

Size and Sex Constraints in Self-Uprighting in Western Hermann's Tortoise *Testudo hermanni* (Gmelin 1789)

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Abstract

Self-righting occurs when the animal rights itself after been overturned on the back, a phenomenon far more pronounced in males than females, as belligerent males often try to flip opponents over during fights for territorial contests. It is said that bigger tortoises struggle to right themselves more than smaller tortoises. Here we studied experimentally this self-righting behaviour in western Hermann's tortoise (*Th hermanni*) in a sample of 30 adult specimens (17 males and 13 females). Body length (lineal distance of plastron) and body weight were obtained at the same time of the experiment. There appeared statistical differences in up-righting time differences between sexes, being those of male are shorter ($0.94' \pm 0.88$ and $1.45' \pm 1.12$ for males and females respectively). This time was also correlated with body length but not with body weight. The body length probably is limited to a certain size in order to avoid excessive up-righting periods.

Keywords: Asymmetry • Lateralization • Testudines • Turtles

Introduction

Tortoises can easily lose their balance and fall on their rounded backs, their feet flailing in the air. When overturned, they can be exposed to suboptimal environment conditions, starvation or predation, thus, self-righting has a vital importance [1]. Self-righting behaviour of turtles has been studied recently [2-6]. It seems that overturning is a phenomenon far more pronounced in males than females, as belligerent males often try to flip opponents over during fights for territorial rights. Equally, bigger individuals struggle to right themselves more than smaller ones.

Here we studied self-righting behaviour in western Hermann's tortoises (*Testudo hermanni*). Hermann's tortoises are small to medium sized tortoises that live in southern Europe [7-9], with adult males being smaller than females. Two subspecies are currently recognized [9]: the western Hermann's tortoise [2] and the eastern Hermann's tortoise (*T. h. boettgeri*) [1].

Materials and Methods

A sample of 30 adult specimens of western Hermann's tortoise (*Th hermanni*) (17 males, 279 g-927 g body weight, 8.8 g-14.5 g carapace length; 13 females, 110 g-1428 g body weight, 7.7 g-17.0 g carapace length) from Centre de Reproducció de Tortugues de l'Albera, in Catalonia (Spain) have been. For three times each individual was placed on its back on a flat and non-slippery surface and then measuring how much time they spent to recover. Body length (lineal distance of plastron) and body weight were obtained at the same time of the experiment. Second author was responsible of this part.

As distribution for sexes was not neither normal (Shapiro Wilk $W=0.846$; $p < 0.001$) nor equal shaped (Kolmogorov-Smirnov for equality of variances $D=0.295$; $p=0.026$) a NPMANOVA (Non Parametric Multivariate Analysis Of Variance) with Mahalanobis distance was done to evaluate up-righting time differences between sexes and a linear fit (log-transformed values)

was applied to correlate metric traits to up-righting time. For this fit we used algorithm was Reduced Major Axis (RMA). Finally, it was done a one way ANCOVA test (ANalysis of COVariance, up-righting time as dependent variable and body length as covariate) to determine if the slopes of the regression lines for both sexes differed.

Analysis were done with PAST v. 2.17c software (Hammer, Harper, and Ryan, 2001). P values less than 0.05 were considered as statistically significant.

Results and Discussion

NPMANOVA reflected statistical differences in up-righting time differences between sexes ($F=5.912$; $p=0.016$), being those of males shorter ($0.94' \pm 0.88$ and $1.45' \pm 1.12$ for males and females respectively) (Figure 1). The linear fit (log-transformed values) was positive and highly significative for body length ($p < 0.0001$) but not for body weight. ANCOVA reflected equality of adjusted means in the two groups ($F=1.553$; $p=0.216$), but equality of slopes could be rejected ($F=4.248$; $p=0.042$), with no discontinuities or clear indications of inflection points in the datasets (Figure 2). The righting time does not diminish in relation to body length showing isometric growth indicating that righting time might continue to increase according to the size.

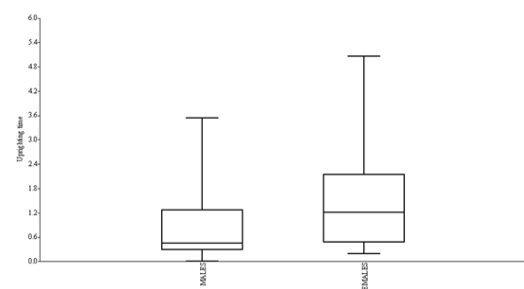


Figure 1. Boxplots for up-righting time (in minutes) between sexes for a

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Received date: 09 April, 2021; **Accepted date:** 23 April, 2021; **Published date:** 30 April, 2021

sample of 30 adult specimens of *Testudo h. hermanni* (17 males, and 13 females). For each sample, the 25-75 percent quartiles are drawn using a box. The median is shown with a horizontal line inside the box. The minimal and maximal values are shown with short horizontal lines ("whiskers").

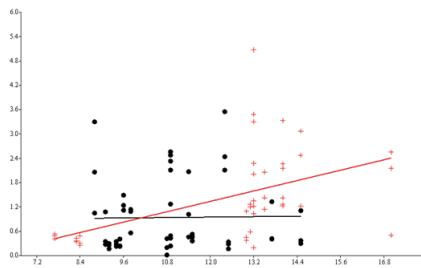


Figure 2. ANCOVA (ANalysis of COVariance) between body length and up-righting time for 30 adult specimens of *Testudo h. hermanni* (17 males, and 13 females). Test reflected equal adjusted means in the two groups could not be rejected at $p < 0.005$ ($F = 1.553$; $p = 0.216$), but equality of slopes could be rejected ($F = 4.248$; $p = 0.042$). There are no discontinuities or clear indications of inflection points in the datasets. Crosses for males and dots for females.

Conclusion

Smaller males are more agile, and their greater mobility allows them to find and mate with more females. But they also fight each other, by actively attempting to flip their rivals onto their backs. So, there is a constraint of size, as larger tortoises are likely to win fights at the same time, as it has been demonstrated in this study the ANCOVA revealed heterogeneous slopes, suggesting that sexes experience different time in self-up righting, but their self-up righting time will be bigger. In brief, in Hermann's tortoises of the Mediterranean size and sex matter, but with limitations.

Authors' Contributions

Authors declare that there are no competing interests regarding the

publication of this paper. There were no funders in study design, data collection and analysis, decision to publish, or preparation of the manuscript. The research was performed as part of the employment of the authors at the University of Lleida.

Acknowledgements

Authors thank the access to Centre de Reproducció de Tortugues de l'Albera in Catalonia, Spain, and especially to Joan Budó. We also acknowledge the reviewers for their insightful comments.

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How to cite this article: Parés-Casanova P.M, Coronado.C, "Size and sex constraints in self-uprighting in western Hermann's tortoise *Testudo hermanni hermanni* (Gmelin, 1789)" J Vet Sci Technol 12(2021)