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Variation in carapace damage within and among Loggerhead Musk Turtle (*Sternotherus minor*) populations in Florida spring-fed ecosystems

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Abstract. Damage to a turtle's shell can provide evidence of past events such as vehicle collisions, disease, predator encounters, or even a behavioural interaction between members of the same species. Documenting shell damage as part of long-term mark and recapture studies enables researchers to determine population trends, intraspecific interactions and identify potential issues within turtle populations. This paper analyses shell damage in populations of the Loggerhead Musk Turtle (*Sternotherus minor*) (Agassiz, 1857). We examined carapace shell damage frequency and severity in 2701 individual *S. minor* (1468 males and 1233 females) captured in spring-fed habitats in one state preserve and five state parks in central and northern Florida. We quantified frequency as percent of individuals with at least some damage, and we created a carapace mutilation index (CMI) to quantify the severity of damage. The frequency and severity of carapace damage varied among sites. Males were more frequently damaged than females at all study sites, and had more severe damage, but only significantly at three sites. There was a positive relationship between CMI and body size (plastron length) for males and for females, suggesting that adults accumulate damage as they age. Damage may vary among sites due to habitat size, quality, or abundance of large adult male turtles. Future research should look at movement patterns, site fidelity, social interactions, and how these are impacted by habitat size, quality, and density, to determine what, if any, these factors have on population stability and fecundity.

Keywords. *Sternotherus minor*, intraspecies aggression, shell damage, carapace mutilation index, Florida, springs, long term population study

Introduction

Damage to a turtle's shell may preserve a record of events that occur during its life. Scars or damage to the shell can serve as evidence of attempted predation (Aresco and Dobie, 2000; Heithaus et al., 2002; Parren, 2013; de Valais et al., 2020), a collision with a boat, automobile, or agricultural machinery (Ashley and Robinson, 1996; Saumure et al., 2007; Heinrich et al., 2012; Hollender et al., 2018). Shells can also display pitting, lesions, or discolouration due to infection or disease (Hernandez-Divers et al., 2009; Woodburn et al., 2019), and can document agonistic human interactions (Moll and Moll, 2004). The ability of the turtle shell to preserve evidence of physical trauma has long been known to researchers who file or drill holes into the marginal scutes and peripheral bones of the carapace to individually identify turtles as part of capture-mark-recapture studies (Cagle, 1939; Plummer, 1979). Damage can also chronicle intraspecific aggression (Jackson, 1969) or coercive mating strategies (Moldowan et al., 2020).

The Loggerhead Musk Turtle (*Sternotherus minor*) is a small freshwater turtle endemic to the south-eastern United States where it inhabits rivers, spring runs, ponds, and lake margins (Ernst and Lovich, 2009; Scott et al., 2018). The range of the turtle is from the Altamaha

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drainage of south-eastern Georgia to the Apalachicola drainage down to central Florida across the aquifer systems (Zappalorti and Iverson, 2006; Ernst and Lovich, 2009; Krysko et al., 2011; Scott et al., 2018). This turtle has well-developed, strong jaw musculature for crushing mollusc and arthropod prey (Zappalorti and Iverson, 2006; Ernst and Lovich, 2009).

Shell damage has been documented in *S. minor* for more than half a century with the first report of carapace damage in the species mentioned as “old, eroded individuals” in Carr and Goin’s (1955) species description. A decade later, Jackson (1965) reported carapace erosion or damage in 40.4 % of juveniles, 61.4% of smaller adults, and 100% of large adults from a pooled sample of 108 individuals. Jackson (1965) hypothesised that intraspecific behavioural interactions caused this damage. Jackson (1969) subsequently provided evidence that intrasexual aggression between males including biting the marginal scutes caused some of the damage he observed. Later observations by Bels and Caram (1994) document males biting females during courtship, an action that may cause the observed shell damage.

The Turtle Survival Alliance’s North American Freshwater Turtle Research Group has been surveying the turtles of various Florida spring-fed habits since 1999 and the Santa Fe River Turtle Project has similarly been sampling freshwater springs in the Santa Fe River basin since 2006. Both groups have been conducting long-term ecological studies of the turtle assemblages in these ecosystems (e.g., Adler et al., 2018; Johnston et al., 2016, 2020; Munscher et al., 2013, 2015a, 2020). Previous reports of shell damage in *S. minor* have been anecdotal and have not included robust data sets or data from multiple sites, which may inform causation, as well as document the extent of the damage.

In this paper, we present data that expands on Jackson’s (1965; 1969) observations. Specifically, we examine how the occurrence and severity of carapace damage vary among six *S. minor* populations from spring-fed habitats in central and northern Florida. Within each population, we evaluate the relationship between carapace damage and body size (plastron length) in each sex.

Materials and Methods

Field-Site Description.—The six Florida study sites for this analysis include: Wekiwa Springs State Park (WS), Orange County (2.67 ha); Volusia Blue Springs State Park (VBS), Volusia County (1.9 ha); Manatee Springs State Park (MS), Levy County (1.53 ha); Fanning Springs State Park (FS), Levy County (0.7 ha); Rock Springs Run State Preserve (RSR), Seminole County (1.41 ha); and Ichetucknee Spring State Park (IS), Columbia and Suwannee Counties (10.99 ha; Fig. 1). These study sites are described more thoroughly by Johnston et al. (2020), Munscher et al. (2015a, b, 2017, 2020), Riedle et al. (2016) and Walde et al. (2016). All study sites are entirely fed by first or second magnitude freshwater springs with clear flowing water.

Data Collection.—Researchers conducted multi-day annual or semi-annual snorkel surveys between 2000 and 2019. For each sampling period, a variable number of snorkelers hand-captured turtles from ca. 0800 – 1600/1900 h, depending on the time of year and weather conditions. We placed turtles in labelled bins within canoes that indicate the capture area and then brought them to a central location for data processing.

We recorded maximum straight-line measurements of carapace length (CL), plastron length (PL), carapace width (CW), and shell height (SH) to the nearest millimetre. We sexed turtles based on secondary sexual

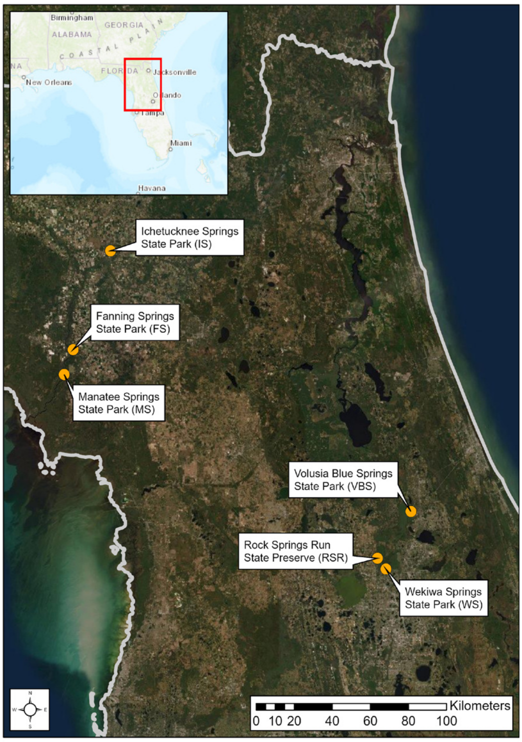

Figure 1. Map depicting the six turtle study sites in Florida, USA.

Figure 2. Carapace damage on *Sternotherus minor* observed at the various study sites in Florida, USA. (A) depicts a turtle with a score of 1. (B) depicts a turtle with a score of 4. (C) depicts a turtle with a score of 6. (D) depicts a turtle with a score of 3. Photographs by Jessica Weber.

characteristics, notably by visual inspection of tail length and girth as described in Ernst and Lovich (2009) (Fig. 2). Females are sexually mature and distinguishable at 80 mm (Iverson, 1978), while males have been documented at maturing at 60 mm (Etchberger and Stovall, 1990), however this is likely ecosystem specific. We noted all unique physical features such as damage, scars, or coloration of each turtle to aid in confirming individual identity. We weighed turtles to the nearest gram (g) using Ohaus top loading digital scales (Ohaus Corp., New Jersey, USA). We individually marked turtles by notching the marginal scutes and peripheral bones of the carapace (Cagle, 1939) and we also notched the plastron when necessary. The notches (created by a saw or Dremel) do not resemble the damage created naturally by the turtles biting each other. Beginning in 2009, we used passive integrated transponder (PIT) tags as a secondary identification method for turtles with CL greater than 70 mm. We injected PIT tags under the turtle's right bridge (Buhlmann and Tuberville, 1998; Runyan and Meylan, 2005). Once we completed processing the turtles, we released them back into the spring run at their approximate capture locations.

When we examined turtles for physical anomalies, we noticed most of the shell damage was located along the posterior marginal scutes, L9, 10, 11 and R9, 10 and 11, the same location where Carr (1952) had observed erosion and Jackson found most of the damage he reported in 1964, presumably because damage occurs when males are in active pursuit of each other. We assigned carapace mutilation index (CMI) scores to each turtle based on a direct count of the number of these scutes that had damage (Fig. 2 and Fig. 3). Damage was categorised by chipped, broken, missing, or eroded scutes. We did not include irregular scutation as potential damage. We assigned a score of 0 if none of these six scutes were damaged, and a score of 6 indicated that all six of these scutes were damaged (Fig. 3). Other researchers use similar scoring systems or "carapace mutilation indexes" (Saumure et al., 2007), but due to the nature of our damage predominantly occurring within the aforementioned rear marginals, we modified this system to better quantify the damage observed.

Statistical analysis.—We used nonparametric tests for PL and CMI scores because these datasets were not normally distributed. An alpha of 0.05 was set for all comparisons. Within sites we used Wilcoxon Rank Sum tests to evaluate CMI scores between sexes. Within sites we compared numbers of turtles with and without damage between sexes using a one-tailed Fisher's Exact Test to test the hypothesis that more males were damaged than females. Among study sites we compared the number of damaged and undamaged turtles by sex with a Pearson's Chi-square test. We then searched for differences between sites with Pearson's Chi-square tests and adjusted the alphas with a Benjamini-Hochberg correction. We also compared CMI scores by sex across sites with a Kruskal-Wallis tests and used Steel-Dwass post hoc tests to determine pairwise significant differences. Finally, we used Pearson's Correlation Coefficients (r) to evaluate the relationship CMI and PL for each sex at each site and used binary logistic regression analyses to test for the influence of plastron length (continuous predictor) on the presence or absence of damage (dichotomous dependent variable).

Results

We evaluated 1468 male and 1233 female *S. minor* across six study sites (Table 1). The number of damaged

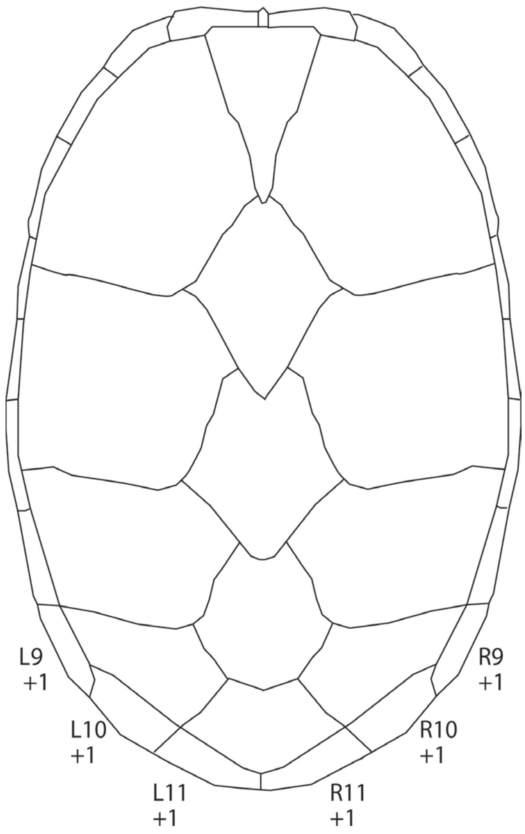

Figure 3. Depiction of Carapace Mutilation Index for *Sternotherus* species with overlapping vertebral scutes.

Table 1. Number of individual *Sternotherus minor* by Carapace Mutilation Index score (% of occurrence) from Florida springs study sites in the USA.

			Carapace Mutilation Index Score						
Site	**Sex**	**N**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Volusia Blue Spring	F	126	78 (62%)	21 (17%)	17 (13%)	5 (4%)	4 (3%)	0	1 (1%)
	M	184	76 (41%)	31 (17%)	51 (28%)	21 (11%)	4 (2%)	1 (1%)	0
Fanning Springs	F	38	31 (82%)	3 (8%)	3 (8%)	1 (3%)	0	0	0
	M	51	32 (63%)	2 (4%)	10 (20%)	4 (8%)	3 (6%)	0	0
Ichetucknee Springs	F	167	149 (89%)	5 (3%)	9 (5%)	3 (2%)	1 (1%)	0	0
	M	320	266 (83%)	16 (5%)	21 (7%)	12 (4%)	2 (1%)	1 (0%)	2 (1%)
Manatee Springs	F	156	99 (63%)	25 (16%)	25 (16%)	2 (1%)	4 (3%)	0	1 (1%)
	M	208	74 (36%)	30 (14%)	57 (27%)	22 (11%)	18 (9%)	5 (2%)	2 (1%)
Rock Springs	F	71	58 (82%)	8 (11%)	5 (7%)	0	0	0	0
	M	84	56 (67%)	9 (11%)	15 (18%)	1 (1%)	3 (4%)	0	0
Wekiwa Springs	F	675	532 (79%)	72 (11%)	56 (8%)	9 (1%)	3 (0%)	3 (0%)	0
	M	621	371 (60%)	76 (12%)	115 (19%)	36 (6%)	17 (3%)	4 (1%)	2 (0%)

versus undamaged individuals varied among sites for both males ($\chi^2 = 150.95$, df = 5, $P \leq 0.0001$) and females ($\chi^2 = 48.71$, df = 5, $P \leq 0.0001$). We found significant differences in damage frequencies for males between: IS and each of the other sites, VBS and FS, VBS and RSR, VBS and WS, FS and MS, MS and RSR, and MS and WS. For females, we found significant differences in damage frequencies between: VBS and FS, VBS and IS, VBS and RSR, VBS and WS, IS and MS, IS and WS, MS and RSR, and MS and WS (Table 2). CMI scores also differed among sites for males ($\chi^2 = 148.94$, df = 5, $P \leq 0.0001$) and females ($\chi^2 = 49.05$, df = 5, $P \leq 0.0001$). We found significant differences in males between: IS and each of the other sites, MS and FS, and MS and RSR. We found significant differences for females between: IS and VBS, IS and MS, IS and WS, VBS and RSR, VBS and WS, MS and RSR, and MS and WS (Table 3). Damage occurred more frequently in males than females at all six sites. CMI was higher in males than in females at all sites, but only significantly at three sites (Table 4).

Among males, damaged individuals were significantly larger (PL) than undamaged individuals at five of the six sites (Table 5). We found significant relationships between CMI and PL for males at VBS ($r = 0.17$, df = 182, $P = 0.021$), FS ($r = 0.422$, df = 49, $P = 0.002$), IS ($r = 0.175$, df = 318, $P = 0.002$), MS ($r = 0.31$, df = 206, $P < 0.0001$), and WS ($r = 0.254$, df = 619, $P < 0.0001$). We found no significant relationship between CMI and PL for males at RSR ($r = 0.105$, df = 82, $P = 0.341$). Among females, damaged individuals were significantly larger (PL) than undamaged individuals at two sites (Table 6). Damaged and undamaged females were similar in size at four sites. We found significant relationships between

Table 2. Among site comparisons of the number of *Sternotherus minor* with damage and without damage from Florida Springs study sites in the USA. Male comparisons are above the diagonal and female comparisons are below the diagonal. * indicates statistical significance ($P < 0.05$). ns indicates no statistical significance. Top axis acronyms only.

Site	VBS	FS	IS	MS	RSR	WS
Volusia Blue Spring (VBS)	-	*	*	ns	*	*
Fanning Springs (FS)	*	-	*	*	ns	ns
Ichetucknee (IS)	*	ns	-	*	*	*
Manatee Springs (MS)	ns	ns	*	-	*	*
Rock Springs (RSR)	*	ns	ns	*	-	ns
Wekiwa Springs (WS)	*	ns	*	*	ns	-

Table 3. Among site comparisons of *Sternotherus minor* CMI scores from Florida Springs study sites in the USA. Male comparisons are above the diagonal and female comparisons are below the diagonal. * indicates statistical significance ($P < 0.05$). ns indicates no statistical significance. Top axis acronyms only.

Site	VBS	FS	IS	MS	RSR	WS
Volusia Blue Spring (VBS)	-	ns	*	ns	ns	ns
Fanning Springs (FS)	ns	-	*	*	ns	ns
Ichetucknee (IS)	*	ns	-	*	*	*
Manatee Springs (MS)	ns	ns	*	-	*	ns
Rock Springs (RSR)	*	ns	ns	*	-	ns
Wekiwa Springs (WS)	*	ns	*	*	ns	-

CMI and PL for females at VBS (r = 0.244, df = 124, P = 0.006), MS (r = 0.236, df = 154, P = 0.003), and WS (r = 0.078, df = 673, P = 0.042). We found no significant relationships between CMI and PL for females at FS (r = -0.155, df = 36, P = 0.352), IS (r = -0.004, df = 165, P = 0.959), and RSR (r = -0.027, df = 69, P = 0.824).

The binary logistic regression analysis showed that shell damage was significantly related to plastron length in females from three sites and males from four sites (Table 7). Shell damage was nearly significantly related to plastron length (P = 0.0515) in males from Ichetucknee Springs.

Discussion

Damage to the posterior marginal scutes was ubiquitous across all sites. At most sites, the severity and percentage of turtles with damage differed between the sexes, with males being more frequently damaged and having more severe damage based on the CMI. The Wilcoxon Rank Sum tests found that males showed a significantly higher percentages of shell injury than females, and larger males exhibited significantly more damage at five of the six sites and the binary logistic regression analysis showed shell damage in males was significant at four sites and nearly significant at Ichetucknee Springs, while being significant in three sites in female tests. This suggests that damage is non-

Table 4. Within site comparisons between sexes of *Sternotherus minor* in Florida Springs study sites in the USA. % Damage = Percent of turtles with any damage; Male vs Female damage = probability that males are more likely to have any damage; Damage Score = probability that damage scores differ between sexes. * indicates statistical significance ($P < 0.05$).

Site	Sex	N	% Damage	Male vs Female damage frequency P	Damage score mean (± SD)	Male vs Female damage severity P
Volusia Blue Spring	F	126	38.1	0.0003*	0.7 ± 1.2	0.0021*
(VBS)	M	184	58.7		1.2 ± 1.2	
Fanning Springs	F	38	18.4	0.0434*	0.3 ± 0.7	0.134
(FS)	M	51	37.3		0.9 ± 1.3	
Ichetucknee Springs	F	167	10.8	0.0459*	0.2 ± 0.7	0.5862
(IS)	M	320	16.9		0.3 ± 1.0	
Manatee Springs	F	156	36.5	<0.0001*	0.7 ± 1.1	<0.0001*
(MS)	M	208	64.4		1.5 ± 1.5	
Rock Springs	F	71	18.3	0.026*	0.3 ± 0.6	0.0894
(RSR)	M	84	33.3		0.6 ± 1.0	
Wekiwa Springs	F	675	21.2	<0.0001*	0.4 ± 0.8	<0.0001*
(WS)	M	621	40.3		0.8 ± 1.2	

Table 5. Within site comparisons of mean (± SD) plastron lengths (PL) between damaged (Y) and undamaged (N) male *Sternotherus minor* in Florida springs Study Sites in the USA. * indicates statistical significance ($P < 0.05$).

Site	N	Damage	PL (mm)	*P*
Volusia Blue Springs	76	N	62.0 ± 14.4	0.0177*
(VBS)	108	Y	67.3 ± 10.6	
Fanning Springs	32	N	54.9 ± 11.3	0.0055*
(FS)	19	Y	66.3 ± 14.6	
Ichetucknee Springs	266	N	59.6 ± 13.1	0.0382*
(IS)	54	Y	63.4 ± 13.0	
Manatee Springs	74	N	61.6 ± 15.6	<0.0001*
(MS)	134	Y	69.8 ± 13.7	
Rock Springs	56	N	54.5 ± 12.1	0.3567
(RSR)	28	Y	56.2 ± 10.9	
Wekiwa Springs	371	N	56.9 ± 11.7	<0.0001*
(WS)	250	Y	62.4 ± 11.3	

random, accumulated over time, and is related to male behaviour.

Males show a higher CMI as turtle size increases while damaged females at two or three sites were larger than undamaged females and similar in size at the other sites. This suggests that male turtles accumulated damage over their lifetime, and not as the result of a singular event. The fact that most of the sites did not show increased female CMI as size increased suggests that larger females may not accumulate damage at the same rate as smaller ones and may stop accruing damage when they rival or exceed the size of the males. This may be because female damage is accumulated during mating events. Males of this species use combative mating tactics (Bels and Crama, 1994) and may therefore prefer smaller adult females that are easier to coerce. We have observed this accumulation of damage over time first hand. Over the near 20-year study many of the hard marks that have been used to identify individuals have been damaged and or broken off entirely, making identification of the individual problematic if not for the use of PIT tags as a secondary marking method. PIT tagging our individual turtles has proven to be a necessary while studying this species, and we recommend anyone conducting long term research on turtle species that may engage in potentially shell

Table 6. Within site comparisons of mean (± SD) plastron lengths (PL) between damaged (Y) and undamaged (N) female *Sternotherus minor* in Florida springs study sites in the USA.*indicates statistical significance ($P <0.05$).

Site	N	Damage	PL (mm)	*P*
Volusia Blue Springs	78	N	66.2 ± 14.7	0.0506
(VBS)	48	Y	71.5 ± 10.2	
Fanning Springs	31	N	59.9 ± 17.0	0.3557
(FS)	7	Y	52.4 ± 18.6	
Ichetucknee Springs	149	N	74.0 ± 10.7	0.5287
(IS)	18	Y	71.7 ± 12.4	
Manatee Springs	99	N	68.1 ± 17.3	0.0022*
(MS)	57	Y	76.2 ± 12.7	
Rock Springs	58	N	58.2 ± 15.5	0.5718
(RSR)	13	Y	56.5 ± 19.2	
Wekiwa Springs	532	N	60.2 ± 13.1	0.0376*
(WS)	143	Y	62.7 ± 11.9	

Table 7. Summary of logistic regression analyses of the influence of plastron length on the presence of damage in *Sternotherus minor* from Florida Springs Study sites in the USA. * indicates statistical significance ($P < 0.05$).

Site	Sex	Coefficient	SE	Wald's X^2	P	Odds ratio	95% CI
Volusia Blue Spring	F	0.031	0.015	4.46	0.0346*	1.03	1.00 – 1.06
(VBS)	M	0.035	0.012	7.83	0.0051*	1.04	1.01 – 1.06
Fanning Springs	F	-0.027	0.026	1.06	0.3030	0.97	0.92 -1.02
(FS)	M	0.069	0.025	7.34	0.0067*	1.07	1.01 – 1.13
Ichetucknee Springs	F	-0.020	0.023	0.75	0.3879	0.98	0.94 – 1.03
(IS)	M	0.022	0.011	3.79	0.0516	1.02	1.00 – 1.04
Manatee Springs	F	0.034	0.012	8.60	0.0034*	1.03	1.01 – 1.06
(MS)	M	0.040	0.011	13.83	0.0002*	1.04	1.02 – 1.06
Rock Springs	F	-0.006	0.019	0.11	0.7419	0.99	0.96 – 1.03
(RSR)	M	0.013	0.020	0.40	0.5254	1.01	0.97 – 1.05
Wekiwa Springs	F	0.015	0.007	4.16	0.0413*	1.02	1.00 – 1.03
(WS)	M	0.041	0.007	31.44	<0.0001*	1.04	1.03 – 1.06

damaging activities, employee a secondary marking technique in order to assure individual recognition.

The difference in the frequency of damage between males and females suggests that male damage is non-random and likely due to competition. Female turtles do not have as strong a correlation between size and damage accumulation. Female turtles may be less aggressive and more likely to flee or hide than males if found in potentially agnostic confrontations. Therefore, the driving factor in female damage accumulation could be sexual activity and not resource based competition. Furthermore, the cohesive mating strategies of this species are not completely understood, as not all reproduction is combative. It is possible that the damage accumulated by female turtles is a result of aggressive mating strategies with males invading new territory, and not caused by the resident males.

The frequency and severity of damage differed among our study sites. This could be due to habitat variability among sites, as these variables are known to impact turtle populations (Sirois et al., 2014). Constructed swimming areas, boat launches, and the removal of debris and fallen limbs at all the sites has been documented as potentially impacting the *S. minor* populations (Riedle et al., 2016; Johnston et al., 2020; Munscher et al., 2020). It is possible that these augmentations eliminate or lessen microhabitats used for refuge, and therefore result in increased interactions and competition. Additionally, there are large differences in the size of these spring systems and the available floodplain habitat. Looking across all these factors; size of spring, anthropogenic impacts, and density, none of them clearly explain the differences in amount of damage we observed at each of the springs but could all result in increased adversarial interactions. Human actions and interactions can have direct negative effects on turtle populations like the alteration and destruction of habitat, including nesting areas (Garber and Burger, 1995; Moore and Seigel, 2006; Selman et al., 2013) and the increase of hazards including chemical pollutants, litter, fishing gear;

Table 8. *Sternotherus minor* Population Density from Florida Springs study sites in the USA.

Site	**Study Site Size (ha)**	**Density (Turtle/ha)**
Volusia Blue Spring (VBS)	1.9	132/ha
Fanning Springs (FS)	0.7	848/ha
Ichetucknee Springs (IS)	10.99	199/ha
Manatee Springs (MS)	1.53	807/ha
Rock Springs (RSR)	1.41	N/A
Wekiwa Springs (WS)	2.67	1279/ha (Munscher et al., 2020)

disturbance, collection, and predator attraction (Burger and Garber, 1995). Human interactions can result in unforeseen impacts like the alteration of food sources (Morrison et al., 2019), increased predation (Munscher et al., 2012), or population crashes from low impact passive recreation and indiscriminate collection (Garber and Burger, 1995; Godwin et al., 2021).

The variation of habitat types and uses makes it impossible to definitively identify the causation in the inconsistent damage. At IS, larger males have a higher percentage of damage. Interestingly, this is the largest site surveyed (199/ha) and damaged turtles were found in the lowest overall percentages despite this site having the third highest population density (Table 8) (Johnston et al., 2020). VBS has the second highest percentage of damaged turtles, and unlike the other sites, is home to a large manatee population which defoliates the spring regularly – potentially decreasing suitable refugia and food resources, while increasing turtle visibility, leading to a heightened potential for intraspecific sightings and aggression (Riedle et al., 2016). The site with the highest percent damage observed, MS, is one of the least impacted anthropogenically, suggesting that habitat augmentation is not the only variable impacting turtle shell damage. The individuals from this site are the largest *S. minor* sampled across all six sites, further supporting our hypothesis that size of the individual is an underlying link to the level of damage observed. This data prompts further investigation into whether aggression is driven by population density resulting in competition for resources, space, and mates within their environments, all factors that favour larger individuals (Berry and Shine, 1980).

The *S. minor* within our study sites are engaging in intraspecies, intrasexual aggression. This species is known to attain very high densities in spring systems, and their potential competitive interactions have long interested turtle biologists. In Carr's *Handbook of Turtles* (1952), he references Marchland (1942) who commented on a robust population of *S. minor* from IS Springs, where 500 or more *S. minor* could be seen on a given day, and both authors question how these large populations find sustenance. Akin to male-male combat in large mammals, we speculate that the aggression between males is likely tied to competition for resources and specifically females. We observed this aggressive behaviour in both human altered and unaltered spring habitats alike, and our results suggest that both individual and habitat size are the drivers of this aggression. Our observations support Jackson's earlier hypothesis that the damage identified in *S. minor* is the result of intraspecies aggression. Additional research should focus on habitat variables, such as subaquatic vegetation density, as we suggest habitat alterations or denudation of vegetation increases aggressive interactions in this species, which may warrant management of these springhead habitats in Florida. If these alterations have not historically influenced aggressive interactions, as they have been cited since the mention of "old, eroded individuals" in Carr and Goin's (1955), then this study is the first to quantitatively document these intrasexual intraspecific competitive interactions in *Sternotherus minor*. Future research should look at movement patterns, site fidelity, social interactions, and how these are impacted by habitat size, quality, and density, to determine what, if any, these factors have on population stability and fecundity.

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