Black soldier fly larvae as nutrient-rich diets for ornamental fish

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Abstract. This study aims to investigate maggot cultivation and application as an alternative feed for ornamental fish. Maggot or black soldier fly (Hermetia illucens) larva is one alternative feed that meets the requirements as a source of protein. Research Center for Ornamental Fish Cultivation (BRBIH) of the Ministry of Maritime Affairs and Fisheries has successfully developed maggot as an alternative raw material for protein sources. Maggot or black soldier fly (Hermetia illucens) larva is one alternative feed that meets the requirements as a source of protein. Besides functioning as a source of protein in fish diet, maggot can be cultivated according to the desired size. Live maggot and maggot flour as feed have been given to both ornamental fish and fish to be used for food. Thus, the use of BSF as an alternative source of protein can reduce production costs in the fishing industry without reducing its quality.

1. Introduction
Water is a natural resource that is an important requirement for humans. Therefore, clean water needs to be maintained. River pollution is an important factor in environmental problems. The river which is the source of water in a settlement, sometimes polluted by factory waste, household waste and other hazardous substances. The major quantities of domestic or from industrial wastewater flowed into the river, will leads to the water system and become bad polluted [1]. Freshwater pollution in Indonesia, more than 80% is caused by domestic waste in liquid and solid form. Nearly two-thirds of the Citarum River's in Bandung City, the biological oxygen demand (BOD) comes from household pollution, as compared to one-third from all industrial and agricultural activities combined, for instance [2]. The increase of wastewater volume is quite high, it is about 5 million m³/year [3] seeing these problems, some efforts of wastewater treatment is needed.

Wastewater treatment methods can be physical, chemical and biological treatment methods. From the three methods, it was considered to be the most efficient way to reduce organic matter in wastewater at relatively low cost is the biological treatment method, namely bioremediation technology. There are many advantages on bioremediation technology. It were low cost, low environmental influence, no secondary pollution or pollutant movement. It may reducing pollutant concentration by the maximum
extent and available for the sites where regular pollution treatment technology is difficult to be applied. The bioremediation technology can be the most promising remediation [1].

Wastewater treatment can be done using simple and environmentally friendly technology. The advantage of using this technology is that it is more economical and practical in its maintenance. Phytoremediation is one of the eco-friendly methods for wastewater treatment. Phytoremediation is one of the method of wastewater treatment by utilizing plants to reduce waste concentrations that exceed quality standards. Irhami (2018) stated that phytoremediation is a technology that uses certain plants that work together with microorganisms in the media (soil, coral and water) to change, eliminate, stabilize, or destroy/remove contaminants or pollutant [4].

The concept of wastewater treatment using plant media has long been recognized by humans, even it is also used to treat hazardous waste or for radioactive waste. Phytoremediation has allowed increasing attention because it can safely remove the soil pollutant via plant uptake, accumulations and plant harvesting for another treatment or function. Dong e.t.al (2012) on their research showed that the leaves of the rescue plant (*Festuca arundinacea*) can remove 14.4% of soil Cadmium (Cd) [5]. However, the efficiency of proper plant to phytoremediation has become a great concern. This study aimed to evaluate the potential of *Salvinia molesta* to phytoremediation of polluted river by organic pollutant. Our objective was to analyze the phytoremediation capacity of *Salvinia molesta* to treat polluted river in Surabaya City.

The selection of kiambang (*Salvinia molesta*) as a phytoremediator plant in this study is based on the consideration that this plant is able to grow in waters with low nutrient content. In addition, morphologically, kiambang (*Salvinia molesta*) has a relatively small leaf diameter (an average of 2-4 cm) but has a thick and long rooting. Based on this, it is hypothesised that kiambang (*Salvinia molesta*) can actively absorb pollutants, but does not prevent the penetration of light into the waters.

2. Methods
The method to be used for this study is study literature. The data obtained are compiled, analyzed, and concluded so as to obtain conclusions regarding the study of literature. Entire data collected were analyzed by desk study using descriptive analysis method. The methodology used was intended to create and described the data obtained for further analysis and interpretation in accordance with the conditions that exist. This study did not evaluate and examine hypotheses but only described the exist information in accordance with the variables studied.

3. Results and discussion

3.1. The development of maggot cultivation
Research Center for Ornamental Fish Cultivation (BRBIH) of the Ministry of Maritime Affairs and Fisheries (KKP) has successfully developed maggots as an alternative raw material for protein sources. Various achievements have been made by BRBIH including producing International Patents with patent numbers PCT/FR2009/050592 "Mini-Larvae" and Use Thereof for Feeding Aquarium Fish, Alevins of Farm Fish and Pets (PCT/FR2009/050592) and National Patents (National Patent) registered in 2017 titled "Black Soldier Fly Larva Culture Method (BSF) for Organic Waste and Fish Feed Bioconversion Agents". Study of characteristics and nutrient content of Black Soldier Fly (BSF), black army fly (*Hermetia illucens*, Diptera: Stratiomyidae) has started to gain attention. These flies originate in America and subsequently spread to subtropical and tropical regions in the world [14]. Black Soldier Fly is black and the abdomen basal segment is transparent (wasp waist) so that at a glance it resembles a bee abdomen. The length of flies ranges from 15-20 mm and has a life span of five to eight days. When an adult fly develops from a pupa, the wing conditions are still folded and then begin to expand perfectly to cover the piston. Adult flies do not have a functional part of the mouth, because adult flies only move to
mate and reproduce throughout their lives. The nutritional requirements of adult flies depend on the fat content that is stored during the pupal period. When fat deposits run out, flies will die [15]. Based on sex, female flies generally have shorter survival compared to male flies [16].

![Figure 1. Difference between House Fly (belatung) and Maggot.](image)

Generally, the insect larvae are known as “belatung” before the term “maggot” is used. However, “belatung” gives rise to negative perceptions, so to distinguish “belatung” (housefly larvae) and maggot (BSF larvae) is necessary. Both types of larvae tend to have different roles, “belatung” tend to be disease vectors, and maggots have more role as agents for overhauling organic material. The difference between the two types of insect larvae also lies in the morphology and physiology. The BSF or maggot larvae have wrinkled body surfaces, the head is orange, does not have a hook, with a flat round body, as long as the maggot body has hair and pores and the maggot pupa has the same shape as the larvae. In contrast to house fly larvae or “belatung” that have slippery body surfaces, blackheads and have hooks, their bodies are round like carrots and pupae from oval-shaped house flies and slippery shells [17]. [18] stated that the life cycle of the fly *Hermetia illucens* has five stages. The five stages are adult phase, egg phase, prepupa phase, and pupa phase. Of the five stages, the prepupa stage is often used as fish food.
The development of BSF is ideal in tropical climates, because these flies live "in a warm atmosphere", and if the ambient air is very cold or lacking food, the maggot does not die but they become vacuum/idle/inactive while waiting for a more favorable, i.e. when the weather is getting warmer or food is available again. They can also live in water or an alcoholic atmosphere [19]. In terms of cultivation, BSF is very easy to develop on a mass-production scale and does not require special equipment. The final stage of larva (prepupa) can migrate from the growing media, thus making it easier to be harvested. In addition, this fly is not a pest fly and is not found in densely populated settlements, so it is relatively safe when viewed in terms of human health [20]. Many people are interested in maggot cultivation because maggot can be used as an alternative source of raw material for fish feed and its cultivation is relatively easy.

Maggot can grow and thrive on organic media, such as BIS, cow dung, pig dung, chicken dung, fruit waste, and other organic waste. The ability of BSF larvae to live in a variety of media is related to their characteristics which have a wide pH tolerance [21]. Therefore, maggot can be used as an organic waste bioconversion agent, a source of protein for feed raw materials and to produce organic fertilizer. [22] stated that maggot or black soldier fly larvae can be used to convert waste produced from agriculture and livestock, or even feces. Research conducted by[19] showed that maggot can be bred to tofu dregs. According to [23], palm kernel meal (PKM) can also be used as a medium for growth of BSF larvae. [24] mentioned that BSF larval development media based on organic waste is an important factor in the production process since it should not compete with human needs to prevent any competitions, such as with the use of fish meal or soy flour. Therefore, the location of BSF larva farming should be close to the source of organic waste.

[17] divided the two cultivation systems, namely maggot cultivation in a closed and open manner. Closed cultivation system is a controlled cultivation system and is more aimed at industrial activities because the number and size of maggot to be produced can be determined with certainty. In contrast, maggot cultivation in open system is not controlled, yet it carried out openly by still fulfilling environmental requirements such as areas with high vegetation or low plants. The development of maggot is not limited to its cultivation but it has penetrated into the business sector. Maggot business categories are divided into small scale (home), medium scale and industrial scale. Based on experience, it is best to start small scale business since it does not require large amount of capital and the most important thing is that people understand the intricacies of BSF maggot cultivation.
Maggot cultivation as a source of fish food is not yet familiar, hence it is necessary to socialize and provide information of maggot cultivation to wider community. The Ornamental Fish Culture Research Center (BRBIH) has conducted socialization and introduction of maggot cultivation in 16 locations on the islands of Java, Sumatra, Kalimantan and Papua which was being well received by many people because they know the importance of alternative protein sources that can be applied to livestock and fish. Maggot opportunities to become alternative fish feed can replace the function of fish meal as a source of protein in pellets, which still depends on imported fish meal. In fact, there have been many companies engaged in the maggot business like PT. Biomag Sinergi Internasional, PT Magot Indonesia Lestari, and an Indonesian company that has successfully exported Black Soldier Fly (BSF), namely BioCycle. Furthermore, there are also many maggot cultivating communities that are the member of BSF Indonesia colony. It means that maggot cultivation provides a lucrative business opportunities for the community.

3.2. Utilization of maggot as ornamental fish feed
Considering its utilization as a new alternative feed, [6] expected that maggot can answer all three problems by providing: 1) feed at cheap price and easy to obtain, 2) feed that does not cause pollution of the aquatic environment, and 3) feed that is able to increase endurance of fish bodies. The results of research on maggot as fish feed for both fish used for food and ornamental fish have been developed in the form of fresh maggot and maggot flour.

Trial utilization of maggot as feed supplement was tested on Balashark fish (Balantiocheilus melanopterus Bleeker) of 2.0 ± 0.2 g size conducted by [6] showed that the provision of fresh maggot resulted in better growth and survival. The impact of the addition of fresh maggot on the fish was observed to be significant to fish blood drawing which showed better fish endurance. In addition, [8] conducted research on the use of maggot in artificial feed on Balashark fish (Balantiocheilus melanopterus Bleeker) with the results showed that maggot substitution treatment significantly affected (P <0.05) weight gain, total length, specific growth, protein retention, and protein efficiency ratio. Maggot substitution up to the level of 16.47% provided the best response to the growth performance of balashark fish seed with a protein source substitution for fish meal recommended to be not higher than 16.47%.

In addition, [28] conducted a research on feed enrichment of feed containing maggot flour with shrimp head flour as a carotenoid source in rainbow kurumoi fish (Melanotaenia parva) showed that administration of maggot pellets with the addition of 5-10% shrimp head flour resulted in the highest color enhancement on the upper body (ventral) but did not produce orange on every part of the body of rainbow kurumoi seeds and did not significantly affect the growth and length of rainbow fish cultivated. As reported by [26], the application of fresh maggot and maggot in artificial feed (maggot pellets) in rainbow kurumoi fish showed that maggot and maggot pellets were found to meet the nutritional requirement for rainbow kurumoi fish with weight gain and length increase. Similar study was also carried out by [27], showed that no significant difference was observed between treatments, but feeding fish with maggot and maggot fish silage resulted in relatively higher growth and length in average compared with pellet administration (control).

[28] conducted a study on the description of the amino acid profile in fish feed formulations at various maggot flour and earthworm flour ratios, showed that the amino acid values in the treatment ratio of 100% earthworm flour and 100% maggot flour were found to always alternately occupy the highest position, while the combined ratio of 50% earthworm flour and 50% maggot flour was always at the lowest position. This indicates that amino acid profile from the combination of two different types of natural food sources did not produce a nutrient balance, but instead reduced the value of the amino acids contained. After knowing the description of amino acids in maggot flour, then [9] re-examined the use of maggot flour and earthworm flour to improve the reproduction of mother rainbow kurumoi fish (Melanotaenia parva). The results of this study indicated that no significant difference was observed
between each maggot flour treatment and the ratio of earthworm flour to survival, initial weight, initial and final length parameters in male and female fish. Significant differences were found in the final weights of females and males. The average total number of larvae produced during the study showed a significant difference between treatments where the use of 100% maggot flour produced the highest number of larvae, while the use of 50% maggot flour and 50% earthworm flour resulted in the lowest outcome.

3.3. Utilization of maggot as fish feed consumption

[12] examined the effect of substitution of fish meal with maggot flour on the growth and survival of catfish (*Pangasius pangasius*). The results showed that the substitution of fish meal with maggot flour produced a greatly significant effect on growth (growth in absolute weight and specific growth rate) and did not significantly affect the survival of catfish. Test feed of fish meal substitution with 25% maggot flour produced the best growth for catfish. Research on jambal catfish (*Pangasius djambal*) with a combination of pellet feed and maggot was found to affect the growth rate, feed conversion, and protein efficiency, but did not affect the survival of jambal catfish. The combination of 75% pellet feed and 25% fresh maggot provided the highest growth rate and protein efficiency as well as the highest feed conversion. Moreover, daily weight growth rate (LPBH) of jambal catfish was found to be optimal in a combination of 82.50% pellets and 17.50% maggot [29].

The provision of additional feed in the form of fresh maggot according to [30] could accelerate the growth rate of relative weight and factor conditions for climbing perch seeds (*Anabas testudineus* Block). Feed provided was at a low conversion rate of 3% fish biomass with pellet feeding frequency of 1% in the morning (mix of pellets and maggot) and 1% in the afternoon (maggot). Furthermore, [31] mentioned that the addition of 20% maggot in artificial feed resulted in the highest value of specific growth rate of 3.36%, protein retention of 16.94%, feed conversion ratio of 1.05%, and 100% survival in tinfoil barb (*Barbonymus schwanenfeldii*) culture that was significantly different (P <0.05) from other treatments, namely the addition of maggot flour at ratio of 10%, 30%, 40% and without the addition of maggot flour (control).

[32] performed substitution of protein sourced from fish meal with maggot flour in BEST tilapia (Bogor Enhanced Strain Tilapia) and found that the substitution of maggot flour up to 15% provided the best response to the growth of BEST tilapia compared to 30% maggot substitution and feed without maggot. Later, feed made of the combination of 50% maggot and 50% artificial feed (pellet) given to tilapia (*Oreochromis niloticus*) by [33] showed good results of survival, growth, FCR and feed efficiency.

Research on the use of maggot as fish feed is indeed more widely applied to fish used for food as conducted by [34] in pomfret (*Colossoma macropomum*). Maggot flour was added to commercial feed with the result showed that the addition of 20% maggot flour produced daily growth rate of 2.027%, the highest increase in total length of 0.990 cm and feed efficiency of 46.80%. The recommendation in this pomfret research is that the optimal addition of maggot flour for pomfret seed growth is 20.63%. [35] reported that maggot application in toman fish (*Channa micropeltes* CV.) culture was able to replace trash fish up to 50% with a feed conversion ratio (FCR) of 3.31 and the best specific growth rate (SGR) obtained.

Moreover, [36] also reported that the administration of maggot flour as much as 0%, 5%, 10%, 15%, and 20% in artificial feed in carp maintenance (*Cyprinus carpio* L.) did not result in significant effect on the growth rate, feed efficiency and survival of carp seeds. Research on the use of maggot flour as a substitute for fishmeal for the growth of fish seed (*Ompok hypoptalmus*) was also reported by [37] in which the percentage of maggot flour and different fish meal used in feed did not significantly affect the growth of fish seed. Percentage dose of 50% maggot flour : 50% fish meal resulted in digestibility value
of 49.49%, feed efficiency of 15.56%, growth rate of 1.51%, and survival rate of 91.67%. Hence, maggot flour can be a substitute for fish meal.

Substitution rate of fish meal with maggot flour as protein source that meet the desired feed quality and growth of siam jambal fish (*Pangasius hypophthalmus*) was reported by [38] in which the use of maggot flour up to 100% was able to replace the role of fish meal in Siamese Jambal fish culture since the use of 100% maggot flour provided the best result. The application of maggot flour in Asian redtail fish (*Mystus nemurus* CV) grow-out according to [39] also did not significantly affect the specific growth rate and feed efficiency. However, the best result in this study was found in the treatment of 100% fish meal with a specific growth rate of 4.88% and feed efficiency of 12.98%.

Research on the application of maggot has been widely reported with the results of maggot did not provide significant effect on fish growth as reported by [40] who stated that the results of analysis of variance in growth rates of weight, relative length and feed conversion in fish (*Anabas testudineus* Bloch) showed no significant effect between treatments with a combination of A (75% maggot + 25% bran), B (50% maggot + 50% bran), C (25% maggot + 75% bran), and D (feed pellet/control). In addition to its application in freshwater aquaculture, maggot can also be applied to fish maintained in brackish water. According to [41], milkfish (*Chanos chanos* Forsskal) fed with various levels fish meal substituted with maggot flour showed a similar effect on protein retention, fat retention, energy retention and efficiency of feed utilization. Therefore, it is concluded that the use of maggot flour up to 100% can replace the role of fish meal in milkfish farming.

The results of a study conducted by [42] showed that feeding maggot and pellet feed to fish significantly affected the growth and survival of mad barb fish seeds. Ratio of 50% maggot feed and 50% pellet feed provided the best result on absolute growth (5.56 grams) and daily growth rate (0.093 gram/day), while 100% maggot feed obtained the best results on feed conversion ratio (1.69) and survival (100%) of mad barb fish (*Leptobarbus hoevenii* (Bleeker, 1851)). Research on the use of maggot is not only concerning its application in fish, there are also researches on the analysis of the business of maggot as fish feed. [13] conducted research on the potential analysis of maggot cultivation business and saving that could be made if maggot was given as an alternative combination of pellets for catfish feed. The results showed that the use of 50% pellets and 50% maggot could save 22.74% of feed procurement costs and maggot had the potential to be cultivated as an alternative feed for catfish (*Clarias* sp). Fresh maggot can also be used as gouramy feed as reported by [43] that gouramy fed fresh maggot grown in market waste media was found to have better growth compared to gouramy fed maggot grown in palm oil cake media.

A study conducted by [44] on catfish (*Clarias gariepinus*) showed that 75% of maggot flour mixed in feed was found to support an increase in average weight (MWG), percentage of weight gain (PWG), specific growth rate (SGR), protein efficiency ratio (PER), and food conversion rate (FCR). In addition, changing 75% of maggot flour was able to reduce operational costs and proven to be profitable. According to [45] the addition of maggot flour to 100% in tilapia feed turned out to reduce production costs, thus it is recommended for tilapia cultivation as a substitute for fish meal.

4. Conclusion
Maggot as a food source that contains high protein (40-50%), has been scientifically proven to be applied to ornamental fish and fish used for food both in the form of fresh maggot and maggot flour. Maggot as an alternative source of protein in fish feed has good prospects. Utilization of maggot flour is expected to reduce the dependence of fish farmers on protein from fish meal and soybean flour that is increasingly expensive and limited in availability since it is scientifically proven that maggot flour can replace fish meal by 50-100%. The ability of maggot to decompose organic waste as a breeding medium and its high tolerance to climate variations in tropical environments makes maggot easy to be mass-produced in a
small-scale business or industry. Thus, the use of BSF as an alternative source of protein can reduce production costs in the fishing industry without reducing its quality.

References
[1] Prasetio A B 2015 *Trobos Aqua Edition* 41 22-23
[2] Kusrini E, Cindelaras S and Prasetio A B 2015 *Media Akuakultur* 10 71-78
[3] KKP (Kementerian Kelautan dan Perikanan) 2016 *Potential of Fresh Fish Aquaculture Business* (Indonesia: KKP)
[4] Afrianto E and Livaiawaty E 2005 *Fish Feed* (Yogyakarta : Kansius) p 65
[5] Hem S, Fahmi M R, Chumaidi, Maskur, Hadadi A, Supriyadi, Ediwarman, Larue M and Pouyoud L 2008 *Valorization Of Palm Kernel Meal Via Bioconversion: Indonesia’s Initiative To Address Aquafeeds Shortage Fish For The People* (Thailand: Bangkok) vol 6 SEAFDEC p 42
[6] Fahmi M R, Hem S and Subamia I W 2009 Maggot Potential for Growth and Health Status of Fish *J. Riset Akuakultur* 4 221- 232
[7] Fahmi M R Hem S and Subamia I W 2007 *Pros. Sem. Nasional Perikanan* (Indonesia: Bogor) Puslitbangnangp p 125-130
[8] Priyadi A, Azwar Z I, Subaima I W and Hem S 2010 *J. Ris. Akuakultur* 4 367-375
[9] Subandiyah S, Meilisza N, Hirnawati R, Sukarman and Murniasih S 2018 *Int. J. of Fisheries and Aquatic Stud.* 6 43-52
[10] Retnosari D 2007 *Effect Of Substitution Of Fish Meal By Maggot Flour On The Growth Of Tilapia Seeds (Oreochromis niloticus)* (Research Report) (Bandung: Universitas Panjadjaran) p132
[11] Hadadi A, Herry S, Surahman A and Ridwan E 2007 *J Budidaya Air Tawar* 4 11-18
[12] Rachmawati D and Samidjan I 2013 *J. Sain. Perikanan* 9 62-67
[13] Fauzi R U A and Sari E R N 2018 *J. Teknologii dan Mana. Agroind.* 7 39-46
[14] i ková H, Newton G L, Lacy R C and Kozánek M 2015 *Waste Manag* 35 68-80
[15] Makkar H P S, Tran G, Heuze V and Andreas P 2014 *Anim. Feed Sci. Techn.* 197 1-33
[16] Tomberlin J K and Sheppard D C 2002 *J. Ento. Sci.* 37 345-352
[17] Fahmi M R 2018 *Maggot High Protein Fish Feed and Organic Waste Processing* (Jakarta: Penebar Swadaya) p 100
[18] Newton L, Sheppard C, Watson D W, Burtle G and Dove R 2005 *Using The Black Soldier Fly Hermetia illucens As A Value- Added Tool For The Management of Swine Manure* (North Carolina: State University Raleigh)
[19] Suciati R and Faraq H 2017 *J. Bio. dan Pendidikan Bio.* 2 8-13
[20] Li Q, Zheng L, Qiu N, Cai H, Tomberlin J K and Yu Z 2011 *Waste Manag.* 31 1316-1320
[21] Mangunwardoyo W, Aulia and Hem S 2011 *Biota* 16 166-172
[22] Olivier P A 2004 *Bio-Conversion of Putrescent Wastes* (Washington DC: ESR LLC)
[23] Rachmawati, Buchori D, Hidayat P, Hem S and Fahmi M R 2010 *J. Entomol. Ind.* 7 28-41
[24] Wardhana A H 2016 Black Soldier Fly (Hermetia illucens) as An Alternative Source of Protein for Animal Feed *Wartazoa : Buletin Ilmu Peternakan Dan Kesehatan Hewan Indonesia* 26 69-78
[25] Prayogo H H, Rostika R and Nurruhwati I 2012 *J. Perikanan dan Kelautan* 3 201-205
[26] Irfan M S and Manan A 2013 *J. Ilmiah Perikanan dan Kelautan* 5 139-143
[27] Himawan Y and Subamia I W 2013 *J. Iktiologi Indo.* 13 153-160
[28] Meilisza N and Subamia I W 2015 *Pros. Sem. Nas. Ikan* 8 154
[29] Hariadi S, Irsan C and Wijayanti M 2014 *J. Akua. Rawa Indo.* 2 150-161
[30] Torang I 2003 *J. Ilmu Hewani Tropika* 2 12-16
[31] Raharjo E I, Rachimi and Paul P 2014 *J. Ruaya* 3 35-40
[32] Setijaningsih L 2011 *Pros. Forum Inovasi Teknol. Akuakultur* 854-860
[33] Murni 2013 *J. Ilmu Perikanan* 2 192-198
[34] Kardana D, Haetami K and Subhan U 2012 J. Perikanan dan Kelautan 3 177-184
[35] Ediwarman, Himawati R, Adianto W and Moreau Y 2008 J. Riset Akuakultur 3 395-400
[36] Cahyoko Y, Rezi D G and Mukti A T 2011 J. Ilmiah Perikanan dan Kelautan 3 145-150
[37] Marno A and Aryani N 2016 J. Online Mahasiswa 3 1-12
[38] Panjaitan J, Suharman I and Adelina 2015 J. Online Mahasiswa 1 1-7
[39] Hulu O, Suharman I and Adelina 2014 J. Online Mahasiswa 1 1-7
[40] Rukmini 2014 Agroscie. 21 23-28
[41] Haryati 2011 J. Iktiologi Indo. 11 185-194
[42] Santoso B 2018 The Effect Of Artificial Feed And Maggot Hermetia illucens To Mad Barb Fish Growth Leptobarbus hoevenii (Bleeker 1851) (Lampung: Lampung University) p 49
[43] Fahmi M R 2015 Proc. of the Nat. Sem. on the Indonesian Biodiversity Society 1 139-144
[44] Olaniyi C O and Salau B R 2013 J. of Agricul. Res. 8 4604-4607
[45] Ali A E, Mekhamar M I, Gadel-Rab A G and Osman A G M 2015 American J. of Life Sci. 3 24-29