Culture of bloodworm (Chironomid larvae: Diptera) using North African catfish *Clarias gariepinus* waste as feed

Bambang Sulistiyarto, Restu

Faculty of Fisheries, Palangka Raya Christian University, Palangka Raya, Central Kalimantan, Indonesia. Corresponding author: B. Sulistiyarto, sulistiyarto@gmail.com

Abstract. The aim of this study was to evaluate the effect of the North African catfish *Clarias gariepinus* waste used as feed in bloodworm (Chironomidae larvae) culture. The experiment was conducted by completely randomized design with three replicates. Different food types were applied in the present study as: fresh solid waste of *C. gariepinus* (A), dried solid waste of *C. gariepinus* (B), and dried poultry manure (C). Fish waste was obtained from *C. gariepinus* culture tank fed with commercial pellet. The bloodworms of all treatments were harvested at 8th day, when the first pupae were observed. The results showed that biomass of harvested bloodworm were significantly influenced by different type of feeds. The use of dry solid waste resulted higher bloodworm biomass than the use of fresh solid waste and dried chicken manure. Biomass of the harvested bloodworm did not differ significantly between the use of fresh solid wastes and dried chicken manure. The results revealed that dried solid waste of *C. gariepinus* is very good feed for mass culture of bloodworm.

Key Words: live feed, aquatic invertebrates, mass rearing, organic waste, reuse of aquaculture waste.

Introduction. North African catfish *Clarias gariepinus* culture has been developed in Indonesia through many years in order to satisfy the increasing demand for food supply. One of the major impacts caused by *C. gariepinus* culture is the production of waste water which is rich in nutrients and suspended organic matter. Solid fish waste production reach 0.45 kg for production of 1 kg fish harvested (Yeo et al 2004). The organic carbon content of fecal material ranged from 33.7 to 46.8% dry weight (Moccia et al 2007). The discharge of aquaculture effluents could modify the limnological characteristics of the water (Pistori et al 2010).

Chironomid larvae, also known as bloodworms, are a major natural food for many species of freshwater fish (Komatsu et al 2000; Medeiros & Arthington 2008; Sulistiyarto 2010). Bloodworms contain suitable nutrients for fish farm diets (Bogut et al 2007). Bloodworms are excellent source of protein (De La Noue & Choubert 1985). Crude protein content of bloodworms is 55.62% (Thipkonglars et al 2010) and crude fat content 9.7%, being energetically sufficient for all warm-water living fish (Bogut et al 2007). Organic matter is the predominant natural food source of bloodworms (Sanseverino & Nessimian 2008). Some good sources of organic matter that had been used as feeds in bloodworm culture, includes: fish food (Habashy 2005), chicken manure (Shaw & Mark 1980; Maleknejad et al 2014), cow dung and vegetable waste (Kumar & Ramesh 2014), palm oil waste (Habib et al 1997), and yeast (Aliu et al 2014). Solid waste of *C. gariepinus* is a potential food source for bloodworms, because they are rich in organic matter (Moccia et al 2007). Naylor et al (1999) reported that chemical composition of fresh fish manure was similar to other livestock manures. Reuse of aquaculture wastes is opportune if it can be collected in sufficient quantity in a cost-effective manner (Yeo et al 2004). Reuse of aquaculture wastes can reduce load of pollutants in the environment.

The aim of our research was to examine the effect of the *C. gariepinus* waste used as feed for bloodworm culture.

Material and Method. Culture of bloodworms was conducted in aquariums (20 x 20 x 30 cm) filled with 10 L of water. The experiment was conducted by completely randomized design with three replicates. Three diets were studied including fresh solid waste of *C. gariepinus* (A), dried solid waste of *C. gariepinus* (B), and dried poultry manure (C). Fresh solid waste was offered at the rate of 30 gram/L (about 2.5 g if dried). Dried *C. gariepinus* waste and poultry manure were offered at the rate of 2.5 g/L. Fish waste was obtained from *C. gariepinus* culture tank fed with commercial pellet. Tank water waste was transferred into a settling tank for 24 hour. Accumulated solid waste at the bottom of settling tank was filtered by nylon cloth to obtained wet waste and used for treatment A. Then wet waste was dried under sunlight for 4 days, ground and sieved, used for treatment B. Poultry manure was provided from household poultry, dried under sunlight for 3 days, ground and sieved, used for treatment C. Proximate compositions of solid waste (moisture, crude protein, crude lipid, ash, organic matter) were determined according to AOAC (2000). Two egg masses (cocoons) of bloodworm were placed in each experiment aquarium. Cocoons were provided from chironomid culture cage as described by Maleknejad et al (2014). The bloodworms of all treatments were harvested at 8^{th} day, when the first pupae were observed. Harvest was done using 1 mm mesh scoop net that was rinsed under tap water to allow waste from the net to be washed away. Total harvested bloodworms were transferred to a piece of filter paper and weighed. Total body length was measured by using digital microscope. 10 larvae were measured and then mean body length was calculated. Water quality parameters were observed at the beginning and ending of the experiment including water temperature, water pH, dissolved oxygen, and total dissolved solid (TDS). Data were analyzed using one way ANOVA and means were separated by LSD (Least Significant Difference) test.

Results. *C. gariepinus* waste was obtained from three culture tanks containing 30 fish per tank with weight of 100 grams/fish reared for 14 days. The amount of solid waste obtained from the fish tank was 0.380±0.024 g dry weight/L of water. The proximate composition of the waste is presented in Table 1. The total organic carbon concentration reaches 67.8±1.14%. The nutritional content of solid waste was still high; protein content reached 24.80±12.22%.

Table 1

Proximate composition of solid waste of *Clarias gariepinus*

Culture tank	*Moisture (%)*	*Ash (%)*	*Protein (%)*	*Fat (%)*	*Organic matter (%)*
1	9.00	23.85	24.56	1.64	67.15
2	8.83	21.77	25.09	2.22	69.40
3	9.13	24.01	24.76	1.78	66.86
Average	8.99	23.21	24.80	1.88	67.80
SD	0.12	1.02	0.22	0.25	1.14

The effectiveness of solid waste of fish for culturing bloodworm was examined by comparing the use of fresh solid waste (A), dried solid waste (B) and dried chicken manure (C). The biomass of bloodworm cultured, using different types of feed is presented in Table 2. Biomass of bloodworm at the experiment termination ranged between 5.30 to 10.30 g wet weight/aquarium. Results of analysis of variance (ANOVA) showed that different types of feed significantly influenced biomass of harvested bloodworm (F_{value} = 5.32). LSD test indicated that the use of dried solid waste obtained the highest biomass of bloodworm, followed by dried chicken manure and fresh solid waste. Bloodworms length at the experiment termination ranged between 7.308 to 10.231 mm. Based on the analysis of variance (ANOVA) the length of the harvested bloodworm did not differ significantly among treatments.

Table 2

Averages biomass and body length of bloodworm at the experiment termination

Feeding regimes	*Biomass (gram)*	*Body length (mm)*
Fresh solid waste	6.83 ± 1.24^{b}	9.722 ± 1.664^{a}
Dried solid waste	9.77 ± 0.50^{a}	8.831 ± 1.974^{a}
Dried chicken manure	7.03 ± 1.66^{b}	8.062 ± 1.333^{a}

Different superscript letters show significant difference ($p<0.05$).

Water quality conditions of bloodworm culture aquariums are presented in Table 3. Results of variance analysis (ANOVA) showed that the treatment of different types of feeds significantly effected on TDS (F_{value} = 567.24), whereas parameters of water temperature, pH, and dissolved oxygen (DO) were not significantly different among the treatments. Water quality parameter that distinguished each treatment was TDS. The highest TDS value was observed of treatment with dry solid waste, followed by wet solid waste and dry chicken manure respectively.

Table 3

Water quality parameters

Parameters	*Feeding regimes*		
	Fresh solid waste	*Dried solid waste*	*Dried chicken manure*
Temperature (°C)	28.75±1.08	29.40±0.75	29.50±0.81
TDS (mg/L)	54.17±5.98	109.17±7.03	45.50±3.51
pH	7.13±0.09	7.73±0.02	6.28±0.05
DO (mg/L)	3.98±0.21	3.17±0.40	3.60±0.45

Discussion. The amount of solid waste obtained from the *C. gariepinus* tank was 0.380±0.024 g dry weight/L of water. Therefore 1 m^3 can provide 380 g dry waste, which is an enough amount for bloodworms production. The total organic carbon concentration reaches 67.8±1.14%. Organic carbon content obtained is higher than reported by Moccia et al (2007) of 33.7-46.8%. The nutritional content of solid waste was still high, protein content reaching 24.80±12.22%. Therefore, solid waste is a potential food source for other organisms cultivated like bloodworms.

The usage of dried solid waste in the present study resulted a bloodworm biomass of 9.77±0.05 g/10 L. Kumar & Ramesh (2014) produced bloodworms using cow manure obtaining bloodworm biomass of 1.5 g/10 L water. Whereas Habib et al (1997) obtained bloodworm biomass of 290 g/10 L water using palm oil waste. Thus the use of dried solid waste can produce higher bloodworm biomass compared to the use of cow manures, but fewer then the use of palm oil waste. Shafruddin et al (2006) showed that the body length of bloodworms fed with chicken manures was in the range between 5 and 9 mm in the first week. Whereas Aliu et al (2014) reported the length of bloodworms fed with *Scenedesmus* and yeast of 2.36±0.06 mm and 2.77±0.12 mm respectively at the same age. Thus the use of dried solid waste in this study resulted bloodworms with fairly large body size.

Ranges of water temperature, dissolved oxygen, and pH in the present study were 27.7–30.1°C, 2.7–4.2 mg/L, 6.20–7.76, and 41–116 mg/L respectively. According to Nebeker (1973) water temperature need for larval development of Chironomidae ranges between 21–32°C. While according to Sahragard & Rafatifard (2010) optimal water temperature for larval development was at 22–26°C. Berezina (2001) stated that optimal pH for freshwater invertebrates are 4.09–8.65. Lawrence (1981) stated that dissolved oxygen for culture of bloodworms is 3 mg/L. Therefore, water temperature, dissolved oxygen, and water pH in our study were still in optimal range for culture of bloodworms. The main water quality parameter that distinguished each treatment was TDS. TDS is total dissolved solids consisting of inorganic ions. TDS shows the nutrient content of the water proficiency level. The use of dried solid waste provided higher TDS (109.17±7.03

mg/L), so higher nutrients content than fresh solid waste treatment (54.17±5.98 mg/L) and dried chicken manure treatment (45.50±3.51 mg/L). Miracle et al (2006) found that high nutrient levels were correlated with the increasing abundance of macro invertebrates. Bloodworms fed dry waste in the present study showed the highest biomass due to highest nutrients content compared other feed types.

Conclusions. In conclusion, our results showed that the use of fresh solid waste of *C. gariepinus*, dried solid waste of *C. gariepinus* and dried chicken manure as bloodworm feed, produces bloodworm biomass of 6.83±1.24 g, 9.77±0.50 g, and 7.03±1.66 g wet weight/aquarium respectively. Bloodworms length at the experiment termination ranged between 7.308 and 10.231 mm. The results revealed that dried solid wastes of *C. gariepinus* are a very suitable feed for mass culture of bloodworms.

Acknowledgements. The authors thank the Ministry of Research Technology and Higher Education, Republic of Indonesia for funding this research. Authors are also grateful to all those who helped the implementation of this study: the Fisheries Laboratory of Palangka Raya Christian University, Laboratory of Nutrition and Animal feed, Lambung Mangkurat University, Students of Fisheries Faculty of Palangka Raya Christian University, and local fish farmer.

References

Aliu S. H., Hussein S. F., Jekeli A. S., Unoyiza U. S., Aminu I. A., Ojochogwu O. M., 2014 Culture of Chironomid larvae using two different feeds. Journal of Natural Sciences Research 4(19):144–153.

Berezina N. A., 2001 Influence of ambient pH on freshwater invertebrates under experimental conditions. Russian Journal of Ecology 32:343–351.

Bogut I., Has-Schon E., Adamek Z., Rajkovic V., Galovic D., 2007 *Chironomus plumosus* larvae a suitable nutrient for freshwater farmed fish. Poljoprivreda 13(1):159–162.

De La Noue J., Choubert G., 1985 Apparent digestibility of invertebrate biomass by rainbow trout. Aquaculture 50:103–112.

Habashy M. M., 2005 Culture of Chironomid larvae (Insecta-Diptera: Chironomidae) under different feeding systems. Egyptian Journal of Aquatic Research 31(2):403-418.

Habib M. A. B., Yusoffa F. M., Phang S. M., Ang K. J., Mohamed S., 1997 Nutritional values of chironomid larvae grown in palm oil mill effluent and algal culture. Aquaculture 158(1–2):95–105.

Komatsu R., Gumiri S., Hartoto D. I., Iwakuma T., 2000 Diel and seasonal feeding activities of fishes in an oxbow lake of Central Kalimantan, Indonesia. Proceedings of the International Symposium on Tropical Peatlands Bogor, Indonesia, 22-23 November 1999, Hokkaido University & Indonesian Institute of Sciences, pp. 455-470.

Kumar D., Ramesh U., 2014 Rearing practices of live feedstuff animal midge fly larvae (*Chironomus circumdatus*) Kieffer (Diptera: Chironomidae). International Journal of Current Science 12:170-177.

Lawrence S. G. (ed), 1981 Manual for the culture of selected freshwater invertebrates. Canadian Special Publication of Fisheries and Aquatic Sciences 54, Department of Fisheries and Oceans, Ottawa, 169 p.

Naylor S. J., Moccia R. D., Durant G. M., 1999 The chemical composition of settleable solid fish waste (manure) from commercial rainbow trout farms in Ontario, Canada. North American Journal of Aquaculture 61:21-26.

Maleknejad R., Sudagar M., Azimi A., Shokrollahi S., 2014 Comparative study on the effect of different feeding regimes on chironomid larvae biomass and biochemical composition. International Journal of Advanced Biological and Biomedical Research 2(12):2880-2883.

Medeiros E. S. F., Arthington A. H., 2008 Diel variation in food intake and diet composition of three native fish species in floodplain lagoons of the Macintyre River, Australia. Journal of Fish Biology 73(4):1024–1032.
Miracle M. R., Moss B., Vicente E., Romo S., Rueda J., Bécares E., Fernández-Aláez C., Fernández-Aláez M., Hietala J., Kairesalo T., Vakkilainen K., Stephen D., Hansson L. A., Gyllström M., 2006 Response of macroinvertebrates to experimental nutrient and fish additions in European localities at different latitudes. Limnetica 25(1-2):585-612.
Moccia R., Bevan D., Reid G., 2007 Composition of fecal waste from commercial trout farms in Ontario: Macro and micro nutrient analyses and recommendations for recycling. Aquaculture Centre, University of Guelph, Ontario, Canada.
Nebeker A. V., 1973 Temperature requirements and live cycle of the midge *Tanytarsus dissimilis* (Diptera: Chironomidae). Journal of Kansas Entomological Society 46(2):160–165.
Pistori R. E. T., Henry-Silva G. G., Biudes J. F. V., Camargo A. F. M., 2010 Influence of aquaculture effluents on the growth of *Salvinia molesta*. Acta Limnologica Brasiliensia 22(2):179-186.
Sahragard A., Rafatifard M., 2010 Biology and effect of temperature on larval development time of *Chironomus riparius* Meigen (Diptera: Chironomidae) under laboratory conditions. Munis Entomology & Zoology 5(suppl.):1025-1033.
Sanseverino A. M., Nessimian J. L., 2008 The food of larval Chironomidae (Insecta, Diptera) in submerged litter in a forest stream of the Atlantic Forest (Rio de Janeiro, Brazil). Acta Limnologica Brasiliensia 20(1):15-20.
Shafruddin D., Parlinggoman B. R., Sumantadinata K., 2006 Growth and productivity of *Chironomus sp*. in enriched substrat by chicken manure 1.0–2.5 g/L. Jurnal Akuakultur Indonesia 5(1):97–102.
Shaw P. C., Mark K. K., 1980 Chironomid farming - a means of recycling farm manure and potentially reducing water pollution in Hong Kong. Aquaculture 212:155-163.
Sulistiyarto B., 2010 Diet composition of fish community of the forested swamp and opened swamp at Rungan river floodplain, Central Kalimantan. Journal of Tropical Fisheries 5(2):499-504.
Thipkonglars N., Taparhudee W., Kaewnern M., Lawonyawut K., 2010 Cold preservation of Chironomid larvae (*Chironomus fuscipes* Yamamoto, 1990): Nutritional value and potential for Climbing Perch (*Anabas testudineaus* Bloch, 1792) larval nursing. Kasetsart University Fisheries Research Bulletin 34(2):1–13.
Yeo S. E., Binkowski F. P., Morris J. E., 2004 Aquaculture effluents and waste by-products: characteristics, potential recovery, and beneficial reuse. University of Winconsin Sea Grant Institute, Madison.
*** AOAC, 2000 Official methods of analysis of the Association of Official Analytical Chemists, 19th edition, Association of Official Analytical Chemists, Arlington.

Received: 03 November 2017. Accepted: 03 April 2018. Published online: 10 April 2018.
Authors:
Bambang Sulistiyarto, Palangka Raya Christian University, Faculty of Fisheries, Department of Aquaculture, Indonesia, Palangka Raya, 73113, RTA Milono Km 8.5, e-mail: sulistiyarto@gmail.com
Restu, Palangka Raya Christian University, Faculty of Fisheries, Department of Aquaculture, Indonesia, Palangka Raya, 73113, RTA Milono Km 8.5, e-mail: restubakrie20@gmail.com

How to cite this article:
Sulistiyarto B., Restu, 2018 Culture of bloodworm (Chironomid larvae: Diptera) using North African catfish *Clarias gariepinus* waste as feed. AACL Bioflux 11(2):476-480.