Domestication of yellow-finned medaka fish (*Oryzias profundicola*)

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Abstract. Lake Towuti located in Malili Complex, South Sulawesi has several endemic species including the yellow-finned medaka fish (*Oryzias profundicola*). This fish was registered in 2019 at the IUCN as a near threatened category. The decline in the population of *O. profundicola* can be increased by domestication. The purpose of this study on domestication was to determine the effect of different natural foods on the survival, growth, and proximate body content of *O. profundicola* during 120 days of maintenance. This study was used a completely randomized design with 3 treatments and 3 replications. The treatments were fed of natural foods i.e. *Chironomus* sp., *Culex* sp., and *Daphnia* sp. The research variables were observed as follows: survival, growth in length and body weight, and the proximate body of fish. The results of this study regarding the survival rate of *Chironomus* sp. was 98.33%±1.67, then *Daphnia* sp. was 96.66%±2.88 and *Culex* sp. was 95.00%±0.00. Furthermore, the highest absolute weight growth was fed of *Chironomus* sp., *Culex* sp., and *Daphnia* sp., respectively 3.16 g±0.05, 2.80 g±0.10 and 2.36 g±0.11. The highest absolute length growth was fed of *Chironomus* sp., *Culex* sp., and *Daphnia* sp., respectively 3.66 cm±0.02, 3.14 cm±0.01 and 2.29 cm±0.28. The highest protein content was given *Chironomus* sp., *Culex* sp., and *Daphnia* sp., respectively 69.34%±1.22, 59.74%±0.08, 61.26%±0.06. The *Chironomus* sp., *Culex* sp., and *Daphnia* sp. was supported the survival, growth rate, and proximate body. The fish successfully spawned during domestication of 120 days was given *Chironomus* sp.

Key Words: survival, growth, proximate body, *Chironomu*s sp.

Introduction. Lake Towuti is located in Malili Complex, South Sulawesi. Lake Towuti has an area of 561.1 km^S and is an ancient and oligotrophic lake (Haffner et al 2001). Lake Towuti is one of the lakes in the Wallacea region which has a variety of endemic fish species (Kottelat et al 1993; Parenti 2011; Parenti & Ebach 2013). Endemic fish in Lake Towuti have distinctive and unique characteristics (Wijaya et al 2009; Nasution et al 2015), also the endemic fish in Lake Towuti have a diversity of species that are ecologically and climatologically different so this species of fish is not found anywhere else in the world (Hutama et al 2016). Endemic fish species in Lake Towuti were reported by Hadiaty (2018), as follows: *Telmatherina bonti*, *Telmatherina celebensis*, *Telmatherina opudi*, *Paratherina striata*, *Paratherina woltereck*i*, Paratherina cyanea, Tominaga sanguicauda*, *Tominanga aurea*, *Oryzias profundicola*, *Oryzias matanensis*, *Oryzias marmoratus*, *Mugilogobius hitam*, *Glossogobius flavipinnis*, *Glossogobius matanensis*, *Glossogobius intermedius* and *Dermogenys megarhamphus.*

Lake Towuti is known as a biodiversity hotspot rich in endemic fish, but its sustainability is critical (Kottelat et al 1993; Tweedley et al 2013). The endemic fish in Lake Towuti were decreased in population, so their sustainability has been disrupted (Parenti 2011; Nasution et al 2014; Prianto et al 2016; Jayadi et al 2019). This is due to over fishing and intensive fishing, the condition of habitat quality has changed due to the presence of domestic pollution and mining waste, also the introduction of invasive fish species as competitors for endemic fish in fighting for space and food, and become prey for the introduced fish.

The endemic fish resources in Lake Towuti such as yellow-finned medaka (*Oryzias profundicola*) according to the IUCN in 2019 this fish is listed as Near Threatened category (Lumbantobing 2019). Resources of yellow-finned medaka fish have economic value as ornamental and consumption fish, as well as potential as model fish (Fahmi et al 2008; Sari et al 2018), and play a role in the stability of the Towuti Lake ecosystem waters for the ecological link in the lake ecosystem. Thus, endemic fish such as yellow-finned medaka fish need to be preserved with sustainable, comprehensive, and integrated management (Nasution et al 2014). One of the management concepts of yellow-finned medaka fish that needs to be done is domestication

Domestication is the process of adapting a species of fish from wild conditions in nature to captive conditions (Teletchea 2018). Domestication is an effort to tame wild fish in nature (Prianto et al 2016). Domestication is the adaptation of fish to the water quality in captive conditions and also the fish was eaten the feed, so that fish can survive, grow, and develop gonads and spawn under maintenance conditions (Jayadi et al 2016; Jayadi 2021). Domestication is a process of adaptation of fish from nature to aquaculture and conservation (Kadarusman et al 2007; Teletchea & Fontaine 2014).

Studies have been done on yellow-finned medaka fish such as taxonomic status and description (Kottelat 1990); a phylogenetic analysis and taxonomic revision (Parenti 2008); ichthyofauna of the endemic fish in Lake Towuti (Jayadi et al 2021); food habit and condition factor (Nursyahran et al 2022a); and analysis of growth patterns (Nursyahran et al 2022b). However, studies on the domestication of yellow-finned medaka fish were not carried out. One of the determinants of successful domestication is the availability of food (Jayadi et al 2016). Recently, this study aimed to determine the effect of different natural foods on the survival, growth, and body proximate content of yellow-finned medaka fish during 120 days of maintenance. The results of research on the domestication of yellow-finned medaka fish can be useful for increasing production and restocking.

Material and Method

Research site. The research was conducted at the freshwater fish farming laboratory at the State Agricultural Polytechnic of Pangkajene and Kepulauan (Pangkep), South Sulawesi, Indonesia from April to August 2022 for 120 days.

Source of fish. *O. profundicola* were collected from Lake Towuti. The fish was caught using a bagged net with a mesh size of 1 mm. The local name of the fishing gear is called "seser". Fish transportation used plastic bags with a density of 10, 15, and 20 fish per bag, and each bag was given pure oxygen. The duration of land transportation from Lake Towuti to the freshwater aquaculture laboratory at the State Agricultural Polytechnic of Pangkep was 24 hours.

Preparation of water. Water sources from natural wells using a pumping system. The water was accommodated in a fiber tank with a volume of 1,200 liters. Before use, the water was precipitated for at least 24 hours, filtered, and then pumped through a filter bag for the domestication of fish.

Adaptation of fish. The fish were maintained in the adaptation fiber tank, a conical spherical fiber tank with a diameter of 1.50 m and a height of 1.50 m, equipped with aeration. The volume of water in the adaptation fiber tank was kept at 500 L. Before the fish were stocked in the adaptation fiber tank, the fish were immersed in 1 mg L^{-1} acriflavine solution for 5 min. The fish were fed after 24 hours adapt in the fiber tank. The food was a mix of *Chironomus* sp., *Culex* sp., and *Daphnia* sp. which was given during fish rearing in the tank. The food dose was 10% of the total weight of the fish. The feeding frequency was 3 times a day. The adaptation time for fish was 15 days. The results of fish in the process of adaptation will be used for domestication research.

Research experimental design. The study used a completely randomized design with 3 treatments and 3 replications. The fish were fed three types of live food: *Chironomus* sp., *Culex* sp., and *Daphnia* sp. for treatment of the research. The research variables were observed as follows: survival, growth in length and body weight, and the proximate content of the fish meat.

Fish rearing for domestication. Fish were maintained in fiberglass tanks (L x W x H; 85 x 60 x 35 cm) which were equipped with an aeration system for oxygen supply. The fiberglass tanks used as many as 9 tanks. The volume of water in each tank was 50 liters. *O. profundicola* were used in domestication are fish from the adaptation process. The density of fish per tank was 20 fish. The fish were fed with *Chironomus* sp., *Culex* sp., and *Daphnia* sp. Food dose was given 10% of total body weight. The frequency of feeding was 3 times a day, at 07.00, at 12.00, and at 16.00 WITA. The water was changed every ten days by as much as 30-50%.

Fish measurement. The total length of the fish was measured using a digital caliper and the total weight was measured using a scale with an accuracy of 0.01 g. The average total weight and total length of *O. profundicola* was maintained for domestication were 0.3 g and 2.0 cm, respectively.

Water quality measurement. The water quality parameters were observed during this study were as follows: temperature, pH, dissolved oxygen. nitrite, nitrate, total ammonia and orthophosphate. Water quality parameters were measured every 10 days.

Calculations. Survival rates were analyzed using the Effendie (1979) formula as follows: SR= Nt / No X 100% (Nt: number of fish at the end of the experiment; No: number of fish in the initial experiment). The absolute weight growth was analyzed using the formula W= Wt - Wo (Wt: total weight at the end of the experiment and Wo: total weight at the initial of the experiment), and absolute length growth was analyzed using the formula Lm = TLt - TLo (TLt: total length at the end of the experiment and TLo: total length at the initial the experiment) (Effendie 1979). Analysis of the proximate body of fish and natural feed were measured on the content of protein, fat, carbohydrates, water and ash according to the AOAC method (2005).

Data analysis. The research parameters were analyzed by analysis of variance (ANOVA), if the results showed a significant effect (P<0.05), then the analysis was carried out with the Turkey test significant difference test. Data processing for this statistical test using software Microsoft Excel 2007 and SPSS version 17. Water quality parameters were analyzed descriptively.

Results

Survival rate. The survival rate of yellow-finned medaka fish were fed natural food, namely: *Chironomus* sp., *Daphnia* sp., and *Culex* sp. are shown in Table 1. Table 1 that the survival of yellow-finned medaka fish was showed results (P>0.05). However, the survival rate of *Chironomus* sp. was 98.33%±1.67 which was the highest, then *Daphnia* sp. was 96.66%±2.88 and *Culex* sp. was 95.00%±0.00 which was the lowest.

Table 1

The survival rate of *Oryzias profundicola* fed with *Chironomus* sp., *Daphnia* sp. and *Culex* sp. for 120 days

Treatment of natural food	*Survival rate (%)*
Chironomus sp.	98.33±1.67[a]
Daphnia sp.	96.66±2.88[a]
Culex sp.	95.00±0.00[a]

Different letters in the same column indicate a significant difference between treatments 5% (P<0.05)

Absolute weight growth. Absolute weight growth of *O. profundicola* during 120 days of rearing were fed natural food, namely *Chironomus* sp., *Daphnia* sp., and *Culex* sp. are shown in Table 2. Table 2 shows that Absolute weight growth of yellow-finned medaka with natural food were showed a significant difference (P<0.05). The highest absolute weight growth of *O. profundicola* was fed of *Chironomus* sp., *Culex* sp. and *Daphnia* sp. were 3.16 g±0.05, 2.80 g±0.10 and 2.36 g±0.11, respectively.

Table 2

Absolute weight growth of *Oryzias profundicola* fed with *Chironomus* sp., *Daphnia* sp. and *Culex* sp. for 120 days

Treatment of natural food	*Absolute weight growth (g)*
Chironomus sp.	3.16±0.05[a]
Daphnia sp.	2.36±0.11[b]
Culex sp.	2.80±0.10[c]

Different letters in the same column indicate a significant difference between treatments 5% (P<0.05)

Absolute length growth. Absolute length growth of *O. profundicola* during 120 days of rearing were fed natural food, namely *Chironomus* sp., *Daphnia* sp., and *Culex* sp. are shown in Table 3. Table 3 shows that the absolute length growth of yellow-finned medaka fish was reared for 120 days with natural food, namely *Chironomus* sp., *Daphnia* sp. and *Culex* sp. a significant difference (P<0.05). The highest absolute length growth of yellow-finned medaka fish was feed with *Chironomus* sp., *Culex* sp. and *Daphnia* sp. were 3.66 cm±0.02, 3.14 cm±0.01 and 2.29 cm±0.28, respectively.

Table 3

Absolute length growth of *Oryzias profundicola* fed with *Chironomus* sp., *Daphnia* sp. and *Culex* sp. for 120 days

Treatment of natural food	*Absolute length growth (cm)*
Chironomus sp.	3.66±0.02[a]
Daphnia sp.	2.29±0.28[b]
Culex sp.	3.14±0.01[c]

Different letters in the same column indicate a significant difference between treatments 5% (P<0.05)

Proximate of natural food and fish. The results of the proximate analysis of natural food: *Chironomus* sp., *Culex* sp. and *Daphnia* sp. are presented in Table 4. Meanwhile, the proximate analysis of the bodies of fish from Lake Towuti is shown in Table 5. The proximate bodies of yellow-finned medaka fish were reared for 120 days with natural food, namely: *Chironomus* sp., *Culex* sp. and *Daphnia* sp. in Table 6.

Table 4

Proximate of natural food, namely: *Chironomus* sp., *Culex* sp. and *Daphnia* sp.

Natural food	*Protein (%)*	*Fat (%)*	*Water (%)*	*Ash (%)*	*Carbohydrate (%)*
Chironomus sp.	64.80	6.55	3.84	14.60	10.21
Daphnia sp.	50.65	11.22	9.56	15.99	12.58
Culex sp.	56.22	13.60	6.23	11.85	12.10

Table 5

Proximate body content of *Oryzias profundicola* from Lake Towuti

Fish sample	*Protein (%)*	*Fat (%)*	*Water (%)*	*Ash (%)*	*Carbohydrate (%)*
Yellow-finned medaka fish	57.46	8.59	7.04	9.99	16.92

Table 6
Proximate body composition of *Oryzias profundicola* reared for 120 days with *Chironomus* sp., *Culex* sp. and *Daphnia* sp.

Proximate composition	Natural food		
	Chironomus sp.	*Daphnia* sp.	*Culex* sp.
Protein (%)	68.34±0.05^{a}	59.74±0.05^{b}	62.10±0.05^{c}
Fat (%)	8.11±0.05^{a}	8.01±0.00^{b}	8.09±3.05^{c}
Water (%)	4.21±0.05^{a}	8.98±0.00^{b}	9.32±0.05^{c}
Ash (%)	7.12±0.00^{a}	10.77±0.05^{b}	8.37±0.00^{c}
Carbohydrate (%)	12.22±0.05^{a}	12.50±0.05^{b}	12.12±0.05^{c}

Different letters in the same column indicate a significant difference between treatments 5% (P<0.05)

Table 6 shows that the proximate body composition of yellow-finned medaka fish after maintained for 120 days were showed significant differences in protein, carbohydrates, ash and water (P<0.05), while the fat content was showed no difference (P>0.05). The body proximate content of *O. profundicola* from Towuti Lake (Table 5) were increased after feeding of *Chironomus* sp., *Culex* sp. and *Daphnia* sp. in Table 6.

Water quality. Water quality were maintained for 120 days of *O. profundicola* with different natural foods in Table 7.

Table 7
Water quality during the rearing of *Oryzias profundicola* with different natural foods

Parameter	*Chironomus sp.*	*Daphnia sp.*	*Culex sp.*
	Range	*Range*	*Range*
Temperature (^{0}C)	27.3-29.6	27.3-29.6	27.3-29.6
pH	7.5-8.2	7.2-8.0	7.5-8.2
Dissolved oxygen (mg L^{-1})	6.5-7.5	5.7-6.9	6.9-7.5
Nitrite (mg L^{-1})	0.020-0.022	0.020-0.027	0.020-0.028
Nitrate (mg L^{-1})	0.025-0.027	0.025-0.030	0.025-0.032
Total ammonia (mg L^{-1})	0.031-0,038	0.031-0.041	0.031-0.043
Orthophosphate (mg L^{-1})	0.15-0.18	0.15-0.19	0.15-0.18

Discussion. Domestication of *O. profundicola* was carried out externally for 120 days with different natural foods, namely *Chironomus* sp., *Daphnia* sp. and *Culex* sp. Table 1 shows survival ranging from 93.78 to 100% and fish were spawned when fed *Chironomus* sp. This were shown that the feed (Table 4) and water quality (Table 7) were in accordance with the life needs of *O. profundicola*, because the fish were adapted ecologically, physiologically and biologically during domestication (Jayadi et al 2016).The success of the domestication of *O. profundicola* in captive conditions was also due to the fact that the fish were reared for 15 days by providing mixed food consisting of *Chironomus* sp., *Daphnia* sp. and *Culex* sp. The success of the physiological response of fish to environmental changes can be through acclimation and homeostatic processes (Affandi & Tang 2002).

Fish adaptation during domestication aims to survive, growth, spawn and produce larvae and seeds (Jayadi et al 2016).The ability to adapt at the beginning of transferring fish from natural conditions to maintenance conditions were determined of the food and the environment, because the energy has been fulfilled to adapt to the new environment (Liao & Huang 2000). Domesticated fish will show plasticity and flexibility in their behavior, so that they can adapt in captive conditions that are different from their natural habitat (Driscoll et al 2009). Fish was consumed food in domestication means that the water quality conditions in the rearing medium were accepted ecologically, biologically and physiologically (Jayadi 2021).

The foods were given during domestication was able to support the growth of yellow-finned medaka fish during rearing 120 showed a significant effect (P<0.05) on absolute weight growth (Table 3) and absolute length growth (Table 4). The results of this study was explained that the best natural food is Chironomus sp for growth.

Table 5 shows that the nutritional content of the food is in accordance with the needs of the yellow-finned medaka fish which causes the fish to grow in weight (Table 3) and grow in length (Table 4). Fish growth variations were influenced by the fish themselves, the environment and food (Handajani & Widodo 2010). Growth was used as an indicator to see individual physiological conditions from the influence of food. Growth occurs when the amount of food eaten exceeds what is needed to sustain life (Huet & Timmermans 1986). The amount of protein was affected the growth of fish (Widyati 2009). Fish growth is closely related to the availability of protein in food, because protein is a source of energy for fish and protein is a nutrient that fish really need for growth (Samad et al 2014). Protein functions as an enzyme, hormone, antibody, tissue builder, and energy source. In general, fish require between 25-55% crude protein in their food, depending on the age and the species of fish (Gore 2006). Fish protein functions as a tissue building agent in the body (Halver & Hardy 2002), as a source of energy and a regulator of metabolic systems (Munthe et al 2016), as well as for growth, tissue maintenance, and antibody formation (Batubara 2009). Protein functions as a building block for fish tissues and organs, therefore, protein must be available in sufficient quantities in food (Nugroho et al 2020). Low protein content in food will result in slow growth of fish. The high or low protein in foods is influenced by the non-protein energy content, which comes from carbohydrates and fats (Halver & Hardy 2002). In an artificial environment, the fish food depends on the food were given, so it will affect the growth rate of the fish (Hofer 1985).

O. profundicola were fed in Lake Towuti consists of: *Ochterra humilis*; *Skeletonema* sp.; *Limulus* sp.; *Chlorella* sp.; *Sinedra* sp.; *Anabaena* sp.; *Thalassionema* sp.; *Coscinodiscus* sp.; *Navicula* sp.; *Rhyzosolenia* sp.; *Merismopedia* sp,; and *Diatoma* sp. (Nursyahran et al 2022a). The results of the proximate analysis of fish bodies from Towuti Lake were 57.46% protein, 8.59% fat and 16.92% carbohydrates (Table 6). The foods were eaten by fish is necessary for energy production for growth, activity, metabolism and reproduction (Hunter 1980). Nutrition status has profound effects on the growth, weight gain and development of somatic tissues, particularly the skeletal muscle (Adewumi 2018). The results of the study in Table 6 showed an increase in proximate body of fish originating from Lake Towuti with proximate body content as shown in Table 5 were given different proximate content of natural foods as shown in Table 4. These shows that the nutritional content of the foods that were given such as *Chironomus* sp., *Daphnia* sp. and *Culex* sp. by the *O. profundicola* has fulfilled its needs for protein, fat and carbohydrates. The results of this study was shown that the yellow-finned medaka fish has high protein. The macronutrients (proteins, lipids and carbohydrates) provide bulk energy for fish metabolic systems (Adewumi 2018).

The condition of water quality during domestication was shown in Table 7. Water quality determines not only how well fish grow in domestication, but whether or not they survive. Each water quality factors interacts with and influences other parameters, sometimes in complex ways. The water quality conditions during domestication in Table 7 were in accordance with the water quality in Lake Towuti. The parameters of water quality in Lake Towuti during the fishing of the *O. profundicola* were used for domestication are: temperature 26.5-29.5°C; pH 6.52-8.27; dissolved oxygen 5.54-6.82 mg L^{-1}; nitrites 0.0024-0.0138 mg L^{-1}; nitrate 0.0009-0.004 mg L^{-1}; orthophosphate 0.001-0.201 mg L^{-1}. Fish that live in unsuitable environmental conditions was tend to consume less foods due to their low appetite (Beveridge et al 2013). Fish need oxygen for metabolic processes so that they get energy were used for swimming, growth, and reproduction (Yulfiperius 2014). Each species has a preferred or optimum temperature range where it grows best (Abbink et al 2012). A good water temperature for domestication of the yellow-finned medaka fish ranged from 27.3–29.6°C (Table 7). Changes in pH that are very acidic or alkaline will disrupt the survival of aquatic organisms because it disrupts the respiration process (Alabaster & Loyd 1982). The pH content is less than the optimum limit causing fish stress and experiencing physiological disturbances can even cause death (Mota et al 2018). The pH of the water during the domestication of *O. profundicola* ranged from 7.2-8.2 (Table 7). Nitrite is toxic to fish and causes "brown blood" diseases (Buttner et al 1993). The nitrite content of water during the domestication of the yellow-finned medaka fish ranged from 0.02-0.022 mg L^{-1} while the nitrate content ranged from 0.025-0.027 mg L^{-1} (Table 7). Ammonia levels >0.5 mg L^{-1} are harmful to fish, if ammonia is too high it can cause gill and kidney damage, stunted growth and disrupted brain function (Xu et al 2021). The ammonia content during the domestication of the yellow-finned medaka fish ranged from 0.031-0.038 mg L^{-1} (Table 7). Orthophosphate is a phosphate element in the form of inorganic compounds that can be utilized directly by aquatic plants (Effendi 2003). Orthophosphate is the simplest form of phosphorus in waters (Boyd 1982). Phosphorus in the form of phosphate is a necessary micro-nutrient in small amounts but is essential for aquatic organisms (Kolliopoulos et al 2015) Phosphorus is not toxic to humans, animals and fish (Effendi 2003).

Conclusions. *O profundicola* were grown and spawned to produce seeds with giving of Chironomus sp. during domestication 120 days. The highest of survival, growth and proximate body content was fed the *Chironomus* sp. Survival was achieved 96.69-100%. Proximate content of the body was domesticated as follows protein 59.74-69.34%, fat 9.85-13.09% and 17.22-19.22% for carbohydrates.

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Conflict of interest. The authors declare no conflict of interest.

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