

Do social factors drive basking aggregations of painted turtles (*Chrysemys picta*)?

by

Phoenix K. Sandroek

8153286

BIO4009 – Honours Research Project

Supervisor: Gabriel Blouin-Demers

April 18, 2022

Department of Biology

University of Ottawa

Abstract

Many animals aggregate for a variety of reasons. Wild painted turtles (*Chrysemys picta*) aggregate at basking sites. Group basking may have asocial or social causations. I tested for social causations of this behaviour by studying the distribution of individuals during basking in the laboratory. Instead of aggregating, painted turtles avoided each other during basking. The frequency of aggressive interactions decreased over the course of the trials, which precedes hierarchy formation in social species. My findings contribute to a growing body of work suggesting that the social behaviour of turtles is more complex than previously believed and warrants further investigation.

Keywords: turtles, behaviour, sociality, basking

Acknowledgements

I want to thank Gabriel Blouin-Demers for his constant support in completing my thesis. I also want to thank Grégory Bulté for his help developing my project and methods, and Malcolm Fenech and David Seburn for their significant assistance with my field work. The Friends of Petrie Island and their knowledge of my study site were indispensable.

The field work for this project was conducted on the traditional territories of Algonquin, Mohawk, and Anishinaabe peoples. This project is possible because of their stewardship of the land and seeks new ways to live in right relation with the earth and all its inhabitants.

Table of Contents

Abstract.....	ii
Acknowledgements.....	iii
List of Figures.....	v
Introduction.....	1
Methods.....	3
Results.....	5
Discussion.....	5
References.....	8

List of Figures

Fig. 1: Photograph of study species (*Chrysemys picta*) in the experimental pool. Distribution of individuals on each basking site was captured every 30 min during trials with a time-lapse camera.

Fig. 2: Mean proportion of painted turtles (*Chrysemys picta*) individuals in largest aggregation, observed versus predicted. Pooled total was significant at $\alpha = 0.05$ (Wilcoxon signed-rank test, $p < 0.01$, $n = 115$); individual comparisons were not significant. The mean proportion in each largest aggregation was compared to a predicted random mean to determine whether turtles were aggregating or avoiding one another.

Fig. 3: Proportion of time where aggressive interactions between individuals (*Chrysemys picta*) visible during acclimation versus trial. Proportion was significantly higher during the first 10 minutes of acclimation than during trial (Wilcoxon signed-rank test, $p < 0.0001$, $n = 101$). All comparisons were significant at $\alpha = 0.05$. Data were used to examine patterns of aggression over time in studied groups.

Introduction

Animals in many taxa aggregate, sometimes in spectacular ways. Broods of cicadas in eastern North America emerge in the billions on 13- and 17-year life cycles (Williams & Simon 1995). Atlantic herring (*Clupea harengus*) form shoals with an estimated hundreds of millions of individuals (Makris et al., 2009). Some birds and mammals maintain permanent social groups. Starlings live and travel in flocks of thousands of birds (Hildenbrandt et al., 2010) and dolphins can live in groups of more than a hundred individuals with complex social structures (Hartman et al., 2008). These remarkable aggregations, among others, have prompted scientists to explore what benefits are conferred to animals that aggregate.

The simplest potential driver of these aggregations is asocial: the presence of a scarce and concentrated resource that many individuals gather to exploit. For instance, access to water is limiting in many environments, which causes animals to gather at high densities at watering holes or near other sources of water (Rozen-Rechels et al., 2015, Martin et al., 2015). In nutrient-poor habitats, the appearance of carrion can attract high densities of scavengers, such as when a whale dies and falls to the bottom of the ocean (Smith & Baco 2003). African elephants (*Loxodonta africana*) return repeatedly to mineral deposits of micronutrients, which are otherwise scarce within their habitat (Sach et al., 2020).

Aggregations may also have social causations: animals may be attracted to conspecifics because the presence of conspecifics is directly beneficial. These social reasons range from simple dilution of risk of predation via the presence of many individuals to the complex teamwork and information-sharing seen in highly social species.

Some animals aggregate as a form of protection from predation. Gathering in large groups allows to detect predators more easily via group vigilance and dilutes an individual's risk of predation (Hamilton, 1971). Vigilance consumes significant time in prey species, who thus

adjust their behaviour second-by-second in response to predation risk (Kent et al., 2019). For instance, vervet monkeys (*Chlorocebus pygerythrus*) experience a reduction in vigilance and an increase in foraging time per individual when in groups, and the level of risk varies depending on the individual's location in the group (Josephs et al., 2016).

Animals can aggregate to assess and compete for mates and to breed (Nishida et al., 1993). Salmon return from living at sea to spawn at high densities in fresh water (Esteve et al., 2005). Species with significant parental care may remain together through oviposition or birth, raising young together in large groups. Size of flock is directly correlated with breeding success in American flamingoes (*Phoenicopterus ruber*), with larger flocks having much higher success than smaller flocks (Pickering et al., 1992).

Highly social animals may aggregate to forage and hunt cooperatively (Suter & Houston 2021). American crows (*Corvus brachyrhynchos*) use aggregations to exchange information about sources of food, predators, and other threats (Cornell et al., 2012). Information transfer can even extend to other species, with bottlenose dolphins (*Tursiops truncatus*) cooperating with each other and with fishers in Brazil to locate fish prey (Pellegrini et al., 2021).

Reptiles also aggregate for various reasons. Some sea turtles return to coastal areas around the world each year to lay eggs on land (Weir et al., 2007). Garter snakes (*Thamnophis sirtalis*) in western Canada exhibit one of the largest breeding aggregations of any vertebrate in North America (Crews & Garstka 1982). Group living has been observed in 18 squamate species and is hypothesized to have evolved independently more than once (Gardner et al., 2016).

At northern latitudes, basking is important for freshwater turtles to increase their metabolic rate (Bulté & Blouin-Demers 2010). In highly-productive and temperate environments, basking (and by extension, body temperature) may be more limiting to a turtle's

energy acquisition than food intake due to abundant food and long digestive turnover time (Congdon, 1989). Thus, basking represents an important aspect of the daily routine of turtles and is integral to their fitness.

Turtles of many species bask in groups, including the painted turtle *Chrysemys picta* (Brattstrom, 1974; Lovich, 1988). The motivation behind this behaviour is not well-understood, especially in light of their occasional aggressive behaviour toward each other while basking (Lovich, 1988). Most aggression at basking sites is not direct. Turtles may express aggression via an open-mouthed gape display, which is a warning toward other individuals (Lovich, 1988). Individuals may physically displace others, at times pushing them into the water (Lovich 1988). The most common reaction to these displays of aggression is for the receiving turtle to defer and move away. Biting is rare in a basking context. It is thought that the use of social cues to determine basking location, rather than direct aggression, is an effective means to reduce energetic output (Lovich, 1988).

I tested the hypothesis that basking aggregations of turtles are socially motivated. Specifically, I predicted that turtles would aggregate during captive trials despite provided basking sites being identical.

Methods

I captured 20 male painted turtles (*Chrysemys picta*) using hoop and dip nets between 22 July and 10 September 2021 at Petrie Island, Ottawa, Canada. Males were used to eliminate the potential injury of females by males from harassment and coercive mating (Moldowan 2020). Five groups of four males each were housed in 200 l plastic pools in the animal care facility at the University of Ottawa. The ambient temperature of the room and water was 23-25°C and the light in the room reflected daylight conditions at the time of the experiment.

I constructed two identical basking sites using wooden planks, rope, bricks, and towels (Fig 1). I lit the basking sites with 60-w heat lamp bulbs, which heated the basking sites to between 28-30°C, depending on room temperature at the time. Temperature was the same on each basking site.

Basking trials began following a 24-hour acclimation period. To lower water temperature and encourage basking, I added approximately 23 kg of ice to the pool immediately before each trial period. This reduced water temperature to 15°C. I photographed turtles every 30 min using a time-lapse trail camera (WingScapes BirdCam) mounted to the wall of the experimental room.

I combined photographs from all turtle groups and recorded the distribution of basking turtles in each photo. I excluded observations where <2 turtles were basking, as there were no other turtles present to influence each turtle's decision of where to bask.

I performed statistical analyses in R. For the first analysis, I recorded the proportion of basking turtles on the most-occupied site in each time-lapse photo. I constructed a null distribution that assumed random choice of basking sites by turtles. The mean of this null distribution was compared to the observed distribution using a Wilcoxon signed-rank test.

I scored each observed aggregation as either low-density or high-density based on the turtles' arrangement and recorded how many frames the aggregation could be seen in. Groups of two turtles on opposite sides, three turtles with two on one site and one on the other, and four turtles where two were on each site were considered low-density; everything else I labeled high-density. I compared the mean length in frames of low-density aggregations with that of high-density aggregations using a Wilcoxon rank-sum test.

In three groups, I filmed turtles immediately after being introduced to the pool. I recorded the proportion of time when turtles were engaged in aggressive actions. I compared this

proportion to the number of time-lapse photos from each trial where turtles were engaged in aggressive actions using a Wilcoxon signed-rank test.

Results

Turtles avoided each other in choosing a basking site (Wilcoxon signed-rank test, $p < 0.01$, $n = 115$). An ANOVA showed no significant difference in turtles' distribution between trials ($p = 0.661$). Low-density aggregations of turtles lasted longer, although this effect only approached significance (Wilcoxon rank-sum test, $p = 0.061$, $n = 58$). The frequency of turtles' aggressive interactions was significantly reduced during trials compared to the acclimation period (Wilcoxon signed-rank test, $p < 0.0001$, $n = 101$).

Discussion

Previous work on the sociality of turtles has been limited, with early studies concluding that turtles were largely asocial. Research has begun to emerge contradicting this conclusion. For instance, male northern map turtles (*Graptemys geographica*) use public social information when assessing and selecting mates (Bulté et al., 2021). There is mounting evidence that turtles are capable of more complex social behaviours than previously thought. Turtles consider the presence of other individuals when selecting basking sites. Therefore, basking site quality is unlikely to be the sole factor driving turtle distributions; social factors are driving their distribution, at least partly.

A common trait of social species is the ability to communicate with displays—ritualized behaviours that convey information to conspecifics. When turtles were first introduced to the study pool, several social interactions occurred. The majority of these interactions were aggressive, including instances of biting, chasing, and an open-mouthed gape which sometimes preceded biting. These interactions mimicked those previously observed in experimental settings

(Moldowan et al., 2020) and in wild populations (Lovich, 1988). In some cases, a gape was enough to cause one turtle to retreat and did not cause further fighting. These turtles displaying aggression via the gape display is an indication that they are capable of more complex social behaviours overall.

Another means of reducing energetic expenditure in social species is the development of social hierarchies. Social hierarchies allow individuals to conserve energy; the established hierarchy reduces fighting for resources or mates (Senar et al., 2010). Hatchling European pond turtles (*Emys orbicularis*) form stable hierarchies when raised in captivity (Masin et al., 2020), a phenomenon which is not observed in asocial species. Comparisons between the pre-trial behaviour of turtles, versus that during the trial, revealed significantly higher rates of aggressive interactions immediately after introduction to the tank. A reduction in aggressive interactions over time is characteristic of animals that form social hierarchies (Issa et al., 1999). This could be a precursor of hierarchy formation in the study groups; however, further research would be needed to determine whether hierarchies are truly formed.

This research supports the existence of social behaviour in turtles. The distribution of turtles in this study, however, contradicted that observed in natural settings, with turtles demonstrating avoidance of conspecifics rather than aggregation. The differing pressures of a laboratory environment may have caused this behaviour to manifest differently. For example, lack of predators or disturbances in the laboratory would reduce the need for antipredator vigilance. The close proximity of other individuals may have increased the frequency of aggressive interactions. Other animal species exhibit social behaviours in captivity that are not reflective of those observed in their natural environment (ref?). More research is needed to determine whether these types of interactions persist in a more natural environment.

Another potential source of this differing response was the absence of female turtles. Adult males were used exclusively in this study to prevent harassment of females by males (as documented by Moldowan 2020). Painted turtles in natural settings, however, including those at the site of capture, bask in mixed groups of adult males, adult females, and juveniles. Thus, there is the potential in the wild for intersexual social effects, such as mate assessment or competition for mates. These effects could not be observed in my study.

Perhaps more confusingly, some male turtles mounted other males, or (in one instance) performed a foreclaw display typically seen in males attempting to attract females. To my knowledge, this is the first documented case of homosexual behaviour in *Chrysemys picta*. Homosexual behaviour has been observed in other chelonian species, including the desert tortoise, Seychelles giant tortoise, and wood turtle (Bagemihl, 1999). There are several hypotheses surrounding the function of homosexual behaviour in animals. Males may have been mistaking other male turtles for females, or attempting to assert dominance. Regardless of function, this behaviour is another indication that freshwater turtles perform complex social interactions.

Further studies involving female turtles, mixed groups, or juvenile turtles could clarify why my results differ from those observed in natural settings. Future research could also determine how turtles' social structures may influence their spatial distribution; for example, how habitat and microhabitat use in natural settings is affected by the presence of other turtles.

References

- Bagemihl, B. *Biological Exuberance: Animal Homosexuality and Natural Diversity*, New York: St. Martin's Press, 1999, 752 pp.
- Brattstrom, B.H. (1974). The Evolution of Reptilian Social Behavior. *American Zoologist*, 14(1), 35-49.
- Bulté, G., Huneault, B., & Blouin-Demers, G. (2021). Free-ranging male northern map turtles use public information when interacting with potential mates. *Ethology*, 127(11), 995–1001. <https://doi.org/10.1111/ETH.13221>
- Bulté, G. & Blouin-Demers, G. (2010). Estimating the energetic significance of basking behaviour in a temperate-zone turtle. *Ecoscience*, 17(4), 387-393.
- Congdon, J.D. (1989). Proximate and Evolutionary Constraints on Energy Relations of Reptiles. *Physiological Zoology*, 62(2), 356-373.
- Cornell, H.N., Marzluff, J.M. and Shannon, P. (2012). Social learning spreads knowledge about dangerous humans among American crows. *Proc. R. Soc. B.*, 279499–508.
- Crews, D., & Garstka, W. R. (1982). The Ecological Physiology of a Garter Snake. *Scientific American*, 247(5), 158–168.
- Esteve, M. (2005). Observations of spawning behaviour in Salmonidae: *Salmo*, *Oncorhynchus* and *Salvelinus*. *Reviews in Fish Biology and Fisheries*, 15, 1-21.
- Gardner, M. G., Pearson, S. K., Johnston, G. R., & Schwarz, M. P. (2016). Group living in squamate reptiles: a review of evidence for stable aggregations. *Biological Reviews*, 91(4), 925–936. <https://doi.org/10.1111/brv.12201>
- Hamilton, W.D. (1971). Geometry for the selfish herd. *Journal of Theoretical Biology*, 31, 295-311.

- Hartman, K. L., Visser, F., & Hendriks, A. J. E. (2008). Social structure of Risso's dolphins (*Grampus griseus*) at the Azores: A stratified community based on highly associated social units. *Canadian Journal of Zoology*, *86*(4), 294–306. <https://doi.org/10.1139/Z07-138>
- Hildenbrandt, H., Carere, C., & Hemelrijk, C. K. (2010). Self-organized aerial displays of thousands of starlings: a model. *Behavioral Ecology*, *21*(6), 1349–1359. <https://doi.org/10.1093/beheco/arq149>
- Issa, F. A., Adamson, D. J., & Edwards, D. H. (1999). Dominance hierarchy formation in juvenile crayfish *procambarus clarkii*. *Journal of Experimental Biology*, *202*(24), 3497–3506. <https://doi.org/10.1242/JEB.202.24.3497>
- Josephs, N., Bonnell, T., Dostie, M., Barrett, L., & Henzi, S.P. (2016). Working the crowd: sociable vervets benefit by reducing exposure to risk. *Behavioral Ecology*, *27*(4), 988-994.
- Kent, M.I.A., Herbert-Read, J.E., McDonald, G., Wood, A.J. & Ward, A.J.W. (2019). Fine-scale behavioural adjustments of prey on a continuum of risk. *Proc. R. Soc. B.* 2862019044820190448.
- Lovich, J. (1988). Aggressive Basking Behavior in Eastern Painted Turtles (*Chrysemys picta picta*). *Herpetologica*, *44*(2), 197-202.
- Makris, N. C., Ratilal, P., Jagannathan, S., Gong, Z., Andrews, M., Bertsatos, I., Godo, O. R., Nero, R. W., & Jech, J. M. (2009). Critical population density triggers rapid formation of vast oceanic fish shoals. *Science*, *323*(5922), 1734–1737. <https://doi.org/10.1126/science.1169441>
- Martin, J., Benhamou, S., Yoganand, K., Owen-Smith, N. (2015). Coping with Spatial Heterogeneity and Temporal Variability in Resources and Risks: Adaptive Movement Behaviour by a Large Grazing Herbivore. *PLoS ONE*, *10*(2).

- Masin, S., Bani, L., Vardanega, D., Chiodini, N., & Orioli, V. (2020). Hierarchies and Dominance Behaviors in European Pond Turtle (*Emys orbicularis galloitalica*) Hatchlings in a Controlled Environment. *Animals* 2020, Vol. 10, Page 1510, 10(9), 1510. <https://doi.org/10.3390/ANI10091510>
- Moldowan, P.D., Brooks, R.J., & Litzgus, J.D. (2020). Demographics of injuries indicate sexual coercion in a population of Painted Turtles (*Chrysemus picta*). *Can. J. Zool.*, 98, 269–278
- Moldowan, P. D., Brooks, R. J., & Litzgus, J. D. (2020). Sex, shells, and weaponry: coercive reproductive tactics in the painted turtle, *Chrysemys picta*. *Behavioral Ecology and Sociobiology*, 74(12), 1–14. <https://doi.org/10.1007/S00265-020-02926-W/FIGURES/4>
- Nishida, T. (1993). Spatial relationships between mate acquisition probability and aggregation size in a gregarious coreid bug, (*Colpula lativentris*): A case of the ideal free distribution under perceptual constraints. *Population Ecology*, 35(1), 45-56.
- Pellegrini, A.Y., Romeu, B., Ingram, S.N., & Daura-Jorge, F.G. (2021). Boat disturbance affects the acoustic behaviour of dolphins engaged in a rare foraging cooperation with fishers. *Animal Conservation*, 1367-9430.
- Pickering, S., Creighton, E., & Stevens-Wood, B. (1992). Flock Size and Breeding Success in Flamingos. *Zoo Biology*, 11, 229-234.
- Rozen-Rechels, D., van Beest, F.M., Richard, E., Uzal, A., Medill, S.A., & McLoughlin, P.D. (2015). Density-dependent, central-place foraging in a grazing herbivore: competition and tradeoffs in time allocation near water. *Oikos*, 124, 1142-1150.
- Sach, F., Yon, L., Henley, M.D., Bedetti, A., Buss, P., de Boer, W.F., Dieren, E.S., Gardner, A., Langley-Evans, S.C., Hamilton, E., Lark, R.M., Prins, H.T.P., Swemmer, A.M. & Watts, M.J. (2020). Spatial geochemistry influences the home range of elephants. *Science of the*

Total Environment, 729, 139066.

Senar, J. C., Camerino, M., & Metcalfe, N. B. (2010). Familiarity Breeds Tolerance: the Development of Social Stability in Flocking Siskins (*Carduelis spinus*). *Ethology*, 85(1), 13–24. <https://doi.org/10.1111/j.1439-0310.1990.tb00381.x>

Smith, C.R. & Baco, A.R. (2003). Ecology of whale falls at the deep-sea floor. *Oceanography and Marine Biology: an Annual Review*, 41, 311-354.

Suter, H.F. & Houston, A.I. (2021). How to Model Optimal Group Size in Social Carnivores. *The American Naturalist*, 197(4).

Weir, C. R., Ron, T., Morais, M., & Duarte, A. D. C. (2007). Nesting and at-sea distribution of marine turtles in Angola, West Africa, 2000-2006: Occurrence, threats and conservation implications. *ORYX*, 41(2), 224–231. <https://doi.org/10.1017/S003060530700186X>

Williams, K. S., & Simon, C. (1995). The Ecology, Behavior, and Evolution of Periodical Cicadas. *Annual Review of Entomology*, 40(1), 269–295. <https://doi.org/10.1146/annurev.en.40.010195.001413>



Fig. 1: Photograph of study species (*Chrysemys picta*) in the experimental pool. Distribution of individuals on each basking site was captured every 30 min during trials with a time-lapse camera.

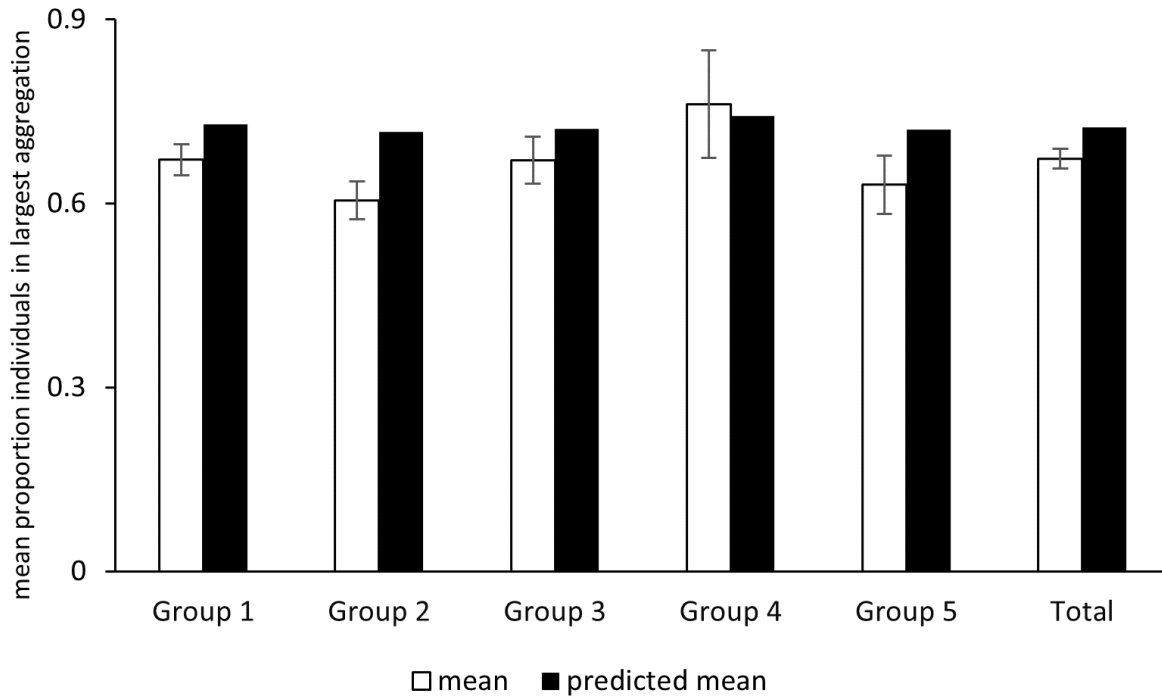


Fig. 2: Mean proportion of painted turtles (*Chrysemys picta*) individuals in largest aggregation, observed versus predicted. Pooled total was significant at $\alpha = 0.05$ (Wilcoxon signed-rank test, $p < 0.01$, $n = 115$); individual comparisons were not significant. The mean proportion in each largest aggregation was compared to a predicted random mean to determine whether turtles were aggregating or avoiding one another.

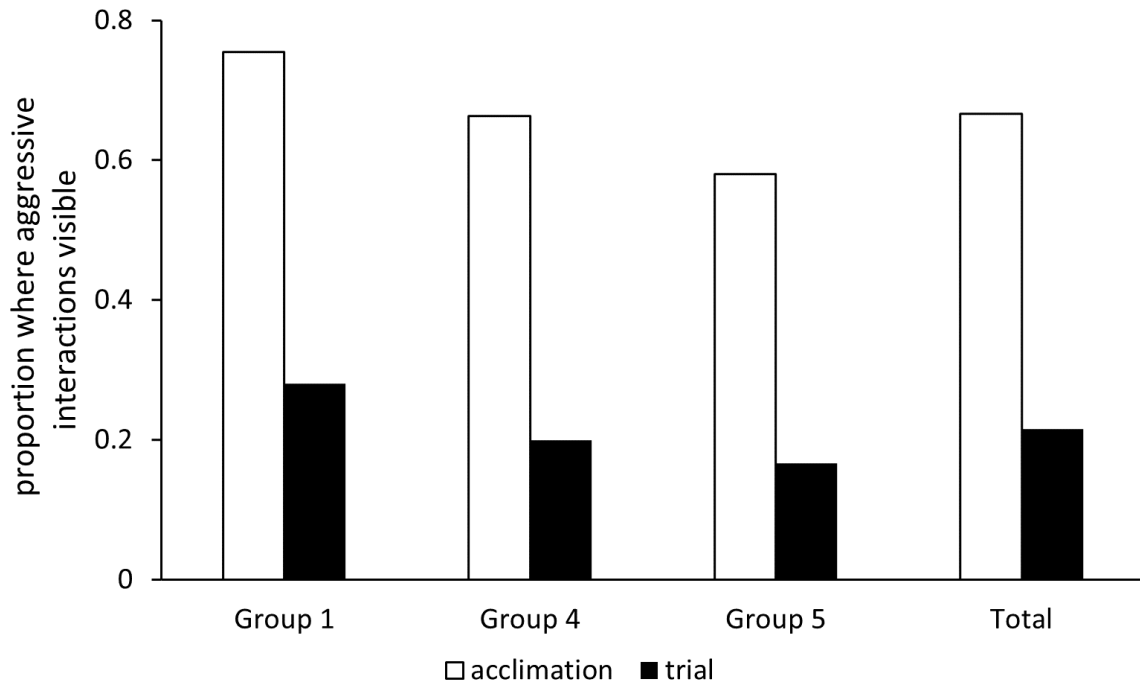


Fig. 3: Proportion of time where aggressive interactions between individuals (*Chrysemys picta*) visible during acclimation versus trial. Proportion was significantly higher during the first 10 minutes of acclimation than during trial (Wilcoxon signed-rank test, $p < 0.0001$, $n = 101$). All comparisons were significant at $\alpha = 0.05$. Data were used to examine patterns of aggression over time in studied groups.