



Sexual Dimorphism in the Dark-Winged Damselfly *Calopteryx Maculata*

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Abstract

Pronounced sexual dimorphisms are suggestive of sexual selection. In *Calopteryx maculata*, a pronounced sexual dimorphism is seen in the degree of wing pigmentation; males have significantly darker wings than females. Territoriality in *C. maculata* makes it difficult to discern the function of sexual dimorphism. Previous studies have suggested that the degree of male wing pigmentation in a related species *Calopteryx haemoroidalis* may serve as a sexual signal to females or other males indicating their genetic quality. Various studies have shown that males of the species *C. haemoroidalis* with a higher degree of wing pigmentation are more likely to defend a territory, obtain more matings, have fewer gut parasites, and have larger fat reserves. In contrast, we found that there is no correlation between the degree of wing pigmentation and male mating or territorial success in *C. maculata*. We found that females were selective of territories but not of males. Our results suggest that the degree of wing pigmentation may play a role in species recognition by females.

Introduction

The spatial and temporal distribution of resources is a major determinant of mating systems. Territoriality is a male response to this sort of uneven distribution of resources and results in two forms of sexual selection based on female mate choice. Females may choose their mates indirectly based on the quality of their territories or directly by honest signals reflecting the male's genetic composition. Both of the above means of female mate choice can lead to sexual dimorphism, which is the existence of physical differences between males and females of the same species.

Sexual dimorphism can function as a sexual signal either in species recognition or as an indicator of male phenotype. Therefore, measuring the effect of sexual dimorphisms on mating success and behavior is key to understanding the dynamics of sexual selection and

mating systems. If the sexual dimorphism is a result of sexual selection, then variation in sexually dimorphic traits should have an effect on mating success. One example is the damselfly *Calopteryx maculata*, in which males have varying degrees of wing pigmentation, body size, and color. Our purpose is to investigate whether the sexually dimorphic wing pigmentation of *C. maculata* functions as a sexually selected signal to females.

Calopteryx maculata is a dark-winged stream damselfly that exhibits sexual dimorphism, territoriality, and post-copulatory guarding due to sperm competition. The males defend discrete clumps of aquatic vegetation in areas of fast flowing water that females need in order to deposit their eggs. Females also benefit from an energetic male to guard them while ovipositing [1].

Studies of a related species *C. xanthostoma* have shown that degree of wing pigmentation is heritable, correlates directly with the size of fat reserves, and is inversely related to the number of parasites hosted. This suggests that wing pigmentation is an honest signal of physical health [2,3].

We are interested in investigating whether degree of wing pigmentation is an honest indicator of male quality in *C. maculata* and whether it correlates with both mating and territorial success of males.

Materials and Methods

We recorded all observations of the natural population of *C. maculata* in July 2004 along the east branch of the Maple River in Cheboygan County, Michigan. Data collected on site consisted of male mating success, male-male interactions, territory characteristics, and territoriality. First, we captured male *C. maculata* with insect nets, marked them with a gold paint-pen, and then released them. We then plotted out ten observable territories based on the uneven distribution of local vegetation on the bank of the river. The start and end times for the recording of the following data for all the damselflies in each territory were noted: male number,

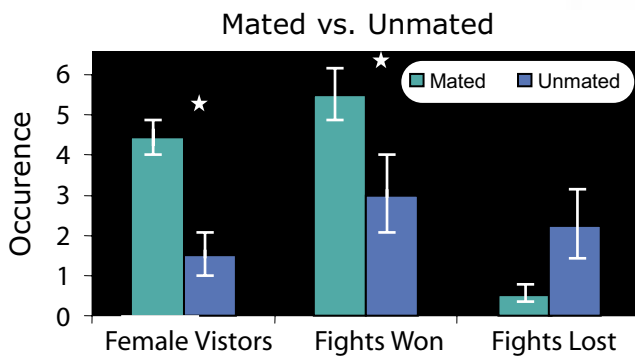


Figure 1: Male damselflies who mated vs. male damselflies who did not mate are compared in three categories: occurrence of female visitors, occurrence of fights won, and occurrence of fights lost.

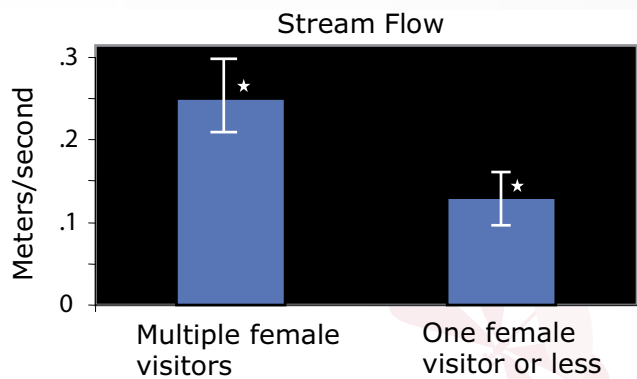


Figure 2: Males with multiple female visitors are compared to males with one female visitor or less. Males with multiple female visitors were, on average, found in areas of higher stream flow.

location (territory number), height of male above water when first observed, number of female visitors to specific male's territory (if dominance of territory is clearly established), number of copulations, fights won, and fights lost. All observed damselflies were captured, scanned for degree of wing pigmentation, weighed, and measured for forewing length and width and abdomen length. Males were then released at our site on the Maple River.

After scanning all the observed male damselflies, actual-sized black and white scans were ranked in order of wing pigmentation from lightest to darkest. Rankings were repeated by the same group of people and an average value for each male was recorded. Separate rankings were shown to be highly correlated, as expected ($r^2 = .81$). Tabulations from the original data taken on site included total fights and wing area.

After data on marked males were collected, we recorded information on all observed territories. Observations included territory length, width, area, substrate level (vegetation on which to oviposit), territory shape, substrate density (low, medium, or high), and flow rate.

Using the statistical software SPSS, data of mated/non-mated, fought/not-fought, and high/low pigment were compared.

Results

Male damselflies visited by females more than once had significantly more copulations ($p = .001$, $t = -4.00$), and their territories had a faster river flow ($p = .036$, $t = -2.294$) and higher vegetation density ($p = .006$, $t = -3.161$). Males who fought at least once had significantly shorter forewing lengths ($p = .01$, $t = 2.765$), lighter wing pigmentation ($p = .024$, $t = -2.376$), and territories with a higher density of vegetation ($p = .041$, $t = -2.149$). Mated

males (defined as males who were observed in copulation with a female on at least one occasion) had significantly more visits from females ($p = .004$, $t = -3.316$), won more fights ($p = .043$, $t = -2.15$), held slimmer territories ($p = .055$, $t = -2.052$) that were smaller in area ($p = .029$, $t = 2.366$), and held territories with greater density of substrates ($p = .014$, $t = -2.738$). Mated males were also observed to follow a trend of losing fewer fights than unmated males ($p = .066$, $t = 1.937$). The fifteen males that were ranked the darkest in wing pigmentation were, on average, significantly heavier ($p = .005$, $t = 2.954$), had larger forewing lengths ($p = .031$, $t = 2.219$) and larger wing areas ($p = .03$, $t = 2.237$) as compared to the twenty lightest males.

Ten damselflies sampled from the study site revealed no parasites upon dissection.

Discussion

Females of *Calopteryx maculata* showed no preference with respect to degree of male wing pigmentation. This contrasts the findings that wing pigmentation in the sister species *Calopteryx haemorrhoidalis* evolved via sexual selection [2]. Females did display preferences for territories with certain characteristics such as high substrate density and faster flow rates, but males defending those territories were not significantly different in wing pigmentation from the rest of the male population. This suggests that the sexual dimorphism seen in *C. maculata* cannot be explained by either direct female mate choice based on male phenotype or indirect female mate choice based on territory quality.

Our finding that males' ability to fight was correlated with mating success but not with wing pigmentation suggests that wing pigmentation does not serve as an intra-sexual signal communicating a male's fighting ability to other males. These findings are supported

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by the fact that a sample of the population dissected for an intestinal parasite known to affect fat reserves in *C. xanthostoma* showed no evidence of infection. Marden and Waage found that the difference in fat reserves among males is the best predictor of the outcome of a fight [4]. Siva-Jothy documented that parasite load was inversely proportional to both wing pigmentation and fat reserves [3]. Since parasites are not limiting the acquisition of energy during foraging, it is unlikely that differences in fat reserves resulting from parasitic infection explain differences in fighting ability.

An alternative explanation for the sexual dimorphism in wing pigmentation exhibited by *C. maculata* supposes that darker male wings aid in species recognition by females. Such species recognition is observed between *C. splendens* and *C. virgo* [5]. At our study site, another closely related species *C. aequabilis* was present. Since similar courtship displays are expressed and unproductive interspecific matings are known to occur, selection against these matings should occur [2]. Cordoba-Aguilar suggests that females might use degree of wing pigmentation to identify conspecific males [2]. This is supported by the finding that the sexually dimorphic wing patterns of *C. aequabilis* differed more in sympatry than allopatry [4].

Complicating our ranking of male wing pigmentation was the fact that we did not have access to computer software capable of ranking pigmentation as was done by Siva-Jothy in 2000 with *C. xanthostoma*. While repeated rankings were correlated ($r^2=.81$), it is important to note that subjective rankings such as those carried out by human beings inherently carry a potential bias. Secondly,

even if degree of pigmentation was accurately assessed, it is unclear whether possible selection on wing pigmentation would be based on overall degree of pigmentation or uniformity of the distribution of pigment.

In order to discern the exact function of the pronounced sexual dimorphic wings of males in *C. maculata*, more investigation is needed. It is important that all possible functions of sexually dimorphic wings, as outlined in our study, be thoroughly explored before concluding the mechanism by which sexually dimorphic wings evolved and persist in the population of *C. maculata*.

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