

Pre-adults mosquito in fish species feeding

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Abstract: The inclusion of *Culex stigmatosoma* and *Cx. quinquefasciatus* pre-adults mosquito was analyzed as live food for fish with ornamental potential (angel fish *Pterophyllum scalare* and zebra fish *Brachidanio rerio*), native (Mexican mojarra *Cichlasoma istlanum*) and endemic (Balsas catfish *Ictalurus balsanus*). Mosquito's characteristics are: high nutritional quality, movement, soft body, availability, abundance and acceptance, which position the pre-adults mosquito as a potential live food for fish species. The aim was analyzing the pre-adults mosquito efficacy in the feeding fish. The information analyzed show significant increases, depending on the species, in fish fed with pre-adults mosquito; increment in weight of 32.10 to 49.32 mg/day, specific growth rate of 1.96 to 3.25% body weight/day, spawning frequency every 14.40 to 28.0 days, eggs number from 506.45 to 1477.2 per spawn, offspring production from 212.71 to 1322.2, survival of larvae from 42.21% to 85.0%, and adults from 85.99% to 100%. However, and despite the good results, the cultivation of mosquitoes is not recommended, but recollection and inclusion as a live food in the diet for freshwater is recommended.

Keywords: Pre-adults mosquito, freshwater fish, living food

Background

Nutrition is one of the biggest problems that affect those activities that pretend, under controlled conditions, produce organisms in culture, for example, massive production of birds, pigs, cattle and particularly fish. Culture of living food is an alternative, and it is not new, it starts as part of Aquaculture in the controlled production of organisms, in order to avoid depending on picking them up from nature.

In aquaculture we can use inert foods, with well-balanced nutritive ingredients, but we can also feed fish with living organisms with a high nutritional value (Luna-Figueroa and Arce, 2017). It is also possible to use living organisms susceptible to be modified in their nutritional content. This is important because the nutritional requirements can vary between the different fish species, and even between the same species, according to their state of development (Ronnestad *et al.*, 2013). Living food has attributes that inert food hasn't, like movement, that provokes being capture by the consumer; color, that is attractive for catching; smell, that is tempting for being detected and consumed; and nutritional content (Arce *et al.*, 2018). The culture organisms used as food, contain the amount and the quality of nutrients essential for the proper development of aquatic species, and they don't affect the quality of the water, because it is

consumed before it dissolves, avoiding decomposition, unlike inert food, that if it doesn't have good buoyancy, it will deposit on the bottom, and decompose, polluting the environment, and sometimes causing, the fish mortality.

The success of feeding depends on the progressive development of the anatomic and physiological availability and the food acceptance through the larval development. The first exogenous feeding is the key for the fish survival. The food catching begins when larvae finish consuming their yolk and catch their first food (Ronnestad *et al.*, 2013). Is in the larvae stage where the highest index of mortality takes place, because is in this period where the organisms are more vulnerable to the environment conditions and more susceptible to illness and to the food characteristics, such as if it is alive or inert, the size, quantity, mobility, color and mainly to proper nutritional content. So in order to achieve the fish larvae survival and that they can reach their next post larvae, youth and adult stages, they need, among other factors, to be able to have quality food in the proper concentration, that as it has been mentioned, it varies depending the stage of development and the specie (Glencross *et al.*, 2007).

Characteristics of living food

In aquaculture exists a great variety of organisms consider as living food, one of the most important are: micro-worm *Panagrellus redivivus*, sludge worm *Tubifex tubifex*, earth worm *Eisenia foetida*, water flea *Daphnia pulex*, mealworms *Tenebrio molitor*, blood worm *Chironomus tentas*, rotifer *Brachionus plicatilis*, *B. rubens*, white worms *Enchytraeus albidus*, algae *Spirulina* sp., and pre-adult mosquito *Culex pipiens* and *C. quinquefasciatus*. These organisms have been used as living food, because their high protein content, high availability, acceptable size, soft body, smell, high culture densities, short life cycle and movement (Luna-Figueroa and Arce, 2017). The insect's larvae are a sustainable food alternative. Coleoptera, Diptera, and Orthoptera were used as food to fish (Barrosa et al., 2014). Other larval like black soldier fly, *Hermetia illucens*, superworms, *Zophobas morio*, and mealworm, *Tenebrio molitor*, were frequently used too (Finke, 2002; Ng et al., 2002; Katia et al., 2017).

In the moment that this organisms are provided as living food, they have a high nutritional value, because in most cases, they haven't been an external process that decreases their original value (Luna-Figueroa, 2009). Living food is not just appreciated for being physiologically a valuable form of nutrients, but also an important behavioral factor for fish, because in a natural state they are hunters, and often they grow indifferent to this activities in the aquariums where they are fed with inert food, causing an imbalance in the behavior, a decrease in the color brightness, less activity, over feeding and little resistance to illness. This is why the living food is consider better than the inert one, either why consuming it induces visual and chemical stimulation or because the enzymes contribute to the digestion and there are differences between digestibility in living and inert food, usually attributed to the differences in the digestibility of protein (García-Ortega, 2000).

Using pre-adults mosquito in fish feeding

Nowadays biocontrol is an important option for mosquito control, because the restrictions of pesticides and the problems caused by insecticides resistance (Valero et al., 2006). Mosquitoes are considering one of the most versatile organisms in the world, because of their capacity of reproduce in any body of water and to survive in almost all the weathers on Earth (Hernandez et al., 2005). They belong to the order of Diptera insects, Culicidae family, and there

are more than 2,500 mosquito species, but they also represent a big problem for public health, because of their role in the transmission of many diseases such as malaria and dengue, than provoke great economical loses and in many cases expensive convalescences, causing sometimes death (Rey, 2006).

Larvivorous fish are one of the most effective biological methods for hematophagous dipterous control (Hernández et al., 2004). This is why to fight mosquito, nowadays, many species of larvivorous fish are used (Kern, 2007), such as *Umbra pygmaea*, *Leptolucania ommata*, *Fundulus lineolatus*, *F. chrysotus*, *Poecilia latipinna*, *Heterandria formosa*, *Elassoma zonatum*, *E. evergladei*, *Enneacanthus gloriosus*, *Centrarchus macropterus*, *Lepomis punctatus*, *L. macrochirus*, *L. microlophus*, *Rivulus uropthalmus*, *Pyrrhulina brevis*, *Poecilia reticulata*, *Carassius auratus*, *Gymnogeophagus brasiliensis*, *Girardinus metallicus*, *Gambusia holbrooki* and *G. puncticulata*. It's needed to mention the great problem that represents controlling these members of the Culicidae family, because among other factors they can adapt very quickly to different aquatic environments, mainly in those that are rich in organic material and without oxygen.

In the particular case of pre-adult mosquito, although they have characteristics as: high nutritional value, short lifecycle, high availability and abundance, acceptable size, soft body and mobility (Luna-Figueroa and Gómez, 2005). However, is necessary to point that culture them is not recommended because of the transmission of diseases, but in countries with an important amount of fish farms, such as Mexico, its advised to recollect pre-adult, mainly in areas nearby to ornate fish farms and to incorporate them immediately in to the diet of reproductive fish or in growing systems (Luna-Figueroa, 2003; Luna-Figueroa and Gómez, 2005). Some researchers have used larvae fish as biological control obtaining good results to reducing the mosquitoes and to fish growth (Marti et al., 2005; Tranchidaa et al., 2010). All studies suggests that fish may be useful as part of a program in vector control (Diemont, 2005; Matias and Adrias, 2010).

The pre-adults mosquito are widely used as living food because they give proteins, carbohydrates, lipids, vitamins and minerals in the proper levels for fish development and because they keep their nutritional content during long periods of time, what does not happen with inert food, because their quality

decreases when they are given in water. The importance of using high nutritional quality food is that the energy that an organism incorporates by ingesting it goes to comply with the basic metabolic activities and the rest goes to growth and reproduction (Sales and Janssens, 2003). Fish, as the rest of the animals, need five basic elements in their diet, which can vary in their concentration, depending on the specie and their stage of life (Rivera and Botero, 2009). Live food contributes with a high protein percentage to daily diets, which include the rest of the components in lower proportion among those that are needed from an energy source to move the body machinery and also an adequate amount on amino acids and fatty acids to sustain life and promote growth.

Evidence of the effect of including pre-adult mosquito in fish feeding

Pre-adult mosquito *Cx. stigmatosoma* and *Cx. quinquefasciatus* identified in the "Centro Regional de Control de Vectores", Cuautla, Morelos, Mexico were included both species for feeding *Pterophyllum scalare*, *Brachidanio rerio*, *Cichlasoma istlanum*, and *Ictalurus balsanus* with the goal of rating the growing, spawning frequency, the number of eggs, the number of springs and survival index. This culicids are abundant in water bodies rich in organic material, that's why they were collected from the culture medium of the water flea *Moina* sp., which is invaded by these organisms. The reason why they are interesting for aquaculture is that they are nutritive units that content the elements of a balanced diet, with the advantage that they keep their nutritional value unit they are consumed by fish. They have a high nutritional level [43.49% protein, 9.44% lipids, 5.23% carbohydrates, and 5.66% fiber. This proximate chemical analyses of mosquitos were determinate according to standard procedures given in Association of Official Analytical Chemists (AOAC, 1980)], and they are used without going throw any drying, freezing or packing process that could decrease their value.

Pre-adults mosquito gives the amount and quality of nutrients that show on the fish development. Proteins formed by amino acid chains, are the most complex and abundant molecules of the cell, and help to repair the damaged tissue and the formation of new tissue or growing. Animal proteins are more digestible than proteins from plants. Carbohydrates give energy to accomplish the daily process and the structural and immunological functions, they are substances that

serve as metabolic fuel in almost all the organisms that give an important amount of energy to mammals, but they seem not to be very useful for fish because the differences in their capacity for digest them. Lipids give energy and intervene in fish physiology as precursors of vitamins and hormones that constitute the vehicle for the absorption of liposoluble vitamins, they play an important role in the energy production process and as a source of fatty acids essentials for fish farm food, especially in carnivorous fish, because they use a very small amount of carbohydrate as energy source. Lipids are essential in the early stages of fish, because they are the main source of energy since the formation of the gastrula until the embryo hatching. Vitamins are the essential organic compounds in the fish diet and they are needed in small amounts for the normal growing, reproduction, health and the proper functioning in aquatic organisms, although the requirements are small, their absence causes symptom that go from poor appetite to severe deformations in tissues. Minerals act directly in the skeletal structure, the maintenance of osmotic pressure, in the viscosity, and in the regulation of the balance of the base acid, they are important components of the hormones, enzymes and enzymatic activations, and they affect significantly in the animal metabolism (Sales and Janssens, 2003; Gore, 2006; Rivera and Botero, 2009, Evans et al., 2013).

P. scalare fish (Luna-Figueroa, 2003; Luna-Figueroa and Gómez, 2005), *B. rerio* (Luna-Figueroa, 2007b), *C. istlanum* (Luna-Figueroa, 2007a; Luna-Figueroa et al., 2003), and *I. balsanus* (Arce and Luna-Figueroa, 2003) fed with pre-adult mosquito increased faster in weight from 40% to 60% more than the ones fed with inert food. The specific growth rate was 50% more with pre-adults; this shows the importance of using mosquito as food in the fish species with ornamental potential, native or endemics, because in that stage, growing is more accelerated (Tab. 1).

In other hand, spawning frequency was from 25% to 75% more constant, the number of eggs and offspring production defer between 42% and 88%, always higher in fish fed with pre-adult mosquito (Tab. 2). It's evident that the higher part of the nutrients and other factors required for growth and reproduction in this species are included in the pre-adults of *Cx. stigmatosoma* and *Cx. quinquefasciatus*, and it's also demonstrated that food quality and quantity affect directly in growth frequency and in fish survival.

Tab. 1: Growth of different fish species fed with pre-adults mosquito.

Growth	A	B	C
Initial mass (mg)	58 ± 2.0	21.5 ± 2.5	415.88 ± 17.00
Final mass (mg)	2080 ± 200	4411.5 ± 110	3273.00 ± 66.00
Absolute increase (mg)	2022.00	4390.00	2857.12
Daily increase (mg/day)	34.27	49.32	32.10
Initial Specific Growth Rate (% mass/day)	6.06	13.90	2.31
Final Specific Growth Rate (% mass/day)	3.25	5.91	1.96
Survival (%)	86	95	100
Ref.	1	2	3
P value	0.05*	0.001**	0.05*

A: Angel fish (*Pterophyllum scalare*), B: Mexican mojarra (*Cichlasoma istlanum*), C: Balsas catfish (*Ictalurus balsanus*)

Ref.: 1: Luna-Figueroa (2003), 2: Luna-Figueroa (2007a), 3: Arce and Luna-Figueroa (2003)

*ANOVA, ** t-student

Tab. 2: Reproductive topics of fish species fed with pre-adults mosquito.

Reproduction	A	B	C
Spawning frequency (days)	14.40 ± 0.73	28.00 ± 1.00	27.5 ± 1.00
Eggs number	506.45 ± 30.61	570.98 ± 179.16	1477.2 ± 16.0
Offspring production	212.71	508.17	1322.2 ± 14.0
Parent's survival (%)	100	100	100
Larvae survival (%)	42	88	85
Ref.	1	2	3
P value	0.05*	0.001**	0.05*

A: Angel fish (*Pterophyllum scalare*), B: Zebra fish (*Brachidanio rerio*), C: Mexican mojarra (*Cichlasoma istlanum*)

Ref.: 1: Luna-Figueroa and Gómez (2005), 2: Luna-Figueroa (2007b), 3: Luna-Figueroa et al., (2003)

*ANOVA, ** t-student

Finally, the importance of including pre-adult mosquito from recollection in feeding, aims to incorporate protein to fish diet, and to decrease the anthropophilic hematophagy, without forgetting that in any circumstance mosquitoes culture is recommended.

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