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Correlation between wing measurements and dry body weight in male and female *Ochlerotatus (Ochlerotatus) caspius* (Pallas, 1771) (Diptera: Culicidae).

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Abstract

The correlation between wing size and dry body weight in male and female *Ochlerotatus caspius* (Pallas, 1771) was studied in the laboratory. Wing size was estimated using wing length (mm), wing width (mm) and by crudely estimating wing surface (wing length x wing width (mm^2)). The relationship between wing size (area) and body weight was significant and positive. Wing length was longer in males than females, but wing width and total wing surface area were higher in females than males.

Key words: *Ochlerotatus caspius*, body weight, wing length, wing width, wing area

Introduction

Fecundity is a major life history trait often used as measure of mosquito fitness. Wing size reflects body size, which is related to survival and reproductive success (Nasci, 1986; Clements, 1992). To study the effects of intra- and inter-specific competition or to describe population dynamics, estimates of fecundity are often based on measurements of body size (Armbruster & Hutchinson, 2002). The accuracy of these measurements can have important consequences for these estimates. For example, mosquito weight can sometimes give unreliable results due to different factors such as gravidity or recent intake of blood meal (Siegel *et al.*, 1994). Wing length is used to estimate body weight because it is easily measured and is a relatively stable character (Siegel *et al.*, 1994). For most species, wing length is greater for females than for males (Nasci, 1990; Agnew *et al.*, 2000, 2002).

Ochlerotatus caspius (Pallas, 1771) (previously *Aedes caspius*, see Reinert, 2000) is widely distributed in Europe (Gabinaud, 1975) and occupies a variety of larval habitats, including salt marshes and rice fields (Rioux, 1958). This species is a ferocious biter and a pest of great economic importance, resulting in the closure of schools and civil engineering enterprises and interference with grape harvests (Becker *et al.*, 2003). As it has been reported that in *Stegomyia aegypti* (L.) (previously *Aedes aegypti,* see Reinert *et al.,* 2004), *Stegomyia albopicta* (Skuse) (previously *Ae. albopictus,* see Reinert *et al.,* 2004), *Oc. triseriatus* (Say) (previously *Ae. triseriatus, see* Reinert, 2000), *Culex quinquefasciatus* Say and *Cx. salinarius* Coquillet, wing lengths of females are longer than in males (Nasci, 1990; Agnew *et al.*, 2000, 2002), it was expected this would also be true for *Oc. caspius*. However, preliminary analysis generated unexpected results - wing length in *Oc. caspius* is greater in males than females.

To verify this observation, the experiment was re-run, also measuring additional characters including body weight (µg) and wing width (mm) of *Oc. caspius*. The wing surface area (mm^2) was also coarsely estimated by

Wing characters	r²	Source	Estimate	t-value
Wing length	0.77	Intercept female	1.846	19.914***
		Intercept male	2.067	10.539***
		Slope (body weight)	0.0018	7.879***
		Interaction (sex: body weight)	NA	3.409$^{ns\ a}$
Wing width	0.89	Intercept female	0.609	15.859***
		Intercept male	0.503	12.245***
		Slope (body weight)	0.0005	5.858***
		Interaction (sex: body weight)	NA	0.414$^{ns\ a}$
Wing surface area	0.76	Intercept female	1.004	7.077***
		Intercept male	0.891	-3.518**
		Slope (body weight)	0.0029	8.072***
		Interaction (sex: body weight)	NA	0.039$^{ns\ a}$

Table 1: ANCOVA results of the relationship of wing measurements (wing length, wing width and wing surface (length x width) as a function of body weight and sex. ns ($p > 0.05$); *($p < 0.05$); **($p < 0.01$); ***($p < 0.001$). [a] F-value of the interactions was calculated using ANCOVA.

multiplying the wing length and the wing width. Regressions between these three wing characters and body weight for both males and females were calculated and compared.

Materials and methods

During the summer of 2006, soil samples were collected from a known *Oc. caspius* breeding site in the Rhône delta in southern France to obtain eggs for rearing in the laboratory. Sampling was carried out using vegetation as an indicator of egg biotopes (Gabinaud, 1975). Ascorbic acid was used to initiate egg hatching (Sinègre, 1974) and larvae were reared to adult stage in the laboratory at 28.4 ± 0.3°C, 52 ± 0.7% RH and 16:8 L:D.

One day after emergence, 20 unfed adults of each sex were killed, transferred to individual 1.5 ml plastic vials, dried at 60°C for at least 12 h, and weighed to a precision of ± 1 µg using a Mettler Toledo MX5 balance (Mettler-Toledo GmbH, Greifensee, Switzerland). Subsequently, the left wing was removed, and its length (from the axillary incision to the wing tip) and maximum width were measured using a stereomicroscope (Zeiss Stemi 2000C) coupled with the measurement software Ellix™ (Microvision instruments, France). The normality of the body weight, wing length, wing width and wing surface (length x width) were tested using the Shapiro-Wilk test (Zar, 1999). Analysis of covariance (ANCOVA) (Zar, 1999) was used to assess the regression between body weight and each wing measurement according to sex. Male and female body sizes were compared with a t-Test (Zar, 1999). All statistical analyses were done using R 2.4.0 software (R Development Core Team, 2005).

Results and Discussion

Body weight, wing length, wing width and wing surface were normally distributed (Shapiro-Wilk test, $n = 40$, $p = 0.158, 0.771, 0.157, 0.692$, respectively). The slopes of the regression for body weight and each wing measurement (length, width and area) were all significant and positive (ANCOVA, $p < 0.01$; Table 1, Figure 1a-c). Moreover, as the interactions between sex and body weight were not significant, the slopes between males and females were not significantly different. Hence, an increase in wing size denoted an equivalent increase in body weight in males and females.

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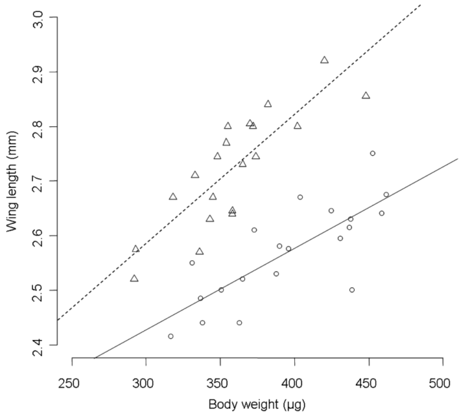
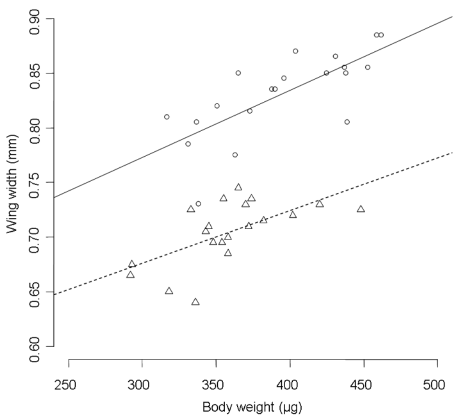
(a)



(b)



(c)

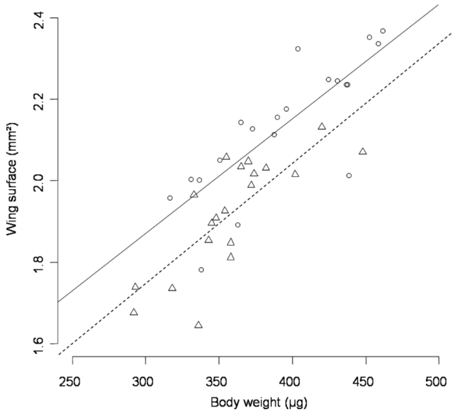


Figure 1: Regression of wing measurements as a function of dry body weight (µg) for males (triangle, dashed line) and females (circle, solid straight line); a) wing length (mm), b) wing width (mm), c) wing surface (wing length x wing width) (mm^2). Regressions presented in each figure were calculated for each sex separately.

The intercepts of wing length, wing width and wing surface area in *Oc. caspius* were different between the sexes (Table 1). The wing length intercept was significantly higher for males than for females (Figure 1a). Therefore for the same body weight, the wing length of male *Oc. caspius* is greater than for females. The intercepts of wing width and wing surface were significantly higher for females than for males (Table 1). Therefore for the same body weight, the wing width (Figure 1b) was significantly larger for females than that for males, and female wing surface was significantly greater than for males (Figure 1c).

Nasci (1990) noted that the slopes of the regression between wing length and body weight were significantly different between the two sexes for three mosquito species reared in the laboratory (*St. aegypti*, *St. albopictus*, and *Cx. quinquefasciatus*) and for five species collected in the field (*St. aegypti*, *St. albopictus*, *Oc. triseriatus*, *Culex quinquefasciatus*, *Cx. salinarius*). Results presented here for *Oc. caspius* were different, and suggest that wing length is not always greater in females. Although the relatively low replicates (n=40) used in this experiment could be criticized, the high r^2 of the ANCOVA suggests that regression values will probably not be altered by increasing the number of replicates, thus use of wing length alone to estimate body size should be used with caution in previously unstudied species

Wing surface area was greater in female *Oc. caspius* than in males, but the converse was true for wing length in contrast to previous studies (Nasci, 1990; Agnew *et al.*, 2000, 2002). As the body weight of the females were significantly higher than the males (t-Test, $p < 0.01$), these results suggest that using wing length alone to estimate body size, may give unreliable results. The results herein suggest that even a crude estimate of wing surface area is a better estimate of body size than wing length alone, perhaps because the former gives a better picture of wing lift. When comparing intra-sex or intra-species, the wing length may appear reliable, but this study shows that changes in wing shape between sexes or species mean that wing lift (and therefore maximum body size) may are better estimated by using surface area.

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