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Short Communication

Fly larvae (*Musca domestica*) as a protein alternative in the feeding of *Macrobrachium tenellum*

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ABSTRACT. The present study evaluates the potential of the house fly larvae (*Musca domestica*) as a protein alternative in the feeding of prawns (*Macrobrachium tenellum)*. Three feeds were used to evaluate the following response variables: growth rate, survival rate, feed conversion ratio and protein efficiency ratio. The first feed (T_1) was a meal obtained after process fly larvae produced in a controlled environment, the second one (T_2) was an experimental formulated feed based on the meal obtained, and the third one (T_3) was a commercial feed. The feeds were supplied to 216 individuals of *M. tenellum*, with an initial weight of 0.897 ± 0.007 g for a 60 days period. After 30 days, the experiment results showed that T_2 presented significant differences in promoting the growth and survival of *M. tenellum* over the other treatments. However, at the conclusion of the study, an improvement was observed for T_3 culminating with no significant differences for T_2, which suggests that the domestic fly larvae possess nutritional characteristics that make viable the incorporation as a protein source in the formulation of a feed for *Macrobrachium tellenum*.

Keywords: *Macrobrachium tellenum*, balanced feed, growth, prawns, aquaculture.

In aquaculture, feed represents a significant factor in production yields (Tacon & Forster, 2003; FAO, 2012). Therefore, it is one of the points on which a considerable amount of research and development has been focused, generating balanced feeds capable of covering the nutritional requirements of the species used within this productive sector (Drew *et al.*, 2007; Canseco *et al.*, 2015). In this case, the formulations developed for aquaculture species have as the main component the protein ingredients, representing between 20-55% of the formula (Glencross *et al.*, 2007; Civera *et al.*, 2010). The protein ingredients supplied are fishmeal and soymeal (FAO, 2014). However, these ingredients present drawbacks in their use, highlighting the availability variation and the increase in their prices (IMF, 2010; FAO, 2014).

During the last decade, the potential of using some insect species as a protein alternative in feed for aquaculture organisms has been studied (Rumpold & Schlüter, 2013; Sánchez-Muros *et al.*, 2013; Makkar *et al.*, 2014). One of the insects that showed great potential is the house fly larvae (*Musca domestica*), containing between 32-60% of the protein in a dry base (Zuidhof *et al.*, 2003; Villamil-Echeverry, 2005; Adesina *et al.*, 2011). Fly larvae meal incorporation in aquaculture feeding studies, reported that an inclusion of 25, 30 and 60% larvae meal, in tilapia, catfish and shrimp diets, respectively, had a statistically similar grow to the use of fish meal (Ogunji *et al*., 2008a, 2008b; Adewolu *et al*., 2010; Cao *et al*., 2012; Ossey *et al*., 2012).

Individuals of the *Macrobrachium* genus are within the interest of aquaculture production, whice in their natural environment they consume insects, fish, mollusks, crustaceans, plankton, plant matter, and organic detritus. Throughout their life cycle, they show the presence of 25 to 50% protein (García-Ulloa *et al.*, 2008; Espinosa-Chaurand *et al.*, 2011, 2012). Based on this, the present work aims to evaluate the fly larvae feed based on a protein source for *Macrobrachium tenellum* juveniles.

Adult houseflies were captured and introduced into an isolated unit with temperature, light and humidity control, to generate a favorable environment for their reproduction. Flies were fed with wheat bran, which served as a place for ovulation. The collection of eggs

Table 1. The feeds proximate analyses.

Composition (%)	T_1 Larvae meal	T_2 Formulated feed	T_3 Commercial feed
Protein	34.72	35.29	35
Lipid	7.85	8.65	9
Carbohydrate	32.36	29.75	31
Fiber	14.53	14.27	13
Ash	10.54	12.04	12

Table 2. Registered values of culture water physical and chemical parameters.

Variable	Registered values			Reported values
	1st block	2nd block	3rd block	
Temperature (ºC)	26.4 ± 3.6	25.8 ± 3.2	25.3 ± 3.5	22 - 32
Dissolved oxygen (mg L^{-1})	5.54 ± 1.12	5.74 ± 1.26	6.03 ± 1.09	4 - 7
Nitrate (mg L^{-1})	4.8	5.5	6.3	< 10
Nitrite (mg $L^{-1)}$	0.288	0.319	0.312	< 2
Ammonium (mg L^{-1})	0.27	0.35	0.31	< 0.5

was carried out during 60 days. Incubated for five days until the desired larvae were obtained. Then, separated from the substrate for later sacrifice, consisting of 24 h cooling at -10°C. They were introduced to an electricdehydrator at 65°C for 24 h, and finally, ground (Pieterse & Pretorius, 2013) to obtain a meal, from which samples were taken for nutrient evaluation through proximate analysis. Subsequently, the treatments to be evaluated were established and the nutritional composition of each feed (Table 1); (T_1) fly larvae meal, (T_2) feed with fly larvae meal as a substitute of the fish meal and (T_3) commercial feed.

An experimental-design of random blocks was used, with three treatments and three replicates, with an experimental unit consisting of 24 individuals. A total of 216 juveniles of *M. tellenum* were observed during a 60 days period with an initial weight of 0.897 ± 0.007 g.

The organisms were distributed in nine ponds at a density of 12 ind m^{-2} (Vega-Villasante *et al.*, 2011; Espinosa-Chaurand *et al.*, 2012).

Constant aeration and 50% of water refills were performed daily (Luna *et al.*, 2007; García-Ulloa *et al.*, 2008) to maintain the water quality. Dissolved oxygen and temperature factors were monitored using a Hach HQ40d® equipment and the nitrogen compounds determined by the Hach DR6000® spectrophotometer by the 8039 method for nitrates, 8057 for nitrites, and 8038 for the ammonium.

The feeding treatments were given twice a day (7:00 AM and 6:00 PM) at a total rate of 6% of the biomass present in each of the ponds (García-Ulloa *et al.*, 2008; Espinosa-Chaurand *et al.*, 2012). Survival rate (SR), growth rate (GR), feed conversion ratio (FCR), and protein efficiency ratio (PER) was the response variables used to evaluate the feeds supplied. To determine the effect of the treatments on the analyzed variables, an analysis of variance (ANOVA) and Tukey's test was performed, both with 95% confidence.

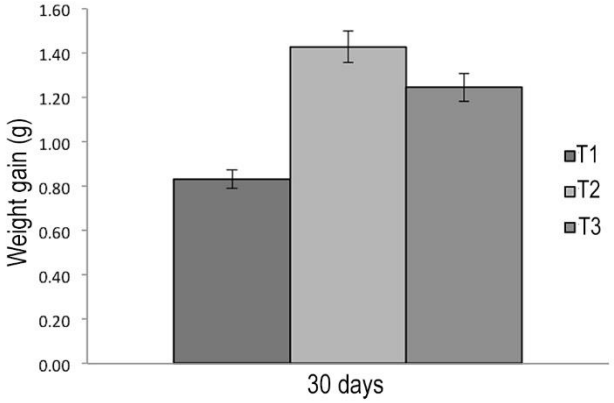

Figure 1. Partial weight (g) of *Macrobrachium tenellum* juveniles in the first experimental period ($P < 0.05$).

During the 60 days of the experiment, the physical and chemical characteristics of the water were kept within the tolerance ranges reported for the cultivation of individuals of the genus *Macrobrachium* (Table 2). During the first 30 days of the experimental period (Fig. 1), the growth rate showed significant differences between treatments ($P < 0.05$); at this moment the results favor the feed generated based on fly larvae meal (T_2). Individuals fed with treatments T2 and T3, in the second part of the evaluation (day 31 to 60), contributed more to the growth of *Macrobrachium tenellum*. Transcending a significantly higher weight

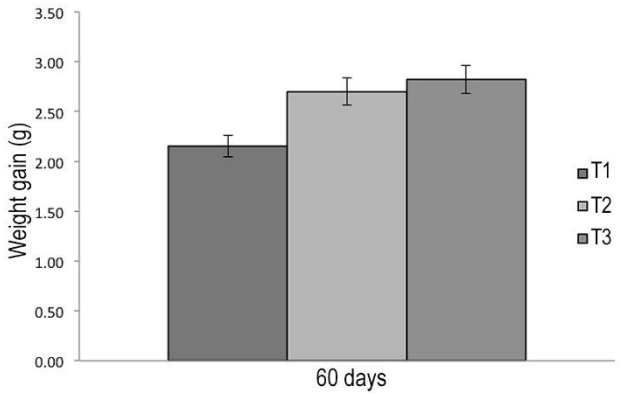

Figure 2. Total weight (g) of the prawn *Macrobrachium tenellum* after 60 days of the experimental culture ($P < 0.05$).

gain ($P < 0.05$) compared to T_1, which did not change its trend during the experimental period (Fig. 2).

The summary of the response variables evaluated for each of the treatments after 60 days of the experimental culture is shown (Table 3).

During this work, water quality remained within limits established for the cultivation of the *Macrobrachium* genus (Ponce-Palafox *et al.*, 2002; Valverde-Moya, 2006); therefore, it is inferred that the water in the ponds was not a limiting factor in the growth of individuals present for each treatment. Treatments, in the first experimental period (day 1 to 30) had on the average a contribution inferior to 45% of the total offered to the final biomass. Which could be related to the observation of a greater molt frequency; since to carry out the molting process the organism could have focused part of the nutrients contributed, thus subtracting the increase in the rate of growth.

Table 3. Biological indices in *M. tenellum* juveniles after being fed during 60 days with the experimental feed. Growth rate (GR), survival rate (SR), feed conversion ratio (FCR) and protein efficiency ratio (PE). Values with the same superscripts do not present significant differences.

Response variable	T_1 Larvae meal	T_2 Formulated feed	T_3 Commercial feed
Start (g)	0.904 ± 0.007	0.897 ± 0.004	0.891 ± 0.005
Finish (g)	3.058 ± 0.022	3.598 ± 0.019	3.714 ± 0.016
GR (g)	2.154 ± 0.034^{b}	2.701 ± 0.01^{a}	2.822 ± 0.008^{a}
SR (%)	66.67^{b}	70.83^{ab}	76.39^{a}
FCF	3.01	2.78	2.61
PE	0.949	1.027	1.091

The organisms fed with the evaluated treatments showed significant differences in GR and SR, these differences showed to T_2 and T_3 with the significant contributions on *M. tenellum* growth. However, after the review of the variable FCR, T_3 was found as the adequate feed, since its value of 2.61 is located 6.11% smaller than T_2. This difference suggests a discrepancy in the assimilation of the nutrients presented in the feed, which could be due to the ingredients quality used and the processing of the formulated feed (T_2).

The incorporation of house fly larvae meal in the feeding of *M. tenellum* as a source of protein is feasible; however, it presents certain limitations such as the production cost and a decrease in growth in late culture phase.

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