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Effects of size on dominance behavior in male fiddler crabs, *Uca pugnax*



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Abstract

Individuals in many group-living species form dominance hierarchies, and higher ranked individuals have more access to resources or mates. Rank often depends on size. Dominance rank is settled quickly between different-sized individuals, but animals that are similar in size exchange behaviors that escalate until one individual withdraws. Dominance displays in male fiddler crabs include waving the large claw and arm wrestling. My objective was to determine if dominance behavior between male fiddler crabs varies between pairs that are similar or different in size. Because size can indicate dominance for fiddler crabs, I predicted that pairs of different-sized crabs would spend more time waving and less time fighting compared to similar-sized crabs. I obtained 10 male fiddler crabs and paired each individual with a similar-sized partner and a different-sized partner. I observed each crab with its partners for 10 min in a neutral arena and recorded display behavior. Different-sized partners tended to spend more time waving than similar-sized partners. However, time spent waving, fighting, or performing other behaviors did not differ. These results did not support my predictions, probably due to the small sample size. I can conclude that behaviors between similar-sized males did not escalate any more than behaviors between different-sized male behaviors.

A. Introduction

Dominance refers to the advantage one individual has over another in obtaining resources, and it is measured by how often an individual submits during social interactions (Bland, 2002). Many group-living species form dominance hierarchies, and higher ranking individuals gain more access to resources and mates (Alcock, 2013). Dominance hierarchies frequently depend on size, with the largest individuals as the highest-ranking members (Moyano, et al., 2016). Size often correlates with strength, so larger individuals tend to win contests. When opponents are more equal in size, they are more evenly matched in strength and test each other by escalating to a physical encounter (Arnott & Elwood, 2009). In fiddler crab males, smaller individuals attempt to avoid disputes with larger crabs, but they are more likely to fight with individuals of similar size (Arnott & Elwood, 2009).

Fiddler crabs live in burrows near the water line (University of Rhode Island, 1998). Males wave their enlarged claw to attract mates or to defend burrows (Yamaguchi & Tabata, 2004). Fiddler crabs are a good choice for this study because they form dominance hierarchies to obtain burrows (Moyano, et al., 2016). They display dominance behaviors (waving and arm wrestling) while claiming territory (Yamaguchi & Tabata, 2004), and size predicts the outcome of interactions (Moyano, et al., 2016).

Objective:

To determine if duration of dominance behaviors, particularly waving displays and fighting, varies between crabs depending on the size of their opponent.

Predictions:

- 1) Pairs of different-sized crabs spend more time waving than similar-sized crabs because fiddler crabs use size to assess strength, and males are unlikely to escalate conflicts with crabs that are significantly larger or smaller because it is not worth the energy expenditure (Arnott & Elwood, 2009)
- 2) Pairs of similar-sized crabs fight more often than different-sized crabs because equally matched opponents cannot use size to assess strength, and thus must escalate to physical encounters to determine dominance (Arnott & Elwood, 2009).

B. Methods

Crab Housing:

I set up 10 isolation tanks to house crabs individually. Each tank measured 19 × 19 × 11 cm and contained sand and brackish water in a beach-like layout, with a thermometer. Five tanks contained a filter at any time. I observed contests between crabs in a neutral arena tank, which measured 26 × 16 × 17 cm and contained sand and a petri-dish sized dish of brackish water to keep crabs hydrated.

Data Collection:

I conducted 2 trials for each male. To keep track of individuals, I marked their shells uniquely with nail polish corresponding with a number written in that color on their isolation tanks. Each crab performed each trial once and only one trial per day. Crabs were matched with one similar-sized (body size ≤ 0.3 cm difference, claw size ≤ 0.5 cm difference) and one different-sized (body size ≥ 0.3 cm difference, claw size ≥ 0.5 cm difference) partner to avoid repeating trials with the same individual. Trials (similar or different size) were chosen at random. I observed both males continuously and used a stopwatch to record time in seconds that the individual spent waving, fighting, or performing other behaviors such as walking and exploring.

Data Analysis:

I analyzed data with Wilcoxon ranked-sign tests using JMP 12.2 (SAS Institute, Inc., 2015) with a significance level of 0.05.



A trial between two similar-sized males

C. Results

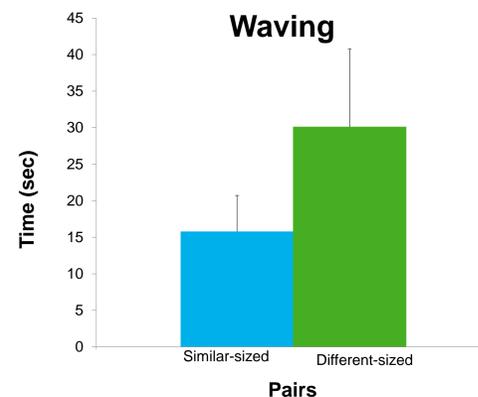


Fig. 1: Mean (+SE) time spent waving by pairs of similar-sized and different-sized fiddler crab males

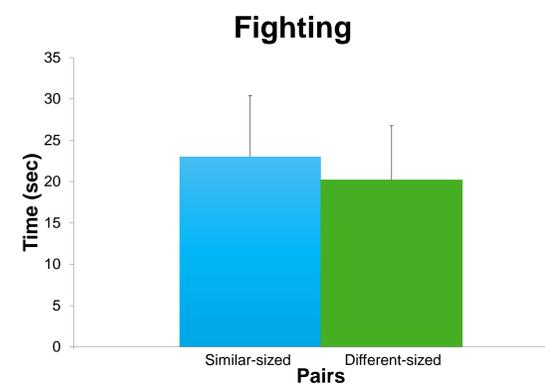


Fig. 2: Mean (+SE) time spent fighting by pairs of similar-sized and different-sized fiddler crab males

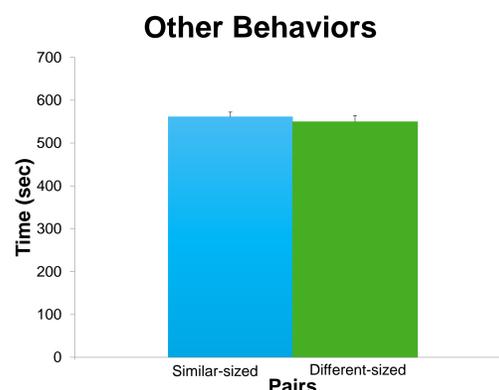


Fig. 3: Mean (+SE) time spent performing other behaviors (including walking, foraging, and exploring) between pairs of similar-sized and different-sized males

Similar and different sized males did not differ in the amount of time spent waving ($S = 9.0$, $n = 10$, $P = 0.36$, Fig. 1), fighting ($S = -6.0$, $n = 10$, $P = 0.65$, Fig. 2), or performing other behaviors ($S = -5.0$, $n = 10$, $P = 0.57$, Fig 3), where other behaviors included walking, exploring, and foraging.

D. Discussion and Conclusion

Pairs of different-sized crabs tended to spend more time waving than pairs of similar-sized crabs, but the results were not statistically significant. Claw displays are a way to assess strength of the opponent (Arnott & Elwood, 2009). Different-sized pairs had a difference in size large enough that males could assess strength and settle dominance interactions using waving displays without escalating to a fight, which allows them to reduce risk of injury and save energy.

Similar-sized crabs had a non-significant tendency to spend more time fighting than different-sized crabs. These males were closer in size, so the claw display was not always a clear indication of strength. These pairs tended to escalate their displays to fights. Perhaps a larger sample size would have given results that were statistically significant because males tended to display behaviors the way I predicted.

The amount of time that males performed other behaviors, including walking, exploring, and foraging, did not differ. This result was expected because neither male performed a behavior to which the other male must respond.

In conclusion, escalations between similar-sized males did not occur more often than between different-sized males. I believe these results were due to a small sample size, because the crabs' behavior tended to follow my predictions. Future studies should use a larger sample size. This study was a good start in determining how size affects dominance displays between male fiddler crabs because, despite the small sample size, males tended to follow a predictable pattern of displays and fighting.

Acknowledgements

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