2):91-93.
Zar J. H., 1999 Biostatistical analysis. IV edition, Pearson Education (Singapore) Pte. Ltd. (Indian Branch), New Delhi, India, 663 pp.

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