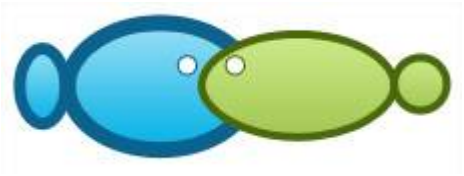

The use of artificial feed, *Tubifex* sp. and their combination on growth and survival of eel (*Anguilla bicolor bicolor*) reared in Situ Cibuntu, Bogor Regency

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Abstract. Eel (*Anguilla bicolor bicolor*) is an economically important fish species with strong potential for cultivation. Eel has slow growth due to low digestibility. Eels need to consume feed with high protein content (> 45%). Protein derived from a combination of several types of sources results in better conversion and growth than a single source. Eel cultivation in open waters is not common and should be further examined in research. In this study, elver eels with a weight of 0.72±0.09 g per fish were used as the test animal. There were 50 fish per hapa net with a density of 0.45 g per liter. Hapa net measuring 40 x 40 x 80 cm with a water column height of ±50 cm and a volume of 80 liters of water were used to keep the eels. A completely randomized design (CRD) experiment with 3 treatments and 4 repetitions was carried out. Artificial feed was used in treatment A, while treatment B used 50% artificial feed and 50% *Tubifex* sp., and treatment C used 100% *Tubifex* sp.. The parameters observed in this study were total feed consumption (TFC), feed conversion ratio (FCR), feed utilization efficiency (FUE), specific growth rate (SGR), absolute weight, survival rate (SR), benefit cost ratio (BCR), and water quality parameters (temperature, dissolved oxygen, and pH). Treatment B resulted in the best growth and survival of eels with TFC of 237.16±17.29 g, FCR of 2.48±0.19, FUE of 40.50±3.15%, SGR of 1.63±0.11% per day, absolute weight of 2.01±0.18 g and SR of 93.5±4.12%. Whereas, treatment A showed the highest BCR.
Key Words: artificial feed, *A. bicolor bicolor*, growth, survival, *Tubifex* sp.

Introduction. Eel *(Anguilla bicolor bicolor*) is a highly valued fish with good nutritional benefits. Prices vary from IDR 160,000 to 245,000 per kg for local sales and up to IDR 2 million per kg for export to Japan, where there is a shortage of eel due to overfishing and habitat loss. Eel production in Indonesia has decreased from 2,376 tons in 2012 to 1,063 tons in 2016, but the country remains among the top ten producers of eel (FAO 2020; Harianto et al 2022). Fluctuations in eel prices occur due to seasonal catches (Lukas et al 2019) and declining global stocks due to overfishing, habitat destruction, pollution, invasive species and climate change. Eel production in Japan is still insufficient due to overfishing and habitat loss (Kasai et al 2021). This condition opens up the opportunity for eel cultivators in Indonesia to penetrate the Japan market. Furthermore, the decline in eel stocks in the world is also due to overfishing, habitat destruction (including the construction of dams), water pollution, attacks by invasive species and parasites, and climate change. Hence, eel cultivation needs to be enhanced (Ringuet et al 2002).

Eel is a catadromous species (Kerans et al 2020; Harianto et al 2021; Kasai et al 2021) which slow growth remains the major obstacle in its cultivation (Kerans et al 2020; Chilmawati et al 2021). The low digestibility and inefficiency of eel feed have been linked to this slow growth (Chilmawati et al 2017; Lukas et al 2019). Feed that contain the

nutritional needs of eels can speed up the growth. Since eel is a carnivorous fish, they need to eat artificial feed with protein content more than 45% (Arief et al 2011). *Tubifex* sp. is one of main ingredients in fish feed with more than 56% protein. *Tubifex* sp. and artificial feeds can be combined for effective fish feeding to accelerate the eel growth and metabolism (Herawati et al 2016; Firmani & Lono 2018; Wijayanti et al 2020; Mulatsih et al 2021).

Investigating eel cultivation in open waters is important for understanding the role of lakes in supporting inland fisheries and in understanding the growth and survival rate of eel. Situ Cibuntu, a small lake in West Java, Indonesia, has the potential to support eel growth and survival due to the presence of benthic macroinvertebrates and phytoplankton (Alavaisha et al 2019; Ibrahim et al 2021). This study was conducted at Situ Cibuntu's natural laboratory by the Limnology Research Center and aimed to determine the effect of artificial feeding, natural feed, and their combination on the growth and survival of eel (*A. bicolor bicolor*).

Material and Method

Study location. This research was performed at Situ Cibuntu, Bogor Regency (July to October 2021). Situ Cibuntu is a small lake under the management of National Research and Innovation Agency of Indonesia with a surface area of 2.11 ha and a maximum depth of 1.20 m (Figure 1).

Figure 1. Location of research activities.

Research materials. In this experimental research, a hapa measuring 40 cm x 40 cm x 80 cm with a water level of ±50 cm and 12 experimental containers with a volume of 80 liters of water per container were used. The test fish was elver eel (*A. bicolor bicolor*) with an average weight of 0.72±0.09 g per fish. We used 600 fish with a density of 50 fish per container with the stocking density of 0.45 g per liter. The completely randomized design (CRD) consisted of three treatments and four repetitions. Different treatments were applied: treatment A (100% commercial artificial feed), treatment B (50% commercial artificial feed + 50% *Tubifex* sp.) and treatment C (100% *Tubifex* sp.). The amount of feed given to the fish was determined based on dry weight. Feeding was done twice a day in the morning and afternoon, where feed was placed in the feed container for practicality purpose. The cultivation lasted for 84 days, and weight sampling was conducted every two weeks.

Data analysis. The parameters observed in this study included total feed consumption (TFC), feed conversion ratio (FCR), feed utilization efficiency (FUE), specific growth rate (SGR), absolute weight, survival rate (SR) and benefit cost ratio (BCR). Several formulae were used in this study as follows (Ratucoreh & Retnoaji 2018; Lukas et al 2019; Wijayanto et al 2020; Chilmawati et al 2021; Harianto et al 2021).

$$TFC = F_1 + F_2 + \dots Fn \quad [1]$$

$$FCR = \frac{F}{(Wt + D) - Wo} \quad [2]$$

$$FUE = \frac{Wt - Wo}{F} x\ 100 \quad [3]$$

$$SGR = \frac{Wt - Wo}{Wo \times t} \times 100 \quad [4]$$

$$W = Wt - Wo \quad [5]$$

$$SR = \frac{Nt}{No} x\ 100 \quad [6]$$

$$BCR = \frac{B}{C} \quad [7]$$

where: TFC = total feed consumption;
F_1 = number of feeds on the first day (g);
F_2 = number of feeds on the second day (g);
Fn = number of feeds on the n day (g);
FCR = feed conversion ratio;
F = weight of feed given (g);
Wt = biomass of test animals at the end of rearing (g);
W_0 = biomass of test animals at the beginning of rearing (g);
D = weight of dead fish during rearing (g);
FUE = feed utilization efficiency (%);
SGR = specific growth rate (% day^{-1});
t = time of experiment (days);
W = absolute weight (g);
SR = survival rate (%);
Nt = number of fish that live at the end of rearing (ind);
No = number of fish that live at the beginning of rearing (ind);
BCR = benefit cost ratio;
B = additional income due to eel growth (IDR);
C = cost of feed (IDR).

Analysis of variance (ANOVA) was performed to see the significant effects of the treatments, followed with Duncan's test with a 95% confidence interval.

Water quality monitoring. Water quality parameters including pH, temperature and dissolved oxygen (DO) were measured twice a day using a water quality checker. While nitrite, nitrate, total nitrogen, total phosphate, ammonia and chlorophyll-*a* contents were measured every two weeks. Water sampling for the water quality test was carried out at three location points around the container net.

Results and Discussion. TFC, FCR, FUE, SGR, absolute weight, and SR data of eels during the study are shown in Table 1.

Table 1

Results of TFC, FCR, FUE, SGR, absolute weight and SR

Variables	*Treatment*		
	A	*B*	*C*
TFC (g)	221.13±8.40[a]	237.16±17.29[a]	240.51±22.38[a]
FCR	2.91±0.19[b]	2.48±0.19[a]	2.86±0.27[b]
FUE (%)	34.45±2.31[a]	40.50±3.15[b]	35.26±3.31[a]
SGR (% day^{-1})	1.40±0.09[a]	1.63±0.11[b]	1.50±0.06[ab]
Absolute weight (g)	1.55±0.010[a]	2.01±0.18[b]	1.73±0.08[a]
SR (%)	91±6.00[a]	93.5±4.12[a]	93.5±4.12[a]

Note: Different superscripts on the same row indicate significant differences ($p < 0.05$).

Total feed consumption. The provision of artificial feed, natural feed, and their combination had no significant effect on the TFC. Fish feed consumption seems to be more influenced by fish appetite, which is one of the most important external signals that stimulate feeding behavior and growth. An increase in fish appetite causes an increase in

the total consumption of fish feed, and vice versa, low appetite can cause slow growth of fish (Assan et al 2021).

The lowest TFC value was found in treatment A, where eels were fed 100% commercial artificial feed, possibly because Elver eel was not used to the artificial feed yet. On the other hand, the highest TFC value was found in treatment C, where eels were fed 100% *Tubifex* sp., presumably due to the natural eating habits of eels at the elver stage. In nature, eels of a certain size tend to prey on fish, crustaceans, phytoplankton, and zooplankton (Setijanto et al 2003).

Tubifex sp. are hermaphrodite water worms which are commonly used as natural food for aquaculture. The life cycle of *Tubifex* sp. takes about 50-57 days. *Tubifex* sp. worms mostly live in clear and flowing fresh water and prefers the muddy bottoms with high organic matter (Mahendra et al 2019). According to Herawati et al (2016), *Tubifex tubifex* is the best natural food for fish and prawn due to its size and nutritional content that is appropriate for their needs.

Feed conversion ratio (FCR). Artificial feed, natural feed and the combination of both showed significant effects on the FCR of eel ($p < 0.05$). The best FCR was obtained in treatment B with a value of 2.48. This value implies that every 1 g growth requires 2.48 g of feed. The combination of artificial feed and *Tubifex* sp. showed the best FCR, indicating that the feed is optimally used for growing. The protein derived from a combination of various sources produces a better conversion rate than single source protein (Hua et al 2019). Proteins are formed by several amino acids. There are more than 200 amino acids, but only 20 amino acids are common and there are 10 essential amino acids that cannot be synthesized by fish, including arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine (Craig et al 2017).

The addition of probiotics to artificial feed has been able to accelerate the process of absorption of eel feed. The fermentation can improve the quality of feed ingredients which will enhance the fish growth. As explained by Chilmawati et al (2017), fermentation in feed is useful for breaking down organic compounds into simpler compounds by involving microorganisms, making them easier to digest by fish and reducing the anti-nutrients. The combination of artificial feed and *Tubifex* sp. supports the growth of eel as smaller the FCR shows better suitability of the feed for the eel to grow. High FCR is affected by several factors, including the amount of feed and feed quality. Excessive feeding causes a lot of leftover feed, resulting in higher FCR. Harianto et al (2021) found the FCR of eels ranged between 1.43 and 1.87. Craig et al (2017) mentioned that FCR of 1.5-2.0 is regarded good for the growth for most fish species, including eel.

Feed utilization efficiency (FUE). Artificial feed, natural feed and the combination of both significantly affected the FUE ($p < 0.05$). The best FUE was found in treatment B with a value of 40.50%. The combination of artificial feed and *Tubifex* sp. has increased the FUE. The high FUE value in treatment B is thought to be because it is easier for the eel to digest the feed. The lowest FUE value was found in treatment A with 100% artificial feed which obtained a value of 34.45%. FUE is related to the weight of biomass derived from protein in the feed, where high feed efficiency value indicates better efficiency in the feed consumption thereby the protein content is used to support the growth. However, optimal growth is not only determined by high protein content but also by fat, carbohydrates, vitamins and minerals. Hence, nutritional content that is adjusted to specific needs of fish from different species and life span becomes very important in supporting the growth of fish (Craig et al 2017).

Specific growth rate (SGR). The uses of artificial feed, natural feed and the combination of two showed significant effects on the SGR of eel ($p < 0.05$). The best SGR was obtained in treatment B of 1.63% day^{-1}. The combination of artificial feed and *Tubifex* sp. gave better results on the SGR of eel, presumably due to better digestive ability compared to other treatments. In addition, the combination of types of feed

provided were able to complement each other that the nutrient intake becomes adequate to support the fish growth. High SGR in treatment B can also be affected by the amount and nutritional content of the feed combination that matched the needs of the eels.

Eel growth can be optimized by increasing the quality of feed that is determined by macro and micro nutrient content of feed, including protein, fat, carbohydrates, vitamins, and minerals (Chilmawati et al 2021). The availability of natural feed plays an important role in the growth of eel, while artificial feed complements the nutritional value that that are not contained in natural feed. The growth of eel is closely related to the quality and quantity of feed given. The high and low SGR is influenced by the feed consumed by fish, where adequate nutritional intake affects the speed of growth. Craig et al (2017) stated that protein is the most expensive component of fish feed. Therefore, it is important to set the protein requirements for fish. The combination of artificial feed and *Tubifex* sp. in treatment B resulted in better growth rate than other treatments because *Tubifex* sp. had a higher nutritional content than other treatments. Natural feed in the form of *Tubifex* sp. and artificial feed is regarded effective as it has balanced nutritional content.

Treatment A showed the lowest SGR of 1.4% day^{-1}, presumably because the nutrient and protein content in treatment A was lower than the other treatments. Eel is a carnivorous fish that needs high protein intake. The proportion between protein and energy content of feed must be balanced as either lack or excess of energy can reduce growth rates. Based on the statement, the combination of artificial feed and natural feed meets the nutritional and protein needs of eels. Ratucoreh & Retnoaji (2018) found that substituting fish meal with *Chlorella vulgaris* flour could increase the SGR of eel. Harianto et al (2021) also reported the SGR of eels ranged between 1.38 and 1.57% day^{-1} in a 60-day experiment with different water levels (the average initial weight of the fish tested was 13.66 g).

Absolute weight. The study found that different types of feed and their combination significantly affected the growth of elver eel ($p < 0.05$). Treatment B using a combination of 50% artificial feed and 50% *Tubifex* sp. resulted in the highest absolute weight of eels (2.01 g). Hence, this combination is regarded more efficient. The nutrients in this treatment likely met the needs of eels better. Overall, factors such as sufficient feed availability, proper feed utilization, normal water quality, and absence of pathogens can impact eel growth (Diansyah et al 2014).

Absolute weight refers to the gain in fish weight before and after the treatment, which provides an overview of growth. In this study, the highest weight growth was observed in treatment B that used the combination of artificial feed and *Tubifex* sp., likely due to a better feeding response and nutritional needs being met. Bokings et al (2017) noted a positive relationship between appropriate protein in feed and absolute weight. Treatment A, which included 100% artificial feeding, had the lowest absolute weight, possibly due to the eel's lack of adaptation to the new formulated feed.

Survival rate (SR). Different types of feed and their combination did not have any significant effect ($p < 0.05$) on the SR of the eel. The highest eel SR was found in treatment B and treatment C that reached 93.5% each. According to Tuan & Duat (2021), the most critical stage for eel cultivation is the stage between glass eel to elver because the SR is very low.

Each treatment had a survival value above 90%, indicating that feed have good quality and quantity which then influenced the SR. SR is affected by biotic factors such as age and adaptation to the environment, and abiotic factors such as feed availability and water quality. Treatments B and C had higher SR likely due to better adaptation to the environment and adequate food intake. High SR suggests that the feed provided supplied sufficient energy for eels to sustain life and perform physical activities. Chilmawati & Suminto (2014) found the energy from feed is first used for body maintenance and body activity functions before being used for growth. Poor water quality can also affect the survival of eel fish, causing stress and potential death (Lukas et al 2019).

Benefit cost ratio (BCR). Despite the effectiveness of *Tubifex* sp. in promoting high eel growth, *Tubifex* sp. are relatively expensive. Treatment A that used 100% commercial artificial feed, has a benefit-cost ratio (BCR) of 1.52. It implies that IDR. 1 spent on feed costs generates income from fish growth of IDR. 1.52. On the other side, treatment B has a BCR of 0.52, and treatment C has a BCR of 0.26. Thus, the cost-effectiveness of different feed types needs to be taken into consideration alongside growth, SR, and FCR when producing eel feed.

In fish farming, nutrition is crucial as feed accounts for approximately 50% of production costs (Craig et al 2017; Wijayanto et al 2020). The global demand for Indonesian eel (*A. bicolor bicolor*) has risen due to the decline of American, European, and Japanese eel populations, making tropical eels a valuable resource (Arai & Chino 2022). Eel is a popular fish in East Asia and a traditional seafood in Japan (Kasai et al 2021). As an eel producer, Indonesia needs to develop eel cultivation to meet the high demand.

Water quality. The water quality in this study has been suitable for eel maintenance. The SR is influenced by appropriate aquaculture management, including stocking density, feed quality, water quality, disease, and parasites (Arief et al 2011). Water quality parameters as shown in Table 2 show that the temperature ranges between 26.4 and 31°C, DO between 3.1 and 5.3 mg L^{-1}, and pH between 6.97 and 8.8. These values are optimal for eel growth and survival.

Table 2

Water quality at Situ Cibuntu Cibinong

Parameter	*Location*			*References*
	Station 1	*Station 2*	*Station 3*	
Temperature (°C)	26.7-31	26.4-31	26.5-30.4	23-32°C [a)]
DO (mg L^{-1})	3.2-5.3	3.2-5.1	3.1-5.2	3.2-7.5 mg L^{-1} [b)]
pH	7.08-8.8	6.97-8.6	6.99-8.58	7-8 [c)]

Notes: [a)] Usui (1974); [b) c)] Fekri et al (2014).

Maintaining water quality during fish farming is the key to successful fish cultivation. Water temperature, pH, and DO are important parameters. Ibrahim et al (2021) showed that the temperature in the waters of Situ Cibuntu ranged from 28.45 to 32.97°C, pH from 5.7 to 7.9, and DO from 5.54 to 10.51 mg L^{-1}. The water parameters values indicate that, in general, Situ Cibuntu can be used as a location for eel cultivation. However, the condition of Situ Cibuntu water quality is greatly influenced by the flow of Kalibaru river. Anthropogenic activities can degrade the water quality of Situ Cibuntu.

Conclusions. Artificial feeding with *Tubifex* sp. and a combination of both significantly affected the FCR, SGR, FUE and absolute weight growth, but did not affect the total feed consumption and survival of eel. The combination of artificial feed and *Tubifex* sp. in feed resulted in the most optimal results, with FCR values of 2.48, FUE of 40.50%, SGR of 1.63% day^{-1}, absolute weight of 2.01 g and SR of 93.5%. Nevertheless, the best BCR in this study was found in treatment A because commercial feed was much more economical than the price of *Tubifex* sp.. Open waters such as Situ Cibuntu can be used as a medium for elver stadia eel development. Suitable water quality conditions are the main factors that should be carefully taken into consideration.

Acknowledgements. The authors would like to thank the Limnology Research Center – BRIN, Cibinong, Bogor, West Java and the LPDP Rispro Invitation activities in 2020-2021 which have funded, facilitated and assisted this research. Gratitude is also expressed Afidatin Najiyah and Giovani Anggasta as research partners for giving huge assistance and cooperation during the research and all parties who have assisted in the implementation and preparation of this scientific article.

Conflict of interest. The authors declare that there is no conflict of interest.

References

Alavaisha E., Manzoni S., Lindborg R., 2019 Different agricultural practices affect soil carbon, nitrogen and phosphorous in Kilombero-Tanzania. Journal of Environmental Management 234:159-166.

Arai T., Chino N., 2022 Contribution of migratory types to the reproduction of migrating silver eels in a tropical eel, *Anguilla bicolor bicolor*. Heliyon 8(5):e09491.

Arief M., Pertiwi D. K., Cahyoko Y., 2011 [Effect of artificial feed, natural feed, and combination between them to growth rate, food convertion ratio and survival rate of Indonesian shortfin eel (*Anguilla bicolor*)]. Jurnal Ilmiah Perikanan dan Kelautan 3(1):61-66. [in Indonesian]

Assan D., Huang Y., Mustapha U. F., Addah M. N., Li G., Chen H., 2021 Fish feed intake, feeding behavior, and the physiological response of apelin to fasting and refeeding. Frontiers in Endocrinology 12:798903.

Bokings U. L., Koniyo Y., Juliana, 2017 [Growth and survival of siamese catfish (*Pangasius hypophthalmus*) seeds fed with artificial feed, silk worms (*Tubifex* sp.) and their combinations]. Jurnal Ilmiah Perikanan Dan Ilmu Kelautan 5(3):82-89. [in Indonesian]

Chilmawati D., Suminto, 2014 [The influenced of paste artificial feed with different protein levels on the growth, feeding efficiency and survival rate of elver (*Anguilla bicolor*)]. Proceeding of Fourth Annual National Seminar on Fisheries Research Results, Universitas Diponegoro, pp. 379-388. [in Indonesian]

Chilmawati D., Suminto, Yuniarti T., 2017 [Production increase of *Anguilla bicolor* by using food fermentation and earth worms flour (*Lumbricus* sp)]. Saintek Perikanan: Indonesian Journal of Fisheries Science and Technology 12(2):86-92. [in Indonesian]

Chilmawati D., Suminto, Subandiyono, Harwanto D., 2021 Performance of growth, nutrition value, total carotene, EPA, and DHA in eel (*Anguilla bicolor*) in the culture with enrichment of earthworm (*Lumbricus* sp.) flour. AACL Bioflux 14(3):1570-1580.

Craig S., Kuhn D. D., Helfrich L. A., Schwarz M. H., 2017 Understanding fish nutrition, feeds, and feeding. Virginia Cooperative Extension, Publication 420-256, 6 pp.

Diansyah S., Budiardi T., Sudrajat A. O., 2014 [Growth performance of 3-g *Anguilla bicolor* bicolor at different density]. Jurnal Akuakultur Indonesia 13(1):46-53. [in Indonesian]

Fekri L., Affandi R., Budiardi T., 2014 [Feeding rate of freshwater eel *Anguilla bicolor bicolor*: at the body weight of 1–2 g]. Jurnal Akuakultur Indonesia 13(1):21-27. [in Indonesian]

Firmani U., Lono, 2018 Effect of feeding silkworm on growth performance and feed efficiency of snakehead (*Channa striata*). IOP Conference Series: Earth and Environmental Science 137:012013.

FAO, 2020 FAO yearbook. Fishery and aquaculture statistic 2016. FAO, Rome, 108 pp.

Harianto E., Supriyono E., Budiardi T., Affandi R., Hadiroseyani Y., 2021 The effect of water level in vertical aquaculture systems on production performance, biochemistry, hematology, and histology of *Anguilla bicolor bicolor*. Scientific Reports 11:11318.

Harianto E., Supriyono E., Budiardi T., Affandi R., Hadiroseyani Y., Sabilu K., 2022 Water and land efficiency in eel (*Anguilla bicolor bicolor*) rearing in development of urban aquaculture through vertical aquaculture system. IOP Conference Series: Earth and Environmental Science 1033:012013.

Herawati V. E., Nugroho R. A., Hutabarat J., Karnaradjasa O., 2016 Profile of amino acids, fatty acids, proximate composition and growth performance of *Tubifex tubifex* culture with different animal wastes and probiotic bacteria. AACL Bioflux 9(3):614-622.

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(3):316-329.

Ibrahim A., Aisyah S., Akhdiana I., Lukman, Rahmadya A., Mayasari N., 2021 Evaluation of the physicochemical properties of Cibuntu Pond, Bogor Regency, West Java. Journal of Natural Resources and Environmental Management 11(4):513-523.
Kasai A., Yamazaki A., Ahn H., Yamanaka H., Kameyama S., Masuda R., Azuma N., Kimura S., Karaki T., Kurokawa Y., Yamashita Y., 2021 Distribution of Japanese eel *Anguilla japonica* revealed by environmental DNA. Frontiers in Ecolology and Evolution 9:621461.
Kerans G., Retnoaji B., 2020 Artificial food effects on growth, survival and gonad development of Indonesian eel (*Anguilla bicolor bicolor* McClelland, 1844). AIP Conference Proceedings 2260:030013.
Lukas A. Y. H., Santoso P., Tobuku R., 2019 Physiological study of Indonesian shortfin eel *Anguilla bicolor* on different temperature medium using a recirculation system. AACL Bioflux 12(6):2227-2235.
Mahendra, Damara D., Nufus M., Putri V. R., 2019 Giving lemna minor and mud to the growth of *Tubifex* sp. Budapest International Research in Exact Sciences (BirEx) Journal 1(3):23-27.
Mulatsih S., Hartanti N. U., Najib A., 2021 The effects of probiotics administration on silkworms (*Tubifex* sp) natural feed on groowth of kancra fish (*Tor soro*). IOP Conference Series: Earth and Environmental Science 755:012008.
Ratucoreh C. Y., Retnoaji B., 2018 The growth and histology structure of Indonesian eel (*Anguilla bicolor bicolor* McClelland, 1844) fed with microalgae. AIP Conference Proceedings 2002:020009.
Ringuet S., Muto F., Raymakers C., 2002 Eels: their harvest and trade in Europe and Asia. TRAFFIC Bulletin 19(2), 27 pp.
Setijanto, Yuwono E., Sukardi P., Sulistyo I., 2003 Study on feeding behaviour of eels and the larvae occurrence in Segara Anakan. Proceeding of Tropical Eel Fishery Resource, BPPT, Ministry of Research and Technology, 8 pp.
Tuan N. T., Duat H. V., 2021 An overview of the Anguillid eel culture in Vietnam. Journal of Aquaculture & Marine Biology 10(3):96-101.
Usui A., 1974 Eel culture. Fishing News, London, UK, 186 pp.
Wijayanti D., Sutarjo G. A., Hakim R. R., 2020 The effect of combination of *Tubifex* sp. and artificial feed on the growth and molting of giant shrimp (*Macrobrachium rosenbergii*) stadia V. Indonesian Journal of Tropical Aquatic 3(1):21-31.
Wijayanto D., Bambang A. N., Nugroho R. A., Kurohman F., Nursanto D. B., 2020 The effect of different low salinities on growth, feed conversion ratio, survival rate and profit of Asian seabass cultivation. AACL Bioflux 13(6):3706-3712.

Received: 17 February 2023. Accepted: 28 April 2023. Published online: 04 June 2023.
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How to cite this article:
Akbar M. T., Chilmawati D., Suminto, Triyanto, Wijayanto D., 2023 The use of artificial feed, *Tubifex* sp. and their combination on growth and survival of eel (*Anguilla bicolor bicolor*) reared in Situ Cibuntu, Bogor Regency. AACL Bioflux 16(3):1618-1625.