# Intraspecific competition among larvae of *Aedes albopictus* in conditions of food abundance and shortage

Fabio Macchioni[1], Daniele Chiavacci[1], Alessandro Biasci[2], Maria Cristina Prati[3]

[1]Department of Veterinary Science, University of Pisa, Via Livornese [Lato Monte]56122, San Piero a Grado, Pisa (PI) Italy.

[2]Entomox Srl, Company of Disinfestation and Rat Extermination, Pisa Italy.

[3]Scuola Normale Superiore di Pisa, Piazza dei Cavalieri 7, 56126 Pisa, Italy.

*Corresponding author: fabio.macchioni@unipi.it*

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**Abstract:** The competition between larvae of *Aedes albopictus* (Skuse, 1987), an invasive mosquito species recently established in Italy, was evaluated in laboratory in conditions of food abundance and shortage. The number of emerging adults, the time of emergence and the size of the adult bodies were recorded and compared. The number of adults that emerge under conditions of food abundance was found to be significantly higher than under food shortage. When food was lacking more males than females emerged and there was no significant difference in their body sizes, while under food abundance females were larger than males. Both males and females with abundant food were on average bigger than under food shortage. There was no difference in the time of adult emergence in the two different food conditions. ***Journal of the European Mosquito Control Association* 34: 14-16, 2016**

Keywords: Intraspecific competition, *Aedes albopictus*, mosquito larvae, food abundance, food shortage.

## Introduction

*Aedes albopictus* (Skuse, 1897) (Diptera: Culicidae), the Asian tiger mosquito, arrived in Italy during the early 1990s with tyres imported from USA and was detected for the first time in Genoa (Sabatini *et al*., 1990; Dalla Pozza & Majori 1992). *Aedes albopictus* spread rapidly in several areas in central and northern Italy (Romi, 2001), because of its high biological adaptability (Hawley, 1988) and its ability to survive during the winter in embryonic diapause. This species tends to colonise mainly urban and suburban environments, sharing the habitat already exploited by *Culex pipiens* L.

The aquatic larvae of *Ae. albopictus* feed on microorganisms and particulate matter in the water column as well as on leaves and other organic detritus (Merritt *et al*., 1992). The effects of competition on mosquitoes that breed in containers and tree-holes are well documented (Ho *et al*., 1989; Walker *et al*., 1991; Juliano, 1998; Lounibos *et al*., 2001). Severe larval densities and limiting resources are frequent in these habitats. It is thus likely that larval competition, inter- or intraspecific, can strongly impact on prolonged (delayed) larval development, survivorship of larvae and adults and reproductive success (Juliano & Lounibos, 2005). Density-dependent competition for food during the first larval stages is one of the most important factors that impact on population dynamics of mosquitoes (Moore *et al*., 1969; Washburn, 1995; Gilles *et al*., 2011; Walsh *et al*., 2011). Nutrition is an important factor that influences larval development (Reisen, 1975; Telang & Wells, 2004) and the reproductive capacity of female mosquitoes (Clements, 1992). The overcrowding of mosquito larvae generally results in a slower growth, high mortality and small or non-uniform adult size (Yoshioka *et al*., 2012).

The aim of this study was to observe competition among larvae of *Aedes albopictus* under conditions of food abundance and shortage. Understanding the mechanisms that control population dynamics is essential for predicting ecological, economic and health impacts of resident and invasive species (Levins, 1969; Legros *et al*., 2009).

## Materials and Methods

This study was carried out between April to November 2014. Sixty plastic cups filled with water were used as breeding containers for *Ae. albopictus* larvae hatched from eggs collected on strips of masonite placed inside ovitraps. These were distributed in two small towns near Florence (Tuscany, central Italy) in the context of a parallel monitoring experiment (Macchioni *et al*., unpublished). Different levels of competition were set by varying larval density (cups with 20, 40, 80, 120, 180 larvae) and different food regime with food shortage (0.06 g of food per cup) and food abundance, in proportion to the number of larvae (0.07g/20, 0.14g/40, 0.28g/80, 0.42g/120, 0.63g/180 food per cup). There were six replicates for each condition. The food provided was dry food for cats with the following composition: chicken proteins (38%), fat content (16%), fibres (3%) and inorganic matter (8%). Mortality of larvae, time of adult emergence, number and gender of emerging adults and length of their adult bodies were measured. Statistical analysis was performed using Pearson chi-square test, Wilcoxon sum of ranks test and Shapiro-Wilk normality test. Significance of a test was reached for P value $<0.05$.

## Results

With mosquito larvae exposed to a shortage of food the total number of emerging adults from 2520 larvae (6 replicates of each larval density) was 536 (133 females and 403 males). In contrast, with 2520 mosquito larvae exposed to food abundance there were 1079 emerging adults (467 females and 612 males). There is a highly significant difference between the two total adult numbers (chi-square test $P<<0.01$). In the case of food abundance the percentage of emerging adults decreased significantly between the conditions with densities of 20 and

40 larvae, then remained more or less constant (chi-square test not significant) between densities of 40 and 120 larvae and finally decreased with a density 180 larvae. Under conditions of food shortage there was a constant significant decrease in the percentage of emerging adults (see Fig.1).

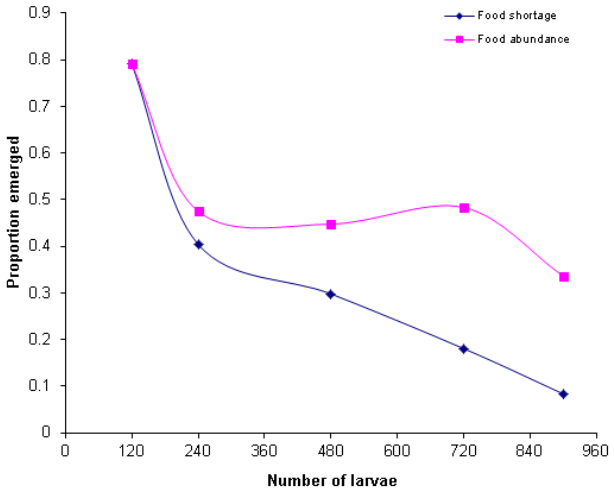


**Figure 1: Proportion of adult emergence under food abundance and shortage.**

There was no significant difference in the proportion of males and females that emerged under food abundance, while under food shortage fewer females emerged (P<0.01). In both food conditions adults emerged between the 8th and 13th day with the peak adult emergence between the 9th and 10th day (see Table 1).

**Table 1: Times of adult emergence under food shortage and abundance: ♀ female; ♂ male.**

| Emergence Day | Food Shortage ♀ | Food Shortage ♂ | Food Abundance ♀ | Food Abundance ♂ |
|---|---|---|---|---|
| 7 | 0 | 45 | 2 | 64 |
| 8 | 12 | 137 | 155 | 379 |
| 9 | 46 | 139 | 208 | 120 |
| 10 | 28 | 46 | 31 | 30 |
| 11 | 15 | 24 | 24 | 11 |
| 12 | 26 | 5 | 17 | 4 |
| 13 | 3 | 0 | 5 | 1 |
| 14 | 2 | 4 | 12 | 1 |
| 15 | 0 | 2 | 4 | 0 |
| 16-19 | 1 | 1 | 9 | 2 |
| **Total** | **133** | **403** | **467** | **612** |

**Table 2: Dimensions (mm) of emerged male and female adults under food abundance and shortage: ♀ female; ♂ male.**

| Larvae | Gender | Food abundance Mean | Var | Median | N. | Food shortage Mean | Var | Median | N. |
|---|---|---|---|---|---|---|---|---|---|
| 20 | ♂ | 3.612 | 0.074 | 3.65 | 43 | 3.531 | 0.091 | 3.53 | 40 |
| | ♀ | 3.935 | 0.041 | 3.93 | 30 | 3.847 | 0.037 | 3.90 | 38 |
| 40 | ♂ | 3.815 | 0.024 | 3.80 | 34 | 3.118 | 0.096 | 3.00 | 45 |
| | ♀ | 3.964 | 0.086 | 4.00 | 37 | 3.118 | 0.256 | 3.00 | 25 |
| 80 | ♂ | 3.639 | 0.083 | 3.60 | 48 | 3.003 | 0.115 | 3.00 | 48 |
| | ♀ | 3.940 | 0.034 | 4.00 | 45 | 3.183 | 0.103 | 3.10 | 27 |
| 120 | ♂ | 3.820 | 0.085 | 3.80 | 48 | 2.877 | 0.031 | 2.90 | 48 |
| | ♀ | 4.198 | 0.058 | 4.10 | 48 | 3.005 | 0.023 | 3.00 | 21 |
| 180 | ♂ | 3.909 | 0.043 | 3.95 | 43 | 2.170 | 0.028 | 2.15 | 43 |
| | ♀ | 4.075 | 0.031 | 4.10 | 42 | 2.368 | 0.098 | 2.35 | 11 |

Since data regarding the body size of adults (Table 2) do not respect normality (Shapiro-Wilk tests all significant), a non-parametric test was used to compare medians of adult sizes. Under conditions of food abundance, there was a significant difference in body size between genders for all larval densities (Wilcoxon test P values «0.01); the body length of males being smaller than those of females. Under conditions of food shortage, apart from the case of 20 larvae, in which experimental conditions are very similar to food abundance, there were no significant differences for higher larval number between the body size of males and females, indicating that food competition tends to homogenize body size (P«0.01). Furthermore adult size of the same gender were compared in the two food conditions, both genders being bigger with abundant food than under food shortage (P«0.01).

## Discussion

Our results indicate that the intra-specific competition for food among larvae of *Ae. albopictus* has a significant impact on the number of adults that emerged, in accordance with the study of Yoshioka *et al.* (2012) on American populations of *Ae. albopictus*.

This phenomenon has already been observed in the inter-specific competition for food between *Ae. albopictus* and *Cx. pipiens*, *Ae. albopictus* and *Ae. aegypti* (Dye, 1984; Carrieri *et al.*, 2003; Yee *et al.*, 2004; Costanzo *et al.*, 2005; Murrell & Juliano, 2008).

There was no significant difference in the proportions of males and females that emerged under conditions of food abundance, showing that the different metabolism between males and females does not affect the numbers of adult emergences in this case, although these findings contrast with other studies (Delatte *et al.*, 2009; Briegel & Timmermannn, 2001; Monteiro *et al.*, 2007).

In this experiment, both with food shortage and food abundance, males and females emerged more or less during the same days, thus overcrowding and lack of food apparently do not affect the time of adult emergence, although other studies disagree (Hawley, 1988).

In accordance with the fact that the body length of males is generally shorter than that of females, one finds that under food abundance there are highly significant differences in size between the two genders for all larval densities. Under food shortage, no significant differences in size between males and females were recorded for high larval densities. This indicates that intraspecific competition for food tends to homogenize the size of females and males. Comparing adults of the same gender in conditions of food shortage and food abundance, the difference in size was highly significant. Thus intra-specific competition for food affects the size of adult mosquitoes. These results agree with Costanzo *et al.* (2005) and Yoshioka *et al.* (2012) on the American population of *Ae. albopictus*.

The size of adult females is correlated to fertility; in fact bigger females are able to lay more eggs. For this reason the measurement of the body size of females is useful to assess reproductive fitness (Steinwascher, 1982; Briegel, 1990).

## Conclusions

Competition for food and overcrowding of larvae determine high mortality, smaller adult size, smaller proportion of surviving females, but does not affect time of adult emergence.

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