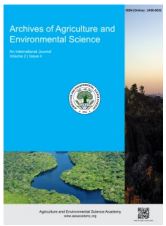
Archives of Agriculture and Environmental Science 9(2): 379-384 (2024)
https://doi.org/10.26832/24566632.2024.0902025

e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes



ORIGINAL RESEARCH ARTICLE

Optimization doses of frozen maggot used as fish food for rearing stinging catfish (*Heteropneustes fossilis*)

Abdus Satter[1], Mufazzal Hossain[2], Partha Sarathi Das[1], Md. Ahsan Bin Habib[3] and Md. Abu Sayed Jewel[4*]

[1]Bangamata Sheikh Fojilatunnesa Mujib Science & Technology University, Melandah, Jamalpur, BANGLADESH
[2]Food and Agricultural Organization (FAO), United Nations, BANGLADESH
[3]Department of Aquaculture, Faculty of Fisheries, Bangladesh Agricultural University, BANGLADESH
[4]Department of Fisheries, Faculty of Fisheries, University of Rajshahi, Rajshai - 6205, BANGLADESH
[*]Corresponding author's E-mail: abujewel75@gmail.com

ARTICLE HISTORY

Received: 13 April 2024
Revised received: 16 June 2024
Accepted: 20 June 2024

Keywords

Fish food
Growth performance
Heteropneustes fossilis
Maggot

ABSTRACT

This study was performed to evaluate growth performance of stinging catfish, (*Heteropneustes fossilis*) by applying different dozes of frozen maggot meal as a protein source and fish meal replacer. The experiment was carried out in 28 days at the Wet laboratory, Department of Aquaculture and laboratory of the Department of Animal Nutrition, Bangladesh Agricultural University (BAU), Mymensingh. The experiment was carried out in 15 glass aquaria with five different treatments, each with three replications. The frozen maggot as feed for *H. fossilis* post-larvae production was designed where five different diets of only frozen larvae such as T_1 (larvae 20%, crude protein 11.20%), T_2 (larvae 40%, crude protein 22.40%), T_3 (larvae 60%, crude protein 33.60%) and T_4 (larvae 80%, crude protein 44.80%) and a control diet T_5 (crude protein 30%) made with fish meal as sole source of protein. It was observed that T_3 (Diet 3) had the significantly highest ($p<0.05$) final weight (1.55g), followed by T_5 (1.50g), T_2 (1.35g), T_4 (1.25g) and T_1 (1.16g). Specific growth rate, protein efficiency ratio, apparent protein utilization and survival rate were also significantly higher in T_3 than other treatments. It is recommended to use the frozen maggot meal as a protein source at a dose of 60% in diet and fish meal replacer, which will be cheaper and profitable to aquaculture sector of the world.

Citation of this article: Satter, A., Hossain, M., Das, P. S., Habib, M. A. B., & Jewel, M. A. S. (2024). Optimization doses of frozen maggot used as fish food for rearing stinging catfish (*Heteropneustes fossilis*). *Archives of Agriculture and Environmental Science*, *9*(2), 379-384, https://dx.doi.org/10.26832/24566632.2024.0902025

INTRODUCTION

Price of fish feed are increasing day by day. In cat fish culture system of Bangladesh are now depending of fish meal as protein source but fish meal price is very high now. So, to solve this problem in present experiment frozen maggot is incorporate in catfish diet as a protein source which is fish meal replacer, and that is cheaper than fish meal. Among the catfish, stinging catfish (*H. fossilis*) is commercially important and valuable species in many Asian countries (Akand *et al.*, 1991). Stinging catfish is very nutritious table fish due to its attractive palatability and high protein content. The species is not only recognized for its delicious taste and market value but also highly esteemed from nutritional and medicinal properties of view. This type of composition is not found in any other fish groups available in culture fishery. So, the fish has a good recuperative value and physicians prescribe the fish for the convalescence and fast growing children. It is a hardy fish can grow easily in ditches and ponds in very less amount dissolved oxygen in water and tolerate adverse aquatic condition. It is well established that this fish a carnivorous fish which can grow fast if fed with fly larvae, live foods available in aquatic body as well as good quality diet (Akand *et al.*, 1991; Rana *et al.*, 2015). Nutritionally well-balanced feeds are needed for intensive culture. Thus, knowledge on the specific requirements of *H. fossilis* is essential for the formulation of a well-balanced supplemental feed for successful intensive culture. Catfishes can also feed well and performed excellent growth when feed on house fly larvae, Chironomus fly larvae and annelids (Shaw & Mark 1980; Habib *et al.*, 1997 & 2005; Rana *et al.*, 2015). Among catfishes, stinging catfish may be cultured and performed good growth when fed on house fly larvae. But research work on optimization of dose of fresh maggot for food of *H. fossilis* in very limited in literature. Therefore, the present experiment was conducted to feed fry of stinging catfish (*H. fossilis*) with frozen house fly (*Lucilia sericata*) larvae to observe the growth performances and select best dose of maggot meal for stinging catfish in the laboratory condition.

MATERIALS AND METHODS

Study area

The fly larvae were grown in try in a poultry farm of Sutiakhali near-by Bangladesh Agricultural University, Mymensingh, Bangladesh. It was produced with three days in poultry waste and collected on fourth day of experiment. The experiments were conducted from the Wet laboratory, Department of Aquaculture and laboratory of the Department of Animal Nutrition, Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh.

Collection and preparation of poultry waste

The poultry waste was collected from Suvro poultry farm, SutiaKhali, Mymensingh. It was used to grow and produce fly larvae (maggot) near the poultry farm. Some raw waste was sun dried, ground, packed in polythene bag and kept in the laboratory for aerobic digestion and chemical analyses. The supernatant of digested poultry waste was used to grow maggots in the laboratory.

Collection of stinging catfish post-larvae

Post-larvae of stinging catfish (*H. fossilis*) of the same age group (10 days old) were collected from a farm in Shombhuganj, Mymensingh, Bangladesh. They were carried to the laboratory through proper handling.

Experimental procedure

The experiment was carried out in 15 glass aquaria with five different treatments, each of which had three replications. The acclimatized fishes were reared for 28 days. The post-larvae of stinging catfish (*H. fossilis*) (mean initial weight 0.192 ± 0.02g) was used as experimental animal. The post larvae were dispersed at a rate of 40 fish per aquaria in a random manner.

Feed formulation

The frozen maggot as feed for *H. fossilis* post-larvae production was designed where five different diets of only frozen larvae such as T1 (larvae 20%, crude protein 11.20%), T2 (larvae 40%, crude protein 22.40%), T3 (larvae 60%, crude protein 33.60%) and T4 (larvae 80%, crude protein 44.80%) and a control diet T5 (crude protein 30%) made with fish meal as sole source of protein (Table 1).

Analysis of fly larvae (maggot), feed ingredients, feeds, and carcass composition of fish

Proximate composition such as moisture, crude protein, crude lipids, ash and nitrogen free extract (NFE) of feed ingredients, experimental feed and fish carcass compositions were analyzed according to standard procedures given by Association of Official Analytical Chemists (AOAC, 2016) and Hamli *et al.* (2021). Growth parameters such as weight gain (%), FCR (Food conversion ratio), SGR (Specific growth rate), PER (Protein efficiency ratio) and survival rate (%) were analyzed following Enyidi *et al.* (2017), Faruk *et al.* (2018), Billah *et al.* (2019), and Islam *et al.* (2021).

Analysis of growth parameters of fish post-larvae

The growth parameters such as, mean weight gain, percent weight gain, SGR %/day, FCR, PER, apparent protein utilization (APU) and NFE were calculated following formulas:

Mean weight gain = Mean final weight -Mean initial weight

$$\text{Percent weight gain} = \frac{\text{Mean final weight} - \text{Mean initial weight}}{\text{Mean initial weight}} \text{x } 100$$

$$\text{SGR } (\%/\text{day}) = \frac{\text{LnW2} - \text{LNW1}}{\text{T2} - \text{T1}} \text{x } 100 \text{ (Brown, 1957)}$$

Where, W_1 = the initial live body weight (g) at time T_1 day; and W_2 = the initial live body weight (g) time T_2 day

$$\text{FCR} = \frac{\text{Feed fed (dry weight)}}{\text{Live weight gain}}$$

$$\text{PER} = \frac{\text{Live weight gain (g)}}{\text{Crude protein fed (g)}}$$

$$\text{Apparent Protein Utilization} = \frac{\text{Nb} - \text{Na}}{\text{Ni}} \text{ x } 100$$

Where, Na = Body nitrogen at the start of the experiment; Nb = Body nitrogen at the end of the experiment; and Ni = Amount of nitrogen ingested.

Statistical analysis

Analysis of variance (ANOVA) of mean cell weight and chlorophyll a, and crude protein, crude lipids and ash of *S. platensis* cultured in different media, and feed, fish body, and different growth performances and parameters of fish fry fed different diets were done following Tukey's test and to find whether any significant difference among treatment means was done by Duncan's Multiple Range Test (DMRT) using statistical package following Zar (1984).

Table 1. Feed containing four different levels of frozen maggot for *H. fossilis* and a control diet.

Ingredients (%)	Treatments				
	1	2	3	4	5 (Control)
Fish Meal	-	-	-	-	53.57
Live Maggot	20	40	60	80	-
Dry matter (On 16% basis)	3.20	6.40	9.80	12.80	-
Wheat flour	-	-	-	-	25
Soybean oil	-	-	-	-	5
Vitamin premix	-	-	-	-	2
Mineral premix	-	-	-	-	3
Chromic oxide	-	-	-	-	1
α-Cellulose	-	-	-	-	10.43
Total	-	-	-	-	100
Crude Protein (%)	11.20	22.40	33.60	44.80	30

RESULTS AND DISCUSSION

Proximate composition of feed ingredients and fly larvae (maggot)

The maggot contained high crude protein (56.60±0.25%), crude lipids (15.80±0.10%) and ash content (15.40±0.07%) with a Nitrogen Free Extract (NEF) value of 1.22±0.02; while the fish meal comprised 56.0±0.23% of crude protein, 11.21±0.07% of crude lipid, 13.34±0.08% of ash content with a 3.25±0.03 value of NEF. On the other hand, the wheat flour comprised lower protein (10.20±0.105), crude lipid (2.10±0.04%), ash content (2.40±0.04%), crude fiber (1.78±0.03%) and high NFE (73.06±0.45) (Table 2). The maggot comprised high protein 56.60%, lipids 15.80%, revealing the potentiality of the maggot as feed material, especially as the protein source for human or cultured animal (Odesanya *et al.*, 2011; Papuc *et al.*, 2020). Despite the many different sources of protein, most of them require culturing in farm and high maintenance standard, hence the impetus to seek for a cheap yet good standard protein source, presenting fly larvae as the most inexpensive, low maintenance production and good quality protein source (Tippayadara *et al.*, 2021).

Table 2. Proximate composition (%) of fish meal, maggot and wheat flour (dry weight basis).

Name of ingredients	Moisture (%)	Crude protein	Crude lipids	Ash	Crude fibre	NFE*
Fish meal	10.70 ± 0.10	56.0 ± 0.23	11.21 ± 0.07	13.34 ± 0.08	4.70 ± 0.03	3.25 ± 0.03
Maggot (Fly larvae)	10.88± 0.10	56.60 ± 0.25	15.80 ± 0.10	15.40 ± 0.07	-	1.22 ± 0.02
Wheat flour	10.45 ± 0.10	10.20 ± 0.10	2.10 ± 0.04	2.40 ± 0.04	1.78 ± 0.03	73.06 ± 0.45

*NFE (Nitrogen Free Extract) = 100 – (Moisture + Crude protein + Crude lipids + Ash + Crude fibre).

Table 3. Carcass composition of stinging catfish fry fed four different diets prepared with frozen maggot, and a control diet.

Poximate (%)	Treatments					
	Initial sample	1	2	3	4	5 (Control)
Moisture	9.90 ± 0.02	9.80 ± 0.02^{a}	9.85 ± 0.02^{a}	9.80 ± 0.02^{a}	9.95 ± 0.02^{a}	9.80 ± 0.02^{a}
Crude protein	45.20 ± 0.75	58.15 ± 1.12^{b}	59.80 ± 1.12^{b}	63.50 ± 1.13^{a}	60.30 ± 1.10^{b}	59.10 ± 1.10^{b}
Crude lipids	8.75 ± 0.03	14.73 ± 0.03^{a}	14.45 ± 0.03a^{a}	12.60 ± 0.03a^{b}	14.10 ± 0.03^{a}	15.30± 0.04^{a}
Ash	26.05 ± 0.24	12.85 ± 0.03^{a}	12.30± 0.03^{a}	10.65± 0.03^{b}	11.90 ± 0.03^{a}	12.20± 0.03^{a}
NFE*	9.70 ± 0.03	4.42± 0.03^{a}	3.55± 0.03^{a}	3.30± 0.03^{a}	3.70 ± 0.03^{a}	3.55± 0.03^{a}

*NFE (Nitrogen Free Extract) = 100 – (Moisture + Crude protein + Crude lipids + Ash). Figures in common letters in the superscript of each row don't differ significantly at 5% level of probability.

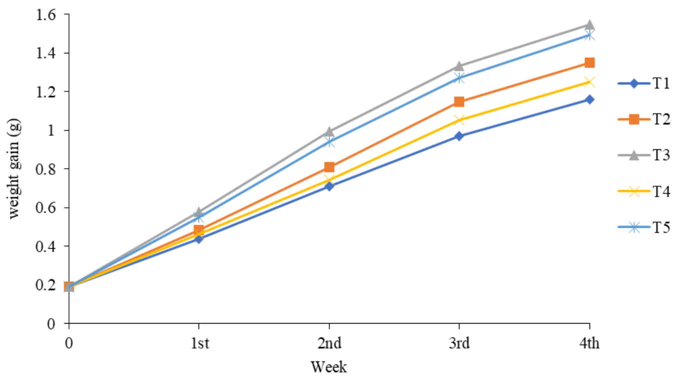


Figure 1. *Weekly weight gain (g) of stinging catfish fed five different diets (T1 to T5) including a control diet.*

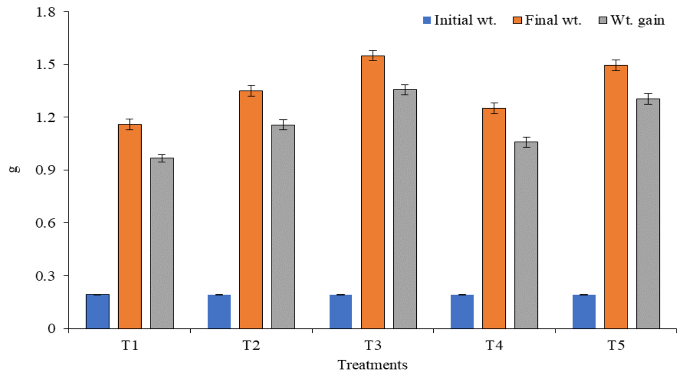


Figure 2. *Initial weight, final weight and weight gain of stinging catfish fed four different diets of frozen maggot, and a control diet. Vertical bars of each column represent standard error.*

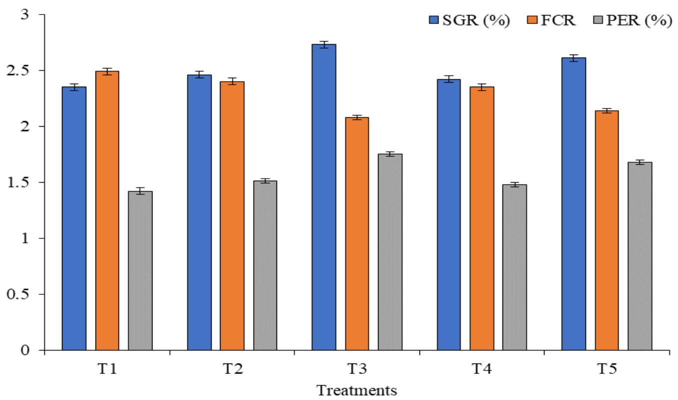


Figure 3. *Specific growth rate (SGR), food conversion ratio (FCR) and protein efficiency ratio (PER) of stinging catfish fed four different diets of frozen maggot, and a control diet. Vertical bars of each column represent standard errors.*

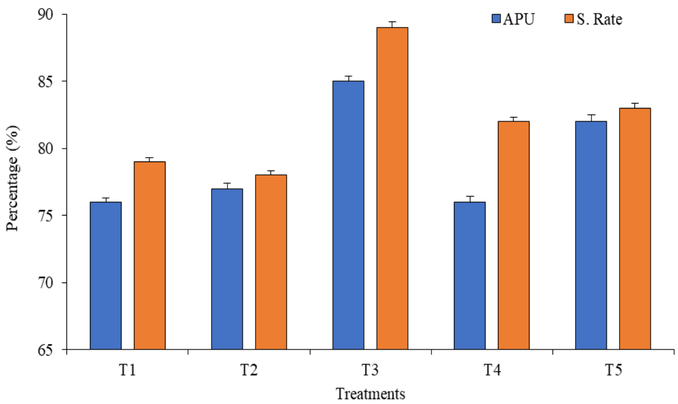


Figure 4. *Apparent protein utilization (APU) and survival rate (S. Rate) of stinging catfish fed four different diets of fresh maggot, and a control diet. Vertical bars of each column represent standard errors.*

Production of stinging catfish (*H. fossilis*) using fly larvae (maggot)

The stinging catfish (*H. fossilis*) post-larvae were allowed to feed five different diets which included four different diets of only frozen larvae such as T1 (larvae 20%, crude protein 11.20%), T2 (larvae 40%, crude protein 22.40%), T3 (larvae 60%, crude protein 33.60%) and T4 (larvae 80%, crude protein 44.80%) and a control diet T5 (crude protein 30%) made with fish meal as sole source of protein (Table 1). The fish post-larvae (Initial weight 0.192 ± 0.01 to 0.193 ± 0.01g) were allowed to feed four different diets of frozen fly larvae and a control diet. Weekly growth trends of fry fed five different diets are shown in Figure 1. The catfish fry was harvested at the end of experiment on 28th days. The weight gain (%) of fish fry fed diet 3 (T3) contained 33% crude protein and fed control diet 5 (T5) contained 30% crude protein were significantly ($p < 0.05$) higher than those fed diet 2 (T2) with crude protein 22.40%, diet 4 (T4) with crude protein 44.80% followed by diet 1 (T1) contained crude protein 11.20% (Figure 3). It was observed that T3 had the significantly highest ($p<0.05$) final weight (1.55g), followed by T5 (1.50g), T2 (1.35g), T4 (1.25g) and T1 (1.16g) (Figure 2). Some previous study suggested that, the catfishes showed higher growth rate and other growth parameters when fed on fresh or frozen maggot (Devic *et al.*, 2018; Saleh, 2020). In nature, *H. fossilis* was found to be a carnivorous and predatory fish species feeding on insects and crustaceans (Narejo *et al.*, 2016) creating the natural habitat condition and providing the live feed might stimulate *H. fossilis* growth rate.

Specific growth rates (SGRs) of catfish fry fed diet 3 (T3) and control diet (T5) had significant ($p < 0.05$) variation from those fed diet 2 (T2), diet 4 (T4) and then diet 1 (T1) (Figure 3), whereas lower food conversion ratios (FCRs) of fish post-larvae fed diet 3 (T3) was found to be varied significantly ($p < 0.05$) from those fed diet 4 (T4) followed by diet 2 (T2) and then diet 1 (T1). The protein efficiency ratio (PER) of T3 (1.75) were found significantly higher amongst the treatments followed by T2 (1.51), T4 (1.48) and T1 (1.42) (Figure 3). Protein efficiency ratio (PER) was found to be one of the most significant indexes for determining how much protein was consumed throughout the trial period; this ratio is useful in determining whether one protein source should be replaced with another in catfish aquaculture (Enyidi *et al.*, 2017). The feed conversion ratio (FCR) of the maggot was found comparatively higher than that of the commercial feed, moreover maggot was cheaper to obtain and the production requires less maintenance, making the overall benefit for use of live maggot in producing *H. fossilis* post larvae profitable for the aquaculture operation (Bosma *et al.*, 2017).The apparent protein utilization (APU) rate of stinging catfish fed with frozen maggot T3 (85%) formulation diet was found significantly higher ($p < 0.05$) amongst the treatments, followed by T2 (77%), and T1, T4 (76%). On the other hand, the survival rate of stinging catfish fed with T3 (89%) formulation was found significantly highest ($p<0.05$), followed by T5 (83%), T4 (82%), T1 (79%), and T2 (78%) (Figure 4).

The carcass composition of stinging catfish post-larvae fed with frozen maggot T3 formulation showed the significantly highest ($p<0.05$) protein value (63.50±1.13%) and less amount of lipid (12.60±0.03%) and ash (10.65±0.03%) percentage than that of other treatments. No significant difference was observed in moisture content and NFE values among the treatments (Table 3). This study also observed the growth rate of *H. fossilis* post-larvae using maggot meal as a replacer of fish meal. The values and concentration of moisture, crude protein, crude lipids, ash content, crude fiber, and nitrogen free extract were found similar in proximate analysis. In order to properly create an experimental diet, it is vitally required to know the approximate composition of such a diet, while the method was to substitute one protein source for another (Bhaskar *et al.*, 2015; Hua *et al.*, 2019; Jahan *et al.*, 2021; Mdhluvu *et al.*, 2021). Therefore it may be concluded that stinging catfish fed on maggot containing around 33.60% crude protein (T3) can grow better than fry fed other levels of frozen maggot and control diet.

Conclusion

H. fossilis post-larval feed with 60% frozen maggots meal as a fish meal replacer showed the best result in the present study. It is recommended to use the frozen maggot meal as a protein source and fish meal replacer, which will be cheaper and profitable to aquaculture sector of Bangladesh.

DECLARATION

Authors contribution

Conceptualization, A.S. and M.H.; methodology, A.S. and P.S.D.; software, A.S..; validation, M.A. B.H; formal analysis, A.S. and M.H.; investigation, M.A.B.H..; data curation, A.S..; writing—original draft preparation, M.A.S.J and A.S..; writing—review and editing, K.A.K. and M.A.S.J.; supervision, M.A.B.H.

All authors have read and agreed to the published version of the manuscript.

Conflicts of interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethics approval: This study was approved by the guidelines and regulations of Wet laboratory, Department of Aquaculture and laboratory of the Department of Animal Nutrition, Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh.

Consent for publication: All co-authors gave their consent to publish this paper.

Data availability: The data that support the findings of this study are available on request from the corresponding author.

REFERENCES

Akand, A. M., Hasan, M. R., & Habib, M. A. B. (1991). Utilization of carbohydrate and lipid as dietary energy sources by stinging catfish, *Heteropneustes fossilis* (Bloch). Proceedings of the 4th Asian Fish Nutrition Workshop, Manila, The Phillipines, *Asian Fisheries Society*, *5*, 93-100.

AOAC. (2016). Official Methods of Analyses, 20th edn. Association of Official Analytical Chemist, Washington, DC., USA.

Bhaskar, P., Pyne, S. K., & Ray, A. K. (2015). Growth performance study of Koi fish, *Anabas testudineus* (Bloch) by utilization of poultry viscera, as a potential fish feed ingredient, replacing fishmeal. *International Journal of Recycling of Organic Waste in Agriculture*, *4*, 31–37.

Billah, M. M., Uddin, M. K., Samad, M. Y. A., Hassan, M. Z. B., Anwar, M. P., Abu Hena, M. K., Shahjahan, M., & Al-Asif, A. (2019). Effects of different stocking density of Nile tilapia (Oreochromis niloticus) and common carp (*Cyprinus carpio*) on the growth performance and rice yield in rice-fish farming system. *AACL Bioflux*, *13*, 789–803.

Bosma, R. H., Lacambra, L., Landstra, Y., Perini, C., Poulie, J., Schwaner, M. J., & Yin, Y. (2017). The financial feasibility of producing fish and vegetables through aquaponics. *Aquacultural Engineering*, *78*, 146–154.

Devic, E., Leschen, W., Murray, F., & Little D. C. (2018). Growth performance, feed utilization and body composition of advanced nursing Nile tilapia (*Oreochromis niloticus*) fed diets containing Black Soldier Fly (*Hermetia illucens*) larvae meal. *Aquaculture Nutrition*, *24*, 416–423.

Enyidi, U.D., Pirhonen, J., Kettunen, J., & Vielma, J. (2017). Effect of feed protein:Lipid ratio on growth parameters of african catfish *Clarias gariepinus* after fish meal substitution in the diet with bambaranut (*Voandzeia subterranea*) meal and soybean (*Glycine max*) meal. *Fishes*, *2*, 1–11.

Faruk, A., Hossain, A., Al-Asif, A., Bhuiyan, M. N. M., & Sarker M. J. (2018). Culture and management techniques of Vietnamese Koi. *Asian-Australasian Journal of Bioscience and Biotechnology 3*, 93–105.

Habib, M. A. B., Yusoff, F. M., Phang, S. M., & Mohamed, S. (1997). Nutritional values of chironomid larvae grown in palm oil mill effluent and algal culture. *Aquaculture*, *158*, 195-205.

Habib, M. A. B., Yusoff, F. M., Phang, S. M., & Mohamed, S. (2005). Experimental production and chemical composition of *Culex* mosquito larvae and pupae grown in agro-industrial effluent. *Asian Fisheries Science*, *18*(1-2), 107-119.

Hamli, H., Hossain, A., Ahmed, S., Al-Asif, A., Rashid, M.H. & Rahman, H. (2021). Biochemical, mineral compositions and microbial assessment of smoked hilsa (*Tenualosa ilisha*) with leaves, juice, and lemon peel. *AACL Bioflux*,*14*, 2241–2251.

Hua, K., Cobcroft, J. M., Cole, A., Condon, K., Jerry, D. R., Mangott, A., Praeger, C., Vucko, M. J., Zeng, C., Zenger, K., & Strugnell, J. M. (2019). The future of aquatic protein: Implications for protein sources in aquaculture diets. *One Earth*, 1, 316–329.

Islam, M. A., Samad, M. A., Paul, D., Asif, A. A., & Hossain A. (2021). Feeding frequency on the growth and production of endemic near-threatened *Ompok pabda* (Hamilton, 1822) in pond setup. *Asian-Australasian Journal of Bioscience and Biotechnology*, *6*, 89–102.

Jahan, H., Tumpa, I.J., Qasem, W. A., Moniruzzaman, M., Pervin, M. A., Akter, R., Omri, A., Min, T., & Hossain, Z. (2021). Evaluation of the partial replacement of dietary Fish meal With fermented or untreated soybean meal in juvenile silver barb, *Barbonymus gonionotus*. *Frontiers in Nutrition*, 8, 733-402.

Mdhluvu, R. M., Mlambo, V., Madibana, M. J., Mwanza, M., & O'Brien, G. (2021). Crocodile meat meal as a fishmeal substitute in juvenile dusky kob (Argyrosomus japonicus) diets: Feed utilization, growth performance, blood parameters, and tissue nutrient composition. *Aquaculture Reports*, *21*, 100779.

Narejo, N. T., Jalbani, S., Khan, P., & Memon, F. (2016). Food and feeding habits of sting catfish, *Heteropneustes Fossilis* (Bloch) from Manchar lake district Jamshoro Sindh Pakistan. *Sindh University Research Journal*, *48*, 473–476.

Odesanya, B. O., Ajayi, S. O., Agbaogun, B. K. O., & Okuneye, B. (2011). Comparative evaluation of nutritive value of maggots. *International Journal of Scientific and Engineering Research*, *2*, 1–5.

Papuc, T., Boaru, A., Ladosi, D., Struti, D., & Georgescu, B., (2020). Potential of black soldier fly (Hermetia illucens) as alternative protein source in Salmonid feeds - A review. *Indian Journal of Fisheries, 67*, 160–170.

Rana, K. M. S., Salam, M. A., Hashem, S. & Islam, M. A. (2015). Development of black soldier fly larvae production technique as an alternate fish feed. *International Journal of Research in Fisheries and Aquaculture, 5*(1), 41-47.

Saleh, H. H. E. (2020). Effect of feeding on fresh (wet) housefly maggots (*Musca domestica*) with or without artificial diet on water quality and growth rates of African catfish (*Clarias gariepinus* Burchell, 1822) fry under laboratory conditions. *Journal of Zoological Research*, *2*, 15–22.

Shaw, P. C., & Mark, K. K. (1980). Chironomidae farming – a means of recycling farm manure and potentially reducing water pollution in Hong Kong. *Aquaculture*, *21*, 155-163.

Tippayadara, N., Dawood, M.A.O., Krutmuang, P., Hoeseinifar, S. H., Van Doan, H. & Paolucci, M. (2021). Replacement of fish meal by black soldier fly (*Hermetia illucens*) larvae meal: Effects on growth, haematology, and skin mucus immunity of Nile Tilapia, *Oreochromis niloticus*. *Animals*, *11*,193-201.

Zar, J.H. (1984). *Biostatistics*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, USA. 718 pp.