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Influence of diets on the rearing of predatory flies of housefly larvae

[*Influência de dietas na criação de moscas predadoras da mosca doméstica*]

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ABSTRACT

The purpose of this study was to evaluate the survival, development time and morphological measures of immature *Ophyra aenescens* and *Ophyra albuquerquei* on different diets. Different proportions of protein and carbohydrates were offered for each species in 10 vials containing 30 eggs each. The vials were placed in a germination chamber at 30°C, relative humidity above 75% and photoperiod of 12 hours. Every day a vial was removed and mortality was evaluated and on the tenth day the length of the cephalic-pharyngeal skeleton (EC) and body size (G) of larvae that survived were evaluated. Survival was higher in diets with more protein (P<0.001). Between the species, mortality was more pronounced in *O. albuquerquei* in all diets (P<0.001). The EC (P<0.01) and G (P<0.01) showed the same sizes in the diets with higher protein content. For the production of pupae of these species, the diet with more protein and fewer components is more appropriate, and the production is higher in *O. aenescens* than in *O. albuquerquei*.

Keywords: *Ophyra aenescens*, *Ophyra albuquerquei*, *Musca domestica*, Muscidae, biological control

RESUMO

Avaliaram-se a sobrevivência, tempo de desenvolvimento e medidas morfológicas de imaturos de Ophyra aenescens *e* Ophyra albuquerquei *em dietas compostas com diferentes proporções de proteínas e carboidratos. Estas dietas foram oferecidas para cada espécie em 10 frascos contendo 30 ovos cada que foram acondicionados em câmara de germinação a 30ºC, UR entre 75% e 90%, fotoperíodo de 12 horas. Para avaliação do padrão de sobrevivência, um frasco foi retirado da câmara diariamente e foi realizada contagem dos indivíduos vivos. No décimo dia foi avaliado o comprimento do esqueleto céfalo-faríngeo (EC) e o tamanho do corpo (G) das larvas que sobreviveram. O esqueleto céfalo-faríngeo (P<0,01) e o tamanho do corpo (P<0,01) apresentaram os mesmos tamanhos nas dietas com maior teor de proteínas, diferenciando-se nas outras dietas. O padrão de sobrevivência foi mais acentuado em* O. albuquerquei *do que em* O. aenescens *(P<0,001), enquanto nas dietas com mais proteínas a mortalidade foi menor que nas dietas com menos (P<0,001).*

Palavras-chave: Ophyra aenescens, Ophyra albuquerquei, Musca domestica, *Muscidae, controle biológico*

INTRODUCTION

The *Ophyra* Robineau-Desvoidy, 1830 (Diptera, Muscidae) species are used in the biological control of *Musca domestica* L., 1758 (Diptera, Muscidae) in poultry and pig farms in the United States and Europe (Farkas *et al*., 1998; Hogsette and Jacobs, 1999), which can be used in production systems for dairy cattle (Hogsette *et al*., 2002). The *Ophyra* larvae are facultative predators and can kill more than 15 house fly larvae per day (Farkas and Papp, 1990). Despite the successful use of *Ophyra* to control *M. domestica*, in Brazil there is still much resistance from producers and difficulty in establishing a pattern of laboratory rearing.

The nutritional basis of the diet for the *Ophyra* larvae is essentially protein, varying slightly from the proportions of protein and

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carbohydrates, making it difficult to obtain a standard production (Hogsette, 1992; Hogsette and Koehler, 1992; Hogsette and Washington, 1995; Ribeiro *et al*., 2000b; Krüger *et al*., 2003). The use of similar diets reduces the cost of components and facilitates the creation of insects as biological control agents. The purpose of this study was to investigate the influence of different proportions of protein and carbohydrates on survival, development, and size of *Ophyra aenescens* (Wiedemann, 1830) and *Ophyra albuquerquei* Lopes, 1985 larvae's.

MATERIAL E METHODS

The colonies of *O. aenescens* and *O. albuquerquei* were obtained from adults caught in poultry farms of Universidade Federal de Pelotas (UFPel), RS, Brazil (31º45'48''S, 52º29'02''W) and placed in an incubator room at 25°±1°C, relative humidity between 75% and 90%, photoperiod of 12 hours, for eight and two years, respectively. The adults were fed with a diet composed of milk powder, sugar and fish meal, in a ratio of 2:2:1, respectively. The diets were modified by Ribeiro *et al*. (2000a) and Krüger *et al*. (2004) from Hogsette and Koehler (1992) and Hogsette *et al*. (2002) that used Gainesville and Budapest diets. The *O. aenescens* and *O. albuquerquei* larvae were fed according to Ribeiro *et al*. (2000b) and Kruger *et al*. (2003) modified from Hogsette and Washington (1995) and Farkas *et al*. (1998), who used Gainesville and Budapest diets for larvae. The pupae were incubated at 26°C in humid sawdust until adult emergence.

Diets were composed considering the variation of protein and carbohydrates (Table 1), and four diets for immature were composed by proportions as presented in Table 2. For each species in each diet 10 vials containing 30 eggs were placed. The vials were placed in a germination chamber at 30±1ºC, relative humidity between 75% and 90% and photoperiod of 12 hours. One vial of each diet for each species was removed for counting of daily living individuals. The larvae found alive were sacrificed in water with temperature between 70 and 80°C and then were measured and packaged in bottles containing 80% alcohol (Skidmore, 1985).

Table 1. Percentage of nutrients that integrate the components of the diets offered to *Ophyra aenescens* and *Ophyra albuquerquei* larvae at temperature of 25º±1ºC, relative humidity between 75% and 90%, photoperiod of 12 hours

	Component (%)	
Nutrient	Fish meal	Wheat flour
Protein	65	11.00
Fat	10	1.10
Ash	15	0.45
Starch	-	75.00
Sugar	-	2.10
Fiber	-	0.35

* Humidity is a component of fish meal and wheat flour.

Table 2. Percentage of nutrients and components of the diets offered to *Ophyra aenescens* and *Ophyra albuquerquei* larvae at temperature of 25º±1ºC, relative humidity between 75% and 90%, photoperiod of 12 hours

	Diet			
	A	B	C	D
Component (%)				
Fish meal	66	50	16	0
Wheat flour	0	16	50	66
Sawdust	34	34	34	34
Nutrient (%)				
Proteins	42.90	34.26	15.90	0.00
Carbohydrates	0.00	12.34	38.55	50.89

Diet A: 66% fishmeal and 34% wet sawdust; Diet B: 50% fishmeal, 16% wheat flour and 34% wet sawdust; Diet C: 16% fish meal, 50% wheat flour and 34% wet sawdust; Diet D: 66% wheat flour and 34% wet sawdust.

The survival, length of the cephalopharyngeal skeleton (ES) and body size (G) were used as biometric measurements, referred to as quantitative parameters of the tested diets. The instars were identified as Skidmore (1985), considering the shape of the cephalopharyngeal skeleton and the number of spiracular slits. The variation in the length of ES and G was assessed by ANOVA with F distribution. Analysis of survival was performed considering the Weibull distribution in the "Survreg" package. The treatments of both tests were compared through contrast analysis (Crawley, 2007). Analyses were performed in the statistical program R (R a language..., 2008) considering $P<0.05$.

RESULTS AND DISCUSSION

The survival of the *O. aenescens* and *O. albuquerquei* larvae was higher in diets with more protein than diets with more carbohydrates ($\chi^2=390.48$, DF=7, $P<0.001$), and mortality was more pronounced in *O. albuquerquei* in all diets ($P<0.001$, Figure 1). These results are not different from those of Ribeiro *et al*. (2000b) and Krüger *et al*. (2003) for these species with diets A and B. Immature stages of *O. aenescens* have higher development rate than *O. albuquerquei* because their larvae are smaller, and require less time to complete their development.

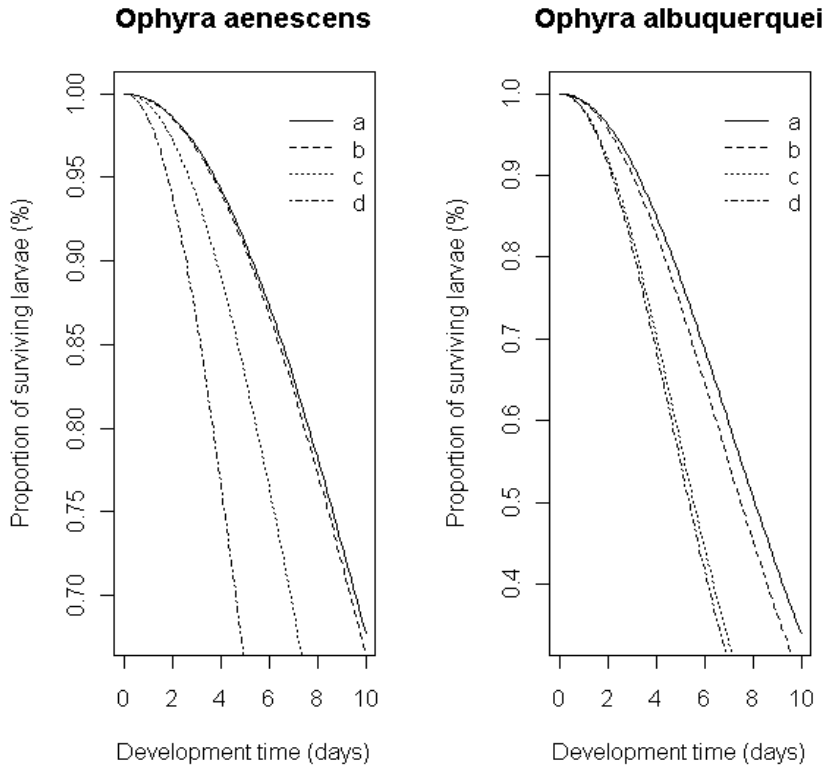


Figure 1. Proportion of surviving *Ophyra aenescens* and *Ophyra albuquerquei* larvae as function of development time on different diets at temperature of 25º±1ºC, relative humidity from 75% to 90%, photoperiod of 12 hours. Diet A: 66% fishmeal and 34% wet sawdust; Diet B: 50% fishmeal, 16% wheat flour and 34% wet sawdust; Diet C: 16% fish meal, 50% wheat flour and 34% wet sawdust; Diet D: 66% wheat flour and 34% wet sawdust.

The mean mortality time in the diets ranged from 8 to 16 days for *O. aenescens* and 6 to 10 days for *O. albuquerquei* according to the estimated models (Table 3). While half the *O. albuquerquei* individuals die in the larval stage, this will only occur in the pupal stage for *O. aenescens* in diets A and B. For *O. aenescens* the results are similar to those found by Hogsette and Washington (1995) and Ribeiro *et al*. (2000b).

Hogsette and Washington (1995) observed that the development and survival of the *O. aenescens* larvae were higher in diets with more protein as well as the results in these experiments. This increase in survival on diets with a higher proportion of protein is due to behavioral characteristics of these species. Furthermore, strains of the species that were used in this experiment are already adapted to artificial diets composed of fish meal in high proportion for several generations (Ribeiro *et al*., 2000a; 2000b; 2001; Krüger *et al*., 2003; 2004). The adaptation of the high proportion of proteins is a prerequisite for the maintenance of predators in the laboratory. Predatory insects get over 90% of amino acids in diets based on protein (Cohen, 2000).

Table 3. Models of survival of *Ophyra aenescens* and *Ophyra albuquerquei* with different diets at temperature of 25º±1ºC, relative humidity between 75% and 90%, photoperiod of 12 hours. Y is the mortality probability and X is the time

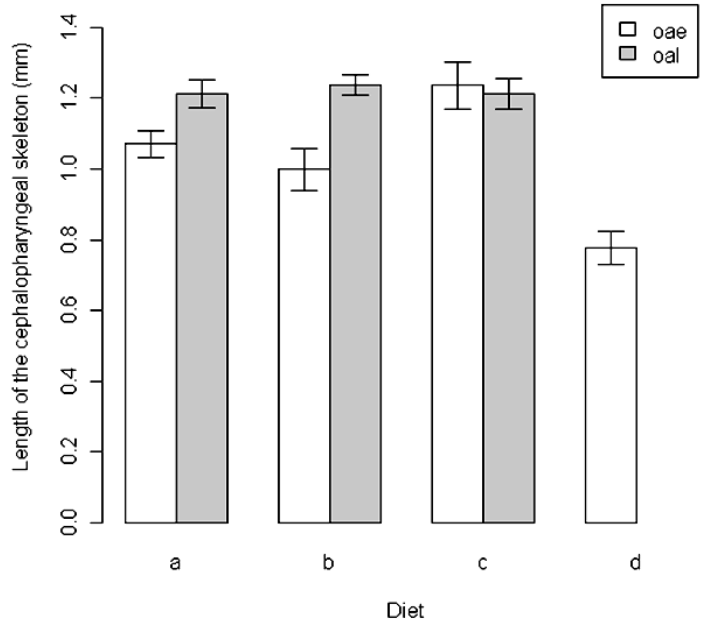
Diet	Species	
	Ophyra aenescens	*Ophyra albuquerquei*
A	$y = e^{15,75^{-2,0746}*x^{2,0746}}$	$y = e^{9,64^{-2,0746}*x^{2,0746}}$
B	$y = e^{15,42^{-2,0746}*x^{2,0746}}$	$y = e^{8,96^{-2,0746}*x^{2,0746}}$
C	$y = e^{11,32^{-2,0746}*x^{2,0746}}$	$y = e^{6,65^{-2,0746}*x^{2,0746}}$
D	$y = e^{7,60^{-2,0746}*x^{2,0746}}$	$y = e^{6,42^{-2,0746}*x^{2,0746}}$

Diet A: 66% fishmeal and 34% wet sawdust; Diet B: 50% fishmeal, 16% wheat flour and 34% wet sawdust; Diet C: 16% fish meal, 50 % wheat flour and 34% wet sawdust; Diet D: 66% wheat flour and 34% wet sawdust.

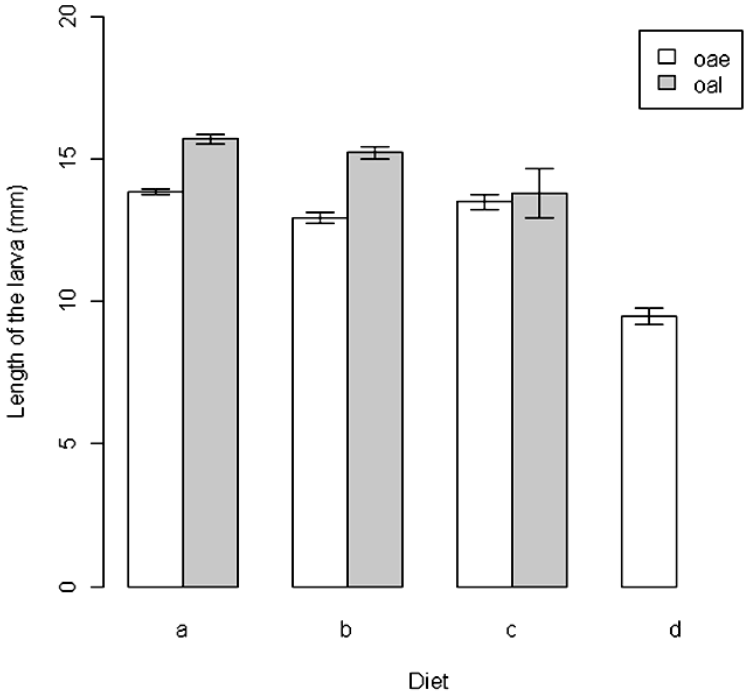
The increase of protein in the diets had a positive effect on the dimensions of the larvae, such as cephalopharyngeal skeleton (EC) and body size (G) (Table 4). Both the EC ($F_{3,111}$=93.15, P<0.01, Figure 2A) and G ($F_{3,111}$=427.50, P<0.01, Figure 2B) from third instar larvae were influenced by the diet. The EC presented the same size in diets A, B and C for *O. albuquerquei* (P=0.76) and A and B for *O. aenescens* (P=0.53). G was equal in diets A and B for *O. albuquerquei* (P=0.27) and in B and C for *O. aenescens* (P=0.38) by analysis of contrasts, and the third instar *O. albuquerquei* larvae had larger dimensions (EC and G) than *O. aenescens* larvae (Figure 2, Table 4).

Nutritional deficiencies can cause serious delays in the development of immature Muscidae (Hogsette, 1992). Hogsette and Washington (1995) found a similar pattern to that obtained in this study when evaluating the weight of *O. aenescens* larvae in different protein concentration. In diets poor in nutrients such as carbohydrate-rich ones the biomass was very low compared to diets rich in protein. Another factor that may influence the measurements of weight and size is the amount of moisture, as observed by Hogsette *et al*. (2002).

Diets A and B offered to *Ophyra* species have been used to rear and maintain other species of Muscidae, *Synthesiomyia nudiseta* (Wulp, 1898) and *Muscina stabulans* (Fallen, 1817) for a long period, with high survival in all stages development and good egg production (Kruger *et al*., 2002; 2008; 2010; Krüger and Erthal, 2006; Zimmer *et al*., 2006). These studies and results confirm the identity rule and the principle of proportionality. The identity rule posits that regardless of the systematic position and food habits, nutritional requirements are the same for most animals. The principle of proportionality of nutrients is key to determine who should receive digestible diets, and the more purified ingredients, higher cost and lower nutritional value for predators (House, 1974; Cohen, 2000) unlike the observed this study.



A



B

Figure 2. Length of the cephalopharyngeal skeleton (A) and length of the larva (B) third instar *Ophyra aenescens* (oae) and *Ophyra albuquerquei* (oal) on different diets at temperature of 25º±1ºC, relative humidity from 75% to 90%, photoperiod of 12 hours. Diet A: 66% fishmeal and 34% wet sawdust; Diet B: 50% fishmeal, 16% wheat flour and 34% wet sawdust; Diet C: 16% fish meal, 50% wheat flour and 34% wet sawdust; Diet D: 66% wheat flour and 34% wet sawdust.

Table 4. Average length and standard deviation of the cephalopharyngeal skeleton (EC), mass (G) and growth rate (GR) of larval instars of *Ophyra aenescens* and *Ophyra albuquerq*uei (Diptera. Muscidae) in relation to different diets at temperature of 25º±1ºC, relative humidity between 75% and 90%, photoperiod of 12 hours

Diet	1st instar		2nd instar		3rd instar		GR
	Average length (mm)						
	EC	G	EC	G	EC	G	
Ophyra aenescens							
A	0.20±0.01	1.87±1.37	0.54±0.23	5.86±2.14	1.07±0.06	12.24±1.88	10.56±2.59
B	0.20±0.02	1.73±1.08	0.52±0.22	5.29±1.38	1.17±0.15	12.42±1.17	9.87±2.79
C	0.18±0.01	1.57±0.88	0.53±0.24	5.33±2.22	1.14±0.08	12.09±2.12	9.77±2.55
D	0.15±0.01	1.51±0.24	0.69±0.14	5.36±1.81	0.86±0.08	9.41±2.01	9.70±3.40
Ophyra albuquerquei							
A	0.21±0.00	1.87±0.00	0.68±0.00	5.32±0.00	1.33±0.12	14.27±2.52	9.19±2.24
B	0.22±0.00	2.05±0.00	0.71±0.16	7.01±2.10	1.32±0.09	14.42±0.92	9.09±2.86
C	0.21±0.00	1.89±0.00	0.56±0.00	3.90±0.00	1.23±0.04	14.05±1.35	9.09±1.97
D	0.23±0.02	1.90±0.85	___	___	___	___	___

Diet A: 66% fishmeal and 34% wet sawdust; Diet B: 50% fishmeal, 16% wheat flour and 34% wet sawdust; Diet C: 16% fish meal, 50% wheat flour and 34% wet sawdust; Diet D: 66% wheat flour and 34% wet sawdust.

CONCLUSIONS

The results suggest that diets with a higher proportion of protein in relation to carbohydrates increase the development period and survival rate of *Ophyra* species. Therefore, diet A is the most efficient for mass rearing of *O. aenescens* and *O. albuquerquei* in a strategy for ecological management of *M. domestica* in livestock production systems.

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