

Exceptional Longevity in the Tephritid, *Ceratitis rosa*, a Close Relative of the Mediterranean Fruit Fly

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ABSTRACT This study shows that the fruit fly, *Ceratitis rosa* (Karsch), has a significantly longer life span than the medfly, *C. capitata* (Wiedemann); the species used as a model organism for the demographics of insect aging. This was somewhat surprising given that both have similar distributions and overlapping niches. We postulate that the greater longevity of *C. rosa* is related to the fact that it can occupy colder habitats where the availability of suitable host plants may be very unpredictable in both time and space.

KEY WORDS biodemographic study, *Ceratitis rosa*, fruit fly, longevity, tephritidae

The Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) and the fruit fly, *Ceratitis rosa*, (Karsch) originated from the same area of East Africa (Baliraine et al. 2004, De Meyer et al. 2008) and were both accidentally introduced into La Reunion in 1939 and 1955, respectively (Duyck et al. 2008). Given that these two polyphagous species are closely related genetically (Malacrida et al. 1996, Baliraine et al. 2004) and have very similar behavior and ecology (Duyck et al. 2006, De Meyer et al. 2008), we performed a study to see if *C. rosa* had a long adult life span, as previously reported for *C. capitata* (Carey 2003). Specifically, we determined the age-specific longevity of both sexes when provided different quality diets under controlled laboratory conditions.

Materials and Methods

The flies used came from a colony that had been reared on artificial diet over 87 generations and the experiments were conducted under laboratory conditions at $25 \pm 1^\circ\text{C}$, $65 \pm 10\%$ RH using a 12:12 L:D photoperiodic regime. Newly emerged adults were placed and mortality was observed daily under three different diet treatments: a full sugar and protein diet (250 males and 250 females), just sugar, or just protein (each with 50 males and 50 females). Water, sugar,

and/or protein were given ad libitum. Differences in longevity related to sex and dietary treatment were assessed using Cox's proportional hazards survival regression, with significance tested using likelihood ratio tests.

Life expectancy at birth was calculated as $\sum_{x=0}^{\infty} \frac{1}{l_x}$ where l_x is the fraction of the cohort alive at age x while the age-specific mortality rate was calculated as $qx = 1 - l_x$.

Results

Adults reared on a complete diet had a relatively high survivorship over the first 3 mo, but showed a more rapid decline in the following time period (Fig. 1). The maximum longevity observed was 328 d for a female and 357 for a male. Females had a higher age specific mortality than males (Fig. 1; sex: $\chi^2 = 8.5$, $df = 1$, $P < 0.0001$), with an average life expectancy at emergence of 143 d whereas for males it was 160 d.

The longevity of both sexes was significantly reduced if either sugar or protein were eliminated when compared with the complete adult diet, although the effect was more pronounced in the absence of sugar (Fig. 1; diet: $\chi^2 = 427.7$ $df = 2$, $P < 0.001$, interaction diet*sex: $\chi^2 = 6.5$ $df = 2$, $P < 0.05$).

Discussion

The observed average life span of both male and female *C. rosa* (Fig. 1) far exceeds the values reported for different populations of the medfly, *C. capitata* (31–76 d; Carey 1992, Diamantidis et al. 2009) or the Mexican fruit fly, *Anastrepha ludens* (Loew) (50 d; Carey et al., 2005). The gender gap we observed for *C. rosa*, with males having a longer life expectancy than

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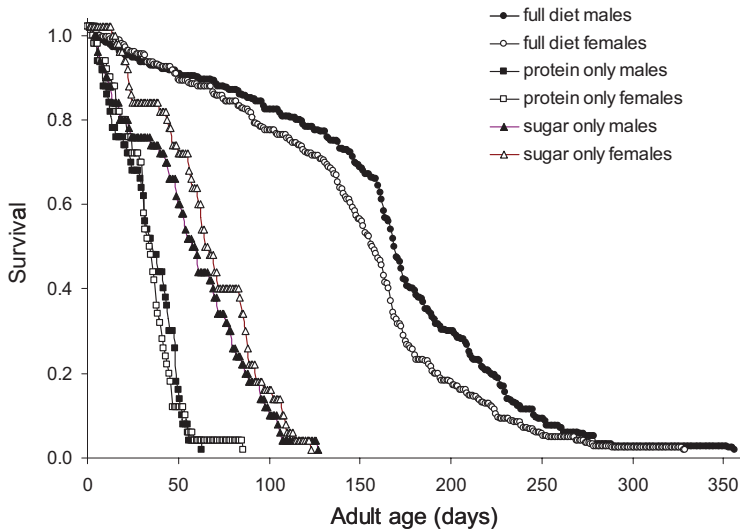


Fig. 1. The age specific survival curves of *C. rosa* males and females at $25 \pm 1^\circ\text{C}$, $65 \pm 10\%$ RH under a 12:12 L:D photoperiodic regime when provided a protein and sugar diet ($N = 250$ males and females), or either a protein or sugar only diet ($N = 50$ males and females in each case).

females, was similar to the lower value of the 20–58 d reported from different populations of medfly (Diamantidis et al. 2009). One could argue that the extreme longevity observed may be an artifact as we used a colony that had been in rearing for many generations, and different traits may be more favored in the laboratory than under field conditions (Price 1984). However, we do not believe that this is the case as similar longevity values were obtained when wild strains were tested under identical conditions (Duyck et al. 2010).

One possible reason for this marked difference in the longevity of *C. rosa* adults compared with other Tephritids may relate to adaptations associated with climatic conditions. While *C. rosa* and *C. capitata* have similar geographic distributions and have overlapping niches, *C. rosa* is more adapted to cold conditions. Because of the strong trade-off between reproduction and longevity, a decreased senescence should be observed in colder places (Williams 1966, Chapman et al. 1998). Diamantidis et al. (2009) also proposed that if fruit availability was unpredictable in time and space this could result in a strong selection for increased longevity. Thus, in colder habitats one might expect a higher temporal and spatial variability of suitable oviposition sites leading to very long lived flies.

Carey et al. (1992, 2005) noted that very long lived *C. capitata* and *A. ludens* adults had a lower mortality rate that shorter lived individuals and a similar trend was noted for *C. rosa*. The reason for this, be it natural selection or live long heterogeneity, is still open to debate (see Mueller et al. 2007, Vaupel et al. 1998).

In the absence of a complete diet the longevity of both *C. rosa* males and females was significantly reduced, especially when provided only protein. Interestingly, when provided only sugar females were longer lived than males, contrary to the pattern seen

when they were provided a complete diet (Fig. 1). Diet related changes in the relative longevity of male and female *C. capitata* have also been reported (Müller et al. 1997), although in their study the patterns were the inverse of those found in our study. The observed intersexual effects of diet deprivation noted in these two studies may be species specific, although density may be a factor for in our study adults were caged individually while Müller et al. (1997) held the adults in group cages. Clearly, more research is required to fully understand the significance of these intersexual differences within an ecological framework and to what extent they relate to resources available to deprived adults within the context of sexual maturation (see Brévault et al. 2008).

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