Original article

Survival to starvation of the house fly, *Musca domestica* L. and blow fly, *Chrysomya megacephala* (F.)

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Abstract Flies deprived of food for 24 hours are used the most in studies of fly behaviour and suitable attractants when searching for appropriate bait. However, each fly species may tolerate starvation differently, and no study has shown survival to starvation clearly for the housefly, *Musca domestica* L. or blowfly, *Chrysomya megacephala* (F.). Therefore, this study investigated the survival to starvation of both species (3-days-old). Survival was recorded after 24, 48 and 72 hours of experimental time. The survival of male and female food-deprived *M. domestica* was significantly lower than a control group of normal-fed flies [10% (w/v) sugar solution mixed with 1.5% (v/v) multivitamin syrup]. At 24 hours, the survival of male food-deprived *M. domestica* rapidly decreased to ~2 fold lower than food-deprived females, and ~2.5 fold lower than normal-fed females. Additionally, all male and female food-deprived *M. domestica* had died at 72 hours, while most of the normal-fed flies (98-100%) were still alive. Regarding *C. megacephala*, the survival of male and female food-deprived flies was similar to that of *M. domestica*. At 24 hours, no significant difference was observed between the survival of food-deprived and normal-fed *C. megacephala* flies. In contrast, survival of food-deprived males and females decreased by more than ~60% that of normal-fed flies at 48 hours. At 72 hours, almost all of the food-deprived flies had died, whereas most of the control flies were still alive, which corresponded with flies of *M. domestica*. In conclusion, more *C. megacephala* of both sexes survived to starvation than *M. domestica* males and females, and more *M. domestica* females survived to starvation than males. These results showed that using a time span to starve flies prior to their use in experiments, particularly those for behavioral observation, would rely on the species and gender of the fly. **Chiang Mai Medical Journal 2014;53(1):1-6**.

Keywords: *Musca domestica*, *Chrysomya megacephala*, starvation, survival

Introduction

The house fly, *Musca domestica* L. and the Oriental latrine fly, *Chrysomya megacephala* (F.), are medically important pests worldwide. Their adults are not only pestiferous, but also play a role as mechanical carriers, and recently bioenhanced transmitters of many disease causing pathogens (e.g. bacteria, viruses and para-

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Received January 3, 2014, and in revised form February 13, 2014.

sites) to humans[1-3]. Several bacteria have been isolated from the adults of both species, for example, *Klebsilla oxytoca*, *Citrobacter freundii*, *Aeromonas hydrophila*, and *Burkholderia pseudomallei* from Malaysia[4] or *Escherichia coli*, *Klebsiella pneumonia*, *Enterobacter cloacae*, and *Proteus mirabilis* in Thailand[3]. Several parasitic eggs have been recovered from both species, for instance, *Ascaris*, hookworm, *Trichuris trichiura*, and *Taenia*[5]. In addition, their larvae can be myiasis-producing agents in humans and animals[6,7]. Fly control strategies regarding this situation have to be investigated and implemented in Thailand.

From the strategies considered, bait-trapping for adult flies was chosen for further investigation. Prior to field trial investigations on bait-trapping efficacy, preliminary laboratory studies were needed to determine fly behaviour and suitable attractants for fly bait-traps, in order to study house flies and blow flies deprived of food for 24-hours[8]. This approach was based on the assumption that hungry flies would be eager to search for food. Knoppien *et al*[9] observed that starved populations (from 16 to 25 hours) of the fruit fly, *Drosophila melanogaster*, were much more active than well-fed ones. Different fly species may tolerate starving in their own way; thus, the aim of this study was to assess the tolerance to starvation in *M. domestica* and *C. megacephala*, the two most abundant filth fly species in Thailand[10], and gain data for future use in bait-trapping experiments.

Methods

The *M. domestica* and *C. megacephala* used in these laboratory tests came from laboratory colonies, which were derived from specimens collected in 2000 in Chiang Mai province, northern Thailand, and had been reared for many generations in ambient temperature averaging 26.2 °C and relative humidity of 59.4%. Adults were fed with 10% sucrose solution mixed with 1.5% (v/v) multivitamin syrup (Syn-O-Vit®, Thailand), which was renewed every other day together with a periodic supply of fresh pork liver. Only 3-day-old flies were used in the experiments. Adult males and females of each fly species were separated without anesthesia and divided into two groups of normal-fed (control) and food-deprived (treated), with each group consisting of 100 flies confined in a standard cage (30x30x30 cm), screened with black net textile (25 mesh/mm^2).

Normal-fed flies were reared with sucrose and multivitamin as previously mentioned, while the food-deprived group was provided with nothing over the 72-hours experimental period. Otherwise, flies in both groups were kept in the same environmental conditions. Those that showed no response or movement after soft stimulation with the tip of pen were pronounced dead, removed from the cage and counted every

Table 1. Average body weight of (Mean±SD) *M. domestica* and *C. megacephala* flies

Weight**	*M. domestica**		*C. megacephala**	
	Male (Mean±SD)	Female (Mean±SD)	Male (Mean±SD)	Female (Mean±SD)
W0	0.01054±0.00174^{a} (n = 50)	0.01154±0.00172^{a} (n = 50)	0.03995±0.00422^{a} (n = 51)	0.03950±0.00580^{a} (n = 40)
W1	0.00562±0.00156^{b} (n = 76)	0.00775±0.00150^{b,d} (n = 30)	0.02729±0.01352$^{b, e}$ (n = 8)	0.02200±0.00200$^{b, e, f}$ (n = 3)
W2	0.00663±0.00189^{c} (n = 16)	0.00586±0.00182^{c,d} (n = 45)	0.02135±0.00545$^{c, e}$ (n = 74)	0.01985±0.00402$^{c, e}$ (n = 84)
W3	ND	ND	0.01916±0.01089^{d} (n = 19)	0.01585±0.00483$^{d, f}$ (n = 23)

ND = Not Determined

* Within the same columns, means different superscript letters that vary significantly (One-Way ANOVA; $P < 0.05$). Unit of body weight in grams.

** W0 = Initial weight, W1, W2, W3 = Weight of dead flies collected at 24, 48 and 72 hours, respectively.

24 hours until 72 hours were completed. All experiments were done in triplicate on different occasions. Percentage survival was calculated as 100 minus the total number of dead flies. Student's t-tests and version 10.0 of the SPSS software package (SPSS for Windows; SPSS, Chicago, IL) were used to determine the significance of survival differences found between the treated and control groups.

The body weight of flies during 3 days of starving also was assessed. Flies used in assessment of body weight were from the starvation group population. When being weighed, they were anesthetized with ether in a 50-mL test tube; and then, each one was weighed individually using a digital decimal scale (Shinko Denshi, Japan). Average body weight was calculated and defined as the initial weight (W0), on the first day of starving, and those weighed at 24, 48 and 72 hours were defined as W1, W2 and W3, respectively. Differences in body weight of the flies were analyzed by one-way analysis of variance (ANOVA), with variations among the groups determined by the Duncan's multiple range test (SPSS for Windows; SPSS, Chicago, IL).

Results

Figure 1 shows the results of survival from 3-days of starving *M. domestica* males and females. At 24 hours, the percentage survival of food-deprived males and females was 27.00% and 62.67%, respectively, which was significantly lower than that recorded for normal-fed flies (Student's t test; $p < 0.05$). This also indicated that ~2 fold more females survived than males after 24 hours of starving. In contrast, the survival rate of food-deprived flies decreased dramatically after 48 hours, with 0.33% of males and 6.67% of females dead of starvation at 72 hours. On the other hand, 98.67 to 99.67% of normal-fed flies were alive and active, respectively, after 72 hours of observation.

Figure 2 shows the survival of *C. megacephala* after 3 days of starving. Starving for 24 hours did not lead to any statistically significant decreases in living male (95.0%) or female flies (94.67%) (Student's t test; $p > 0.05$); however, a drastic reduction in flies that survived occurred after starving for 48 hours in the case of both males (40.33%) and females (42.33%) (Student's t test; $p < 0.05$), which indicated ~60%

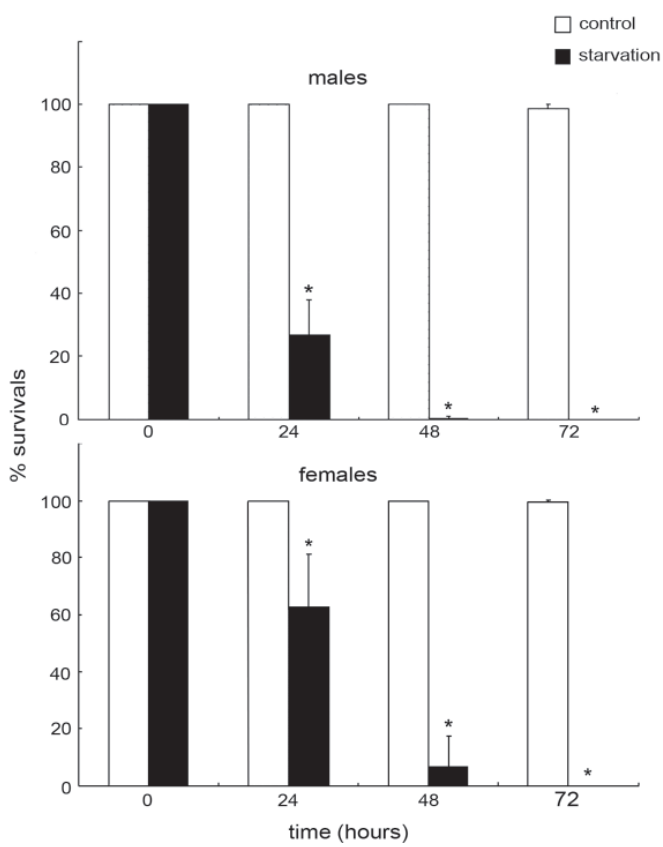

Figure 1. Percentage of surviving *M. domestica* to starvation.
*Significant difference ($p < 0.05$)

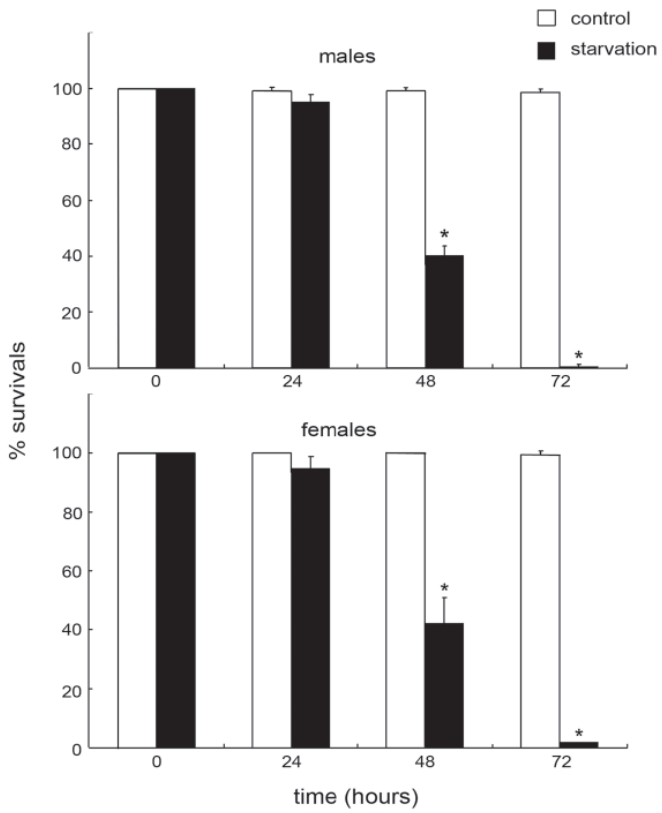

Figure 2. Percentage of surviving *C. megacephala* to starvation.
*Significant difference (p <0.05)

decreased survival when compared to normal-fed flies. Only 0.33% of male and 2.00% of female food-deprived flies had survived at 72 hours, but even they lay inactive on the floor of the cage. Most of the control flies (98.67-99.33%) were alive and active at 72 hours, which was similar to *M. domestica*.

The body weight of flies dropped consistently in both species during 72 hours of starving. The average initial body weight (0.01054 g) of male *M. domestica* dropped significantly at 24 hours (0.00562 g) and 48 hours (0.00663 g) of starving. Likewise, the initial body weight (0.01154 g) in females dropped markedly at 24 hours (0.00775 g) and 48 hours (0.00586 g). A similar trend of decreasing body weight was found in *C. megacephala*. The body weight decreased continually from an initial 0.03995 g and 0.03950 g to 0.01916 g and 0.01585 g for male and female flies, respectively, after starving for 72-hours.

Discussion

These results indicated that fewer males survived to starvation than females, as observed in *M. domestica*. A similar finding was noted in the mean life span of houseflies reared in the laboratory; i.e., 17 days for males, 29 days for females (at 25°C, 45% RH)[11]. This might be because male flies utilized most of their energy for mating behavior, beginning at the day after emergence (minimum 18 hours)[11]; thus, they were less able to maintain energy reserves for other aspects of life. This phenomenon agreed with experiments on the fleas, *Xenopsylla conformis* and *Xenopsylla ramesis*[12], where male survival was shorter than that of females[12], but a veritable reason for this is unknown.

In comparing the two species used in this study, *M. domestica* and *C. megacephala* tolerated starving differently. However, they displayed a similar trend for utilizing stored nutrients to compensate for their normal daily food uptake.

The body weight data taken during the starvation period indicated that in both species males compensated for their diet less than females did. Survival to starvation of the mosquito, *Aedes aegypti* (Diptera: Culicidae), was the function of accumulating reserves, mainly lipids, which probably resulted from a history of food availability[13]. Besides, stored nutrients might be utilized when weight is decreased through possible water loss or the dehydration process. In the current result, the mystery remains of why body weight loss was higher after starving for 48 hours than that after starving for 24 hours in male *M. domestica*. Water is lost from insects via three routes; transpiration through the cuticle, diffusion through open spiracles, and excretion [14]. Furthermore, water is an essential nutrient that is a major part of insect tissue, and necessary for all bodily functions[15]. Thus, water should be provided for starving flies in future laboratory tests in order to prevent dehydration and possibly reduce the number of dead flies, especially in *M. domestica*. It should be noted that most control flies of *M. domestica* and *C. megacephala* were alive and appeared healthy during the observation periods of this study. This suggests that the diets (10% sucrose solution mixed with 1.5% multivitamin syrup) provided to adult flies were sufficient for the healthy survival of fly colonies, as previously reported[11,16].

In conclusion, more *C. megacephala* of both sexes survived to starvation than those of *M. domestica*, and more female *M. domestica* survived to starvation than males. This information could be useful in future experiments using flies as an animal subject, particularly in behaviour or fly control experiments of *M. domestica* and *C. megacephala*.

Acknowledgement

This work received support from the Faculty of Medicine, Chiang Mai University. There is no conflict of interest.

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การรอดชีวิตต่อการอดอาหารของแมลงวันบ้าน *Musca domestica* และแมลงวันหัวเขียว *Chrysomya megacephala*

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บทคัดย่อ ในการศึกษาพฤติกรรมและเหยื่อล่อที่เหมาะสมสำหรับดึงดูดแมลงวัน มักใช้แมลงวันที่อดอาหารนาน 24 ชั่วโมง อย่างไรก็ตามแมลงวันแต่ละชนิดมีความทนต่อการอดอาหารได้ไม่เท่ากัน และยังไม่มีรายงานถึงความรอดชีวิตของแมลงวันบ้านและแมลงวันหัวเขียว *C. megacephala* เมื่ออดอาหาร วัตถุประสงค์นี้เพื่อศึกษาการรอดชีวิตของแมลงวันทั้งสองชนิดที่อายุ 3 วัน เมื่ออดอาหารนาน 24, 48 และ 72 ชั่วโมง พบว่าแมลงวันบ้านที่อดอาหารทั้งเพศผู้และเพศเมียตายมากกว่ากลุ่มควบคุมที่ให้อาหารคือสารละลายน้ำตาลร้อยละ 10 รวมกับวิตามินร้อยละ 1.5 เมื่ออดอาหารนาน 24 ชั่วโมง แมลงวันบ้านเพศผู้ตายมากขึ้นประมาณ 2 เท่า เมื่อเปรียบเทียบกับเพศเมียที่อดอาหารนาน 24 ชั่วโมง และคิดเป็นประมาณ 2.5 เท่าเมื่อเปรียบเทียบกับเพศเมียที่ให้อาหารปกติ อย่างไรก็ตามทั้งเพศผู้และเพศเมียตายหมดเมื่ออดอาหารนาน 72 ชั่วโมง ในขณะที่กลุ่มที่ให้อาหารปกติมีการรอดชีวิตสูงถึงร้อยละ 98-100 ส่วนในแมลงวันหัวเขียวพบว่าทั้งเพศผู้และเพศเมียรอดชีวิตเมื่ออดอาหารนาน 24 ชั่วโมงได้ใกล้เคียงกัน อย่างไรก็ตามเมื่ออดอาหารนาน 48 ชั่วโมง ทั้งสองเพศตายเพิ่มขึ้นประมาณร้อยละ 60 ของกลุ่มที่ได้รับอาหารปกติ ส่วนการอดอาหารนาน 72 ชั่วโมงแมลงวันหัวเขียวตายหมด เมื่อเปรียบเทียบระหว่างแมลงวันทั้งสองชนิด สรุปได้ว่าแมลงวันหัวเขียวรอดชีวิตได้มากกว่าแมลงวันบ้านเมื่อไม่มีอาหาร และแมลงวันบ้านเพศเมียรอดชีวิตได้ดีกว่าเพศผู้ ดังนั้นในใช้แมลงวันที่อดอาหารเพื่อการทดลองต่าง ๆ โดยเฉพาะอย่างยิ่งการศึกษาถึงพฤติกรรม ควรคำนึงถึงชนิดของแมลงวันและเพศ **เชียงใหม่เวชสาร 2557;53(1):1-6.**

คำสำคัญ: แมลงวันบ้าน แมลงวันหัวเขียว การรอดชีวิต อดอาหาร