THE LATEST APPLICATION OF *TUBIFEX* AS LIVE FEED IN AQUACULTURE

Tohap Simangunsong[1]*, Jefri Anjaini[1], Nurbaity Situmorang[2], Chun-Hung Liu[3]

[*1]Department of Aquaculture Fisheries and Marine Science Faculty, Universitas Jenderal Soedirman
[2]Department of Biology Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan
[3]Department of Aquaculture National Pingtung University of Science and Technology, Taiwan

*Email: tohap.simangunsong@unsoed.ac.id

ABSTRACT

The food industry with the fastest rate of growth in more than 50 years is the fisheries sector. The sector of aquaculture and capture has grown to be very promising. In order to support the success of this business, the aquaculture industry in freshwater and marine environments is currently progressing. In the larval stage, choosing fish feed that is of high quality is crucial. The primary food source for fish larvae to support the growth and development of farmed fish is natural feed with a high protein content. Numerous varieties of farmed fish and ornamental fish have been fed *Tubifex tubifex*, a natural silkworm food. Protein and fat content in this polichaeta class worms are respectively 66% and 12%. When farmed fish are growing and developing, the high protein content of these worms may serve as their primary source of protein. Several initiatives are currently being made to enhance worm protein quality by consuming more food that contains macro- and micronutrients. Agricultural waste that has fermented or decomposed, which is typically regarded as waste, has nutritional value that can be combined with mud or sand to keep worms for a while. The nurture of fish larvae or fry may one day be possible using silkworms.

Keywords: *Aquaculture, fish larvae, live feed, Tubifex tubifex*

1. INTRODUCTION

The aquaculture sector has grown incredibly quickly. Globally, in 2020 the aquaculture sector (including aquaculture and capture fisheries) produced total fish production reaching 178 million tons with a total value of US$ 406 trillion. Natural feeds are said to be effective in promoting the growth and health of fish like eels (*Anguilla sp*.), catfish (*Ictalurus punctatus*), goramy (*Osphronemus goramy*), milkfish *Chanos chanos*), carp (*Cyprinus sp*), guppy (*Poecilia reticulate*), angel fish (*Pterophylum scalare*), koi carp (*Cyprinus carpio*), comet goldfish (*Carassius auratus auratu*), and goldfish (*Carassius auratus*) in the cultivation of freshwater and seawater fish as well as ornamental fish. One of the naturally occurring foods that is frequently used as fish larval food is silk worms. The high protein content of silk worm *Tubifex tubifex*, which supports the best possible growth of fish larvae, is one of the reasons it is preferred as an alternative to natural feed. The growth and development of worms will be supported by cultivation media supported by organic substrates rich in nutrients, which is directly proportional to the rise in worm populations and total biomass during the cultivation period. Worms enriched with nutrients will support the growth and development of farmed fish (Alam *et al*., 2021; Hamid, Chowdhury, Razzak, &; Roy, 1993; Khaerunnisa, Safitri, Ikhsan, Purwanti, & Lestari, 2021; Mahendra, Nufus, &; Daughter, 2019; Safrina, Putri, &; Wijayanti, 2015; Umidayati, Rahardjo, &; Ilham, 2020). In order to increase worm biomass, it is also taken into consideration in practice to choose a good substrate that will increase worm populations. Mud and sand as maintenance media, as well as the combination of these materials with fermentation of agricultural waste and aquatic weeds that are rich in protein, fiber, and sources of carbohydrates and fats continue to be studied (Barades & Witoko, 2018; Khaerunnisa *et al*., 2021; Mahendra *et al*., 2019; Safrina *et al*., 2015; Selvarani, Padmavathy, Srinivasan, & Jawahar, 2015). The reviews in this paper can provide information on the use of *Tubifex* in aquaculture, particularly when raising fish larvae or in hatcheries. The potential of *Tubifex* as a natural feed in aquaculture, its nutritional value, efforts to boost production, the ecology

of *Tubifex* in relation to water quality, and *Tubifex* in the future as one of the high protein natural feed sources for fish will all be covered in this literature.

1.1 Nutritional profile of silkworms, Tubifex

Crude protein, different amino acids, and essential fatty acids are all present in *Tubifex*, making them an excellent source of nutrition for fish larvae and fry (Barkhordar, Valizadeh, Safari, Ahmadi, &; Naserian, 2018). All metabolism processes that take place in the worm's body will use this organic material as a source of energy. According to research by Herawati, Nugroho, Hutabarat, and Karnaradjasa (2016), nutrient-enriched *Tubifex* worms can achieve total protein and fat levels of 66% and 12%, respectively. The profile of fatty acids and amino acids, including linoleic acid, lysine, and linolenic acid, was noted to be 7.3%, 3.6%, and 6.1% respectively.

1.2 *Tubifex* as a natural feed; one of the main source of protein for the development of fish fry

According to Safrina et al. (2015), *Tubifex*, which has a protein content of up to 64%, is one of the alternatives for the development of the larval stage of farmed fish. According to Mandal *et al*., (2016), *Tubifex* is frequently used in hatcheries for a number of catfish, cork, and ornamental fish varieties. For their bodies to properly develop and grow, young fish need to consume a lot of protein. The metabolic functions of fish will be improved by an adequate intake of nutrients. Fish in their vulnerable catfish larval stage need a lot of protein to build their bodies. According to Nuswantoro et al. (2018), *Tubifex* that has been given to catfish larvae first and chopped will be easier for 5-10 day-old tilapia fry to digest. However, the findings of the observations revealed that the survival, daily growth rate, and growth rate of fish larvae did not significantly differ depending on whether *Tubifex* was chopped or not. Because rotting worm fragments and other organic materials can cause water quality to deteriorate and encourage the growth of unexpected microorganisms, it is advised that in practice it is best to give silk worms to fish larvae in whole form. This can occasionally result in a drop in the amount of dissolved oxygen in fish farming water (Nuswantoro & Rahardjo, 2018). Due to its extremely high caloric value, which can reach up to 5.57 kcal per gram of dry weight, *Tubifex* has been thought to be crucial in the development of fish larvae. Osphronemus goramy, *Tubifex* carp farming combined with manufacturer feed in biofloc aquaculture systems reported improved digestive performance and growth of carp fry. However, no different results were obtained. Comparatively to carp cultivation without a mix of natural and artificial feed, biofloc cultivation systems have higher protease activity, longer villi, and a larger surface area. Protease activity in the intestine suggests that fish's digestive system will break down protein into simpler amino acid molecules, which fish can then absorb and use as an energy source for all of their metabolic processes. Villi and the surface area of the fish intestinal wall cause the expansion of the absorption area of food juices in the fish intestine due to increased blood vessels in the fish intestinal wall when combined with natural feed that is extremely high in protein content and supported by the presence of floc caused by the activity of microorganisms in the aquaculture aquatic environment (Amriawati *et al*., 2021).

The ornamental fish industry in aquaculture is also seeing growth, especially when it comes to commerce. Ornamental fishes, like guppy (*Poecilia reticulate)*, ramiraze fish (*Mikrogeophagus ramiraze*), angelfish (*Pterophylum scalare*), koi carp (*Cyprinus carpio*), comet goldfish (*Carassius auratus auratu*), goldfish (*Carassius auratus*) have been widely cultivated because to the rising cost and increased demand from consumers for both commercial and recreational uses (Alam *et al*., 2021; Barkhordar *et al*., 2018; Budianto *et al*., 2019; Görelşahin, Yanar, &; Kumlu, 2018). Additionally, ornamental fish require a diet high in protein. When fed with *Tubifex* three days a week as opposed to two or four, guppies grow very well. When given natural food in the form of *Tubifex*, guppies can grow up to 4-5 cm in length. Furthermore, it was noted that during their 80–100 days of rearing in ponds with high survival rates (97–99%), female fish grew at a rate that was twice that of male fish. Koi carp, comet goldfish, and goldfish fed with *Tubifex* combined with artificial feed at a ratio of 1: 1

had better growth performance, according to information obtained (Alam *et al*., 2021).

Anguilla bicolor, a Japanese eel, is regarded as one of the fish species with the potential to meet the needs of the community for animal protein. Eel prices are currently competitive on the market because they can economically generate significant profits for farmers. Eels typically grow slowly because of their slow digestion and absorption. The ideal diet for eels should contain >45% protein. According to reports, feeding eels a mixture of natural feed like *Tubifex* and artificial feed at a 1:1 ratio increased their total feed consumption (TFC), feed conversion ratio (FCR), feed utilization efficiency (FUE), specific growth rate (SGR), absolute weight, and survival rate (SR). Additionally, it appears that the results are proportional to the costs incurred because purchasing or preparing natural feed to support cultivation activities is more expensive than just getting good growth parameters. *Tubifex* is therefore anticipated to be able to supplement manufactured feed in aquaculture practices in the future as a natural feed (Akbar, Chilmawati, & Wijayanto, 2023).

1.3 Intensifying production of *Tubifex*

Agricultural waste is frequently wasted and dumped in landfills where it rots. According to several studies (Alam *et al*., 2021; Khaerunnisa *et al*., 2021; Mandal *et al*., 2016; Petrova-Tacheva, Ivanov, & Atanasov, 2020; Safrina et al., 2015; Umidayati et al., 2020), organic waste is rich in organic materials that can be useful after fermentation. *Tubifex* can be created using organic waste. Agriculture waste can be used as a source of energy for growing *Tubifex*. According to (Mandal *et al*., 2016), cow dung, milk waste, and rice milling waste can all be used as food sources to cultivate *Tubifex*. It was further stated that it appeared that products high in nutrients and containing carbohydrate and protein content from agricultural waste, such as waste from the processing of rice and milk, could effectively raise the total amount of protein and fat in *Tubifex*.Complex carbohydrates and vegetable proteins are abundant in corn cobs, which are frequently discarded. These wastes can be utilized as a cultivation medium to raise silkworm colonies rather than being thrown out or burned. The quality of silkworm cultivation media is said to be improved by fermented corn cob waste because, following fermentation processes, the media will be more digested, absorb nutrients, and produce the worms' necessary energy for growth and development (Khaerunnisa *et al*., 2021). *Tubifex* is becoming more and more in demand for carp farming. The cost of producing ornamental fish will be reduced by *Tubifex*, which is reasonably priced. When fed *Tubifex* natural feed, *Cyprinus carpio* carp, comet *goldfish Carassius auratus auratu*, and carp *Carassius auratus* are said to grow exceptionally well. Numerous independent initiatives to raise *Tubifex* production are still ongoing. As a source of worm energy to grow and develop, some maintenance media in the form of agricultural waste, such as vegetable meal, wheat bran, soybean meal, rice bran, and cow dung, can be used (Alam *et al*., 2021).

The percentages of crude lipids, protein, crude fiber, and carbohydrates in banana peels, respectively, range from 59% to 32% to 2% to 1%. According to Anhwange, Ugye, and Nyiaatagher (2009), banana peels also contain trace amounts of bromine, rubidium, and strontium as well as minerals like manganese, potassium, calcium, and sodium. Although banana peels are frequently discarded, they are actually rich in organic matter and can be used as a medium for raising silkworms. Worms will be able to more readily absorb simpler compounds from fermented banana peels, which they can then use as an energy source for their body's metabolism. According to Safrina *et al*., (2015), the total silkworm population reached 5870 ind/m^2 with a total biomass of 15.21 gr/m^2 after 40 days of *Tubifex* silkworm maintenance.

Lemna minor is frequently regarded as an invasive species because it grows in freshwater ecosystems. *Lemna minor* is recognized as a bioindicator of the purity of freshwater water. *Lemna minor*, whose population occasionally grows out of control (Hamid *et al*., 1993; Selvarani *et al*., 2015), can be used as extra food for fish and ducks. *Lemna minor* contains about 35%, 17%, and 5% protein, fiber, and fat respectively. Flavonoids, phenolics, vitamins, and other micromolecular components are among the active ingredients found in *Lemna minor* (Petrova-Tacheva *et al*., 2020). *Lemna minor* fermented in mud was used in an experiment by (Mahendra *et al*., 2019) as a food

source substrate for worms. *Lemna minor* supplemented *Tubifex* was said to have fermented for 50 days, reaching a population of 6250 ind/gr and a total biomass of 8.6 gr/m^2.

The increasing number of worm harvests will benefit farmers because the abundant availability of worms will support farmers to provide one of the good natural feed alternatives to fish larvae or fry. Healthy fry and fish are proportional to the increasing number of fish harvests for the success of aquaculture supported by good handling in ponds and the ability to prevent and overcome various pathogenic microorganisms that may at any time come to attack aquaculture ponds (Casselman, 2005).

1.4 Water quality in the growth and development of Tubifex

Fermented feed sourced from a mixture of tofu dregs, fish silage, bran, and vegetables is also rich in organic content. The mixture of the material applied in *Tubifex* cultivation which was carried out for 21 days fed with 20 grams of feed was reported to have an average growth of 41 gr/container with productivity reaching 457 gr/m^2/cycle (Umidayati *et al*., 2020). It seems that fermented feed can increase the appetite of worms because worms are easier to digest food because fermentation activity can break down macromolecules into simpler molecules. Silk worms will experience good growth when the worms can absorb nutrients well as well. Worms that experience good growth will quickly develop and mature and can increase the number of populations or colonies (Romano Spica *et al*., 2014). *Tubifex* generally grows well in organic substance-rich environmental conditions in poor places (Mandal *et al*., 2016). Therefore, it is not difficult to find *Tubifex* in nature, although it only grows in small amounts. But the need for aquaculture is becoming a new and important challenge in aquaculture as the need increases in the growth and development phase of fish larvae. Freshwater bodies of water, such as dams, rivers, and other bodies of water, appear to be facing new environmental challenges related to water quality, water temperature, and changes in ambient temperature. The body of the worm in the water has metabolic processes and respiration that are maintained by temperature. According to research by Çelik (2019), temperature has a significant impact on the development and growth of *Tubifex*. The ability of *Tubifex* to survive in freshwater environments can be impacted by water temperatures that are too high or too low. The ideal temperature is crucial to the development and growth of fish. According to (Çelik, 2019), the temperature range between 18 ˚C and 24 ˚C is ideal for *Tubifex* survival in freshwater aquariums. According to (Khaerunnisa *et al*., 2021), these silkworms can still survive in an ideal manner in a temperature range of 24 ˚C to 32 ˚C. The average temperature of the silkworm water they found in nature, according to the report (Khaerunnisa *et al*., 2021), was between 28 ˚C and 30 ˚C. They kept the silkworms at the ideal temperature range of 27 ˚C to 28 ˚C when they collected them, in actuality in new maintenance media in aquariums. Of course, the pH level of the water and the silkworm maintenance medium also affect the biochemical processes that take place in the worm's body. For maintaining *Tubifex*, a pH of 6.9 to 7.6 is ideal. This discovery was made as a result of maintaining healthy, controlled environmental conditions for worms. Because it is at a neutral pH state to support the occurrence of various biological processes, such as biodegradation, respiration, microbiological processes, fermentation, balanced dissolved oxygen levels, and other natural biochemical processes that occur in water, this environmental condition with pH is recommended as the best condition for maintaining silkworms (Khaerunnisa *et al*., 2021). Climate change appears to have an impact on variations in the temperature of the aquatic environment in the natural world, which may have an indirect impact on the availability of silkworms in the wild. Everything on this planet, including on land and in the aquatic environment, has changed as a result of the industrial revolution that has lasted for the past two centuries. Changes in the pH of water and mud, adjustments to aquatic vegetation, and adjustments to fish species in swamp, river, and lake environments are just a few of the real effects of the industrial revolution on the aquatic environment.

Table 1. Application of *Tubifex* and stage of uses in aquatic animal development

Animals	Stage of uses	Important features	References
Ompok bimaculatus	Larvae/Fry	Fish larvae's ideal first diet; increased feed intake; increased survival rate	(Malla & Banik, 2015)
Osphronemus goramy	Larvae	Fish larvae's perfect first meal; high survival rate; stocking density to promote better larval growth—no more than 1.2 individuals L^{-1}	(Arifin *et al.*, 2019)
Clarias batrachus (Linn.)	Larvae/Fry	Up to 97% survival rate	(Sinha *et al.*, 2014)
Betta splendens (Regan, 1910)	Fry	90% hatching rate; higher than the formulated diet's (29.80%) saturated fatty acid content (63.23%)	(Mandal *et al.*, 2012)
Puntius filamentosus (Valenciennes, 1844)	Fry	Fish can catch worms more easily with Tubifex, making it a more cost-effective option than more expensive Artemia nauplii or artificial feed	(Saurabh *et al.*, 2013)
Ompok bimaculatus (Bloch)	Larvae	The best SGR was discovered than other feed	(Basavaraja *et al.*, 2013)
Acipenser ruthenus L.	Larvae	Maximizing production; lowering the expenditures and efforts involved in developing technology for rearing larvae	(Rónyai & Feledi, 2012)
Rana pipiens	Larvae	High-protein live food	(Kaltenbach *et al.*, 2012)
Ceratophrys ornata	Larvae	Live feed with high protein	Kaltenbach *et al.*, 2012)
Osphronemus goramy	Larvae	Growth and survival rate of giant gourami larvae	(Prakoso *et al.*, 2019)
Ompok pabda (Hamilton-Buchanan, 1822)	Larvae	With a 92% survival rate, mass-cultured zooplankton and tubifex appear to be appropriate for an ex-situ rearing system	(Banik & Malla, 2015)
Pterophyllum scalare	Fry	Substitute high-protein live feed following fish fry maturation	(Patra & Ghost, 2015)
Notopterus notopterus	Fry	Improved growth and survival rate when fed Tubifex from day 6 to day 20	(Devkota *et al.*, 2023)
Heteropneustes fossilis	Larvae	Maximum growth rates; a mixed diet may be utilized as a substitute for some feed	(Ahmmed *et al.*, 2016)
Acipenser ruthenus L.	Larvae	Even though sterlet larvae may be able to consume and absorb nutrients from artificial feed, the survival rate of sterlet larvae can be increased by providing live food from the start of feeding	(Feledi, 2013)
Clarias batrachus	Larvae	Superior growth performance when fed Tubifex instead of	(Rahman *et al.*, 2012)

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Animals	Stage of uses	Important features	References
		Moina; access to vital nutrients and digestive enzymes for improved absorption and digestion for fish growth	
Cyprinus carpio	Juvenile/seed	Intensify the amount of protein in it	(Alam *et al.*, 2021)
Carassius auratus auratu	Juvenile/seed	Intensify the amount of protein in it	(Alam *et al.*, 2021)
Carassius auratus	Juvenile/seed	Intensify the amount of protein in it	(Alam *et al.*, 2021)
Carassius auratus	Juvenile/seed	High protein content necessary for fish growth and development	(Dwiardani *et al.*, 2020)
Hucho taimen	Fry	A viable technique for intensive fry culture	(Jia *et al.*, 2012)
Pterophyllum scalare Schultze, 1823	Adult	Maximum hatchability and fecundity	(Kasiri *et al.*, 2012)
Clarias sp.	Larvae	High rate of growth, survival, and SGR	(Nuswantoro & Rahardjo, 2018)
Pangasianodon hypophthalmus	Larvae	Artificial feed and Tubifex can be used to feed catfish larvae	(Jusadi *et al.*, 2015)

The presence of chemicals or pollutants from businesses that generate waste harmful to the aquatic environment due to pollutants that settle for a long time are some alarming changes. A key component of this is food security, as all harmful carcinogenic chemicals must be removed from human food. Because they are the first food source for fish larvae, which are one of the primary sources of protein for humans, silkworms play a significant role in the food chain. The food we eat begins with a protracted process of food chains that have developed naturally in nature (dos Santos Dalbelo &; Rutkowski, 2021).

A dead price in the aquatic environment is the abundance of oxygen that is available. Naturally, various types of chlorophyll organisms produce oxygen in the water as a byproduct of photosynthesis. In some cases, the amount of dissolved oxygen in the water can be impacted by both fermentation processes and water temperature. According to (Khaerunnisa *et al.*, 2021), dissolved oxygen levels in nature typically range from 4 to 10 ppm. It was added that the researchers' fermentation of the media used to maintain silkworms resulted in a 2–6 ppm decrease in dissolved oxygen levels. Due to an increase in the fermentation process's byproduct, carbon dioxide (CO_2), the maintenance pond's water quality is decreased by this process. Even though the fermentation process takes place in nature, it typically proceeds slowly because there is a plentiful supply of organic matter that is ready to ferment and there aren't many facultative anaerobic bacteria to speed up the biodegradation process. Additionally, symbiosis between trophic levels occurs in aquatic ecosystems as a result of a protracted series of biological processes in which all biotic and abiotic elements are interconnected to form a web (Ljungdhal, 1986).

1.5 *Tubifex* as a natural feed of fish today and in the future

During the development of fish larvae, natural feed from aquaculture, including *Daphnia*, microalgae, copepods, moina, rotifers, *Artemia* nauplii, and some nematodes, has been used extensively. The use of this natural feed in practice can be applied according to the size of the mouth of the fish larvae that is raised. Added protein and essential fatty acids can be added to natural feeds today (Dhert & Sorgeloos 1995). The aquaculture industry has

experienced significant growth. All limitations imposed by nature can now be overcome using controlled cultivation systems and laboratory scale technology. The use of technology and related research can now be used to increase the production of natural feed with the goal of producing in large quantities that are high-quality, secure, and sustainable. The production of *Tubifex* must, above all else, contain a lot of protein (Amriawati *et al*., 2021; Herawati et al., 2016; Khaerunnisa *et al*., 2021). Future fish fry production will need to increase as demand for fish rises and stays elevated. High protein intake is crucial for fish to grow properly when they are being raised for ornamental fish and fish fries. Japanese eel, cork, tilapia, carp, catfish, and other farmed fish species have high protein needs. Similar to marine fish species like rainbow trout, salmon, tuna, snapper, halibut, milkfish, and others, humans also need a lot of protein to maintain a healthy metabolism (Kaushik, S. J., & Seiliez, 2010).

2. CONCLUSION

To ensure the continued success of aquaculture, the sector now needs high-quality feed. As one of the natural feeds with a high protein content that fish require to develop their body protein, silkworm, *Tubifex*, is now advised. Aquaculture worms are now enriched with micronutrients. Worms can use household waste, fermented or decomposing food, protein-rich plants, and agricultural waste as a source of the nutrients they need to carry out metabolism. The future of fish larvae and ornamental fish may turn to *Tubifex* as one of their sources of high-protein natural feed to satisfy their protein requirements. Based on the size of fish larvae's mouths, some other natural feeds appear to support the need to many smaller fish's larvae.

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