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Juvenile invasive red-eared slider turtles negatively impact the growth of native turtles: Implications for global freshwater turtle populations

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ABSTRACT

Invasive species are a significant cause of biodiversity declines on a global scale with novel species interactions often causing ecological damage through predation or competition. Red-eared slider turtles (*Trachemys scripta elegans*) have been introduced to wetlands throughout the world and have negatively impacted native species, particularly other species of turtles. In our controlled feeding experiments in mesocosms juvenile red-eared slider turtles negatively impacted the growth of juvenile red-bellied turtles (*Pseudemys rubriventris*), an IUCN near threatened species and a Pennsylvania threatened species, through exploitative competition for limited food. In mixed species experimental treatments, in which food resources were abundant, juvenile red-bellied turtles grew significantly faster and ate more food than juvenile red-eared slider turtles. In mixed species experimental treatments, in which food resources were limited, red-eared slider turtles ingested more food, gained mass faster, and maintained body condition while red-bellied turtles lost body condition. There were significant differences in growth rates seen between resource availability regimes. In treatments in which resources were abundant there were no significant differences between turtles housed in mixed species or single species groups. In limited resource treatments red-bellied turtle body condition was significantly different between single and mixed species groups while there were significant differences in mass and body condition for red-eared slider turtles. Our results suggest that one mechanism by which red-eared slider turtles detrimentally impact ecologically similar species is through competition for limited food resources. We hypothesize that growth of red-eared slider turtle populations will lead to population declines of native turtle species throughout their introduced ranges because they use limited food resources more efficiently for their growth and development than native species.

1. Introduction

Invasive species negatively impact the fitness of native species through predation, competition (Alison et al., 1995; Schoener and Spiller, 1996) or other mechanisms. Predation can have immediate negative effects and can lead to the collapse of entire faunas (Rodda et al., 1997; Schoener and Spiller, 1996), while the effects of competition are often delayed (Petren and Case, 1996) and exacerbated or perturbed by concurrent events such as habitat alteration (Davis, 2003). To determine the long-term, delayed effects of competition between species it is necessary to determine whether an introduced species shares resources with native species (Polis and McCormick, 1987) and whether the introduced species cause reductions in the growth rates, reproductive rates or survivorship of a native species (Polis and McCormick, 1987; Amarasekare, 2002). Natural experiments, which determine resource use of wild organisms, coupled with controlled experiments that determine the mechanisms of competition, are necessary to determine the potential for competition between wild animals and the mechanisms by which species compete. Underlying mechanisms are difficult to ascertain in natural experiments. Mechanisms of competition may include competition for dietary or spatial resources.

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Fitness metrics such as growth rates, fecundity and survivorship have all been used to estimate an organism's long term fitness (Schmidt and Levin, 1985; Stearns et al., 2000). The Body Condition Index (BCI) is a method that has been used to estimate short-term shifts in an organism's health status and to infer instantaneous fitness levels throughout different stages of an organism's life (Litzgus et al., 2008; Shine et al., 2001; Wallis et al., 1999). The effects of resource limitations on fitness are demonstrated when fitness metrics are different between high and low resource environments. Competition is demonstrated when fitness metrics are suppressed by the presence of a competitor (Polis and McCormick, 1987).

Here we report the results of an experiment in which a species of turtle (red-eared slider turtle (*Trachemys scripta elegans*)), known to be highly invasive on a global scale was competitively superior to a native species (red-bellied turtle (*Pseudemys rubriventris*), which is not known to have invasive tendencies. Our experiment reveals a mechanism by which red-eared slider turtles cause reductions of fitness in red-bellied turtles and potentially other native turtle species.

1.1. Study species

Red-eared slider turtles are native to the Mississippi River Valley of the United States with a broad distribution between Texas in the south and Illinois in the north (Ernst and Lovich, 2009). Red-eared slider turtles are the most widely introduced turtle species with a current global distribution on all continents except for Antarctica (Lever, 2003). They are often introduced through the pet trade, as escaped food items or for religious purposes (Ng et al., 2005; Ramsay et al., 2007). In Europe red-eared slider turtles negatively impact native species including the European Pond turtles (*Emys orbicularis*) and the Spanish terrapin (*Mauremys leprosa*) through exploitative and interference competition (Cadi and Joly, 2003, 2004; Polo-Cavia et al., 2009a, 2011) and may negatively impact many other turtle species within their introduced range. In the coastal plain of the mid-Atlantic region of the United States the red-bellied turtle is an ecologically similar turtle that may be negatively impacted by introduced sympatric red-eared slider turtles (Pearson et al., 2013; Stone, 2010). These species are sympatric in areas where the red-eared slider turtles has been introduced into the range of the red-bellied turtle. Both species are carnivores as hatchling and shift toward herbivory as they mature (Ernst and Lovich, 2009). In general red-bellied turtles are larger than red-eared sliders at hatching and attain larger body size within their respective home ranges but red-eared slider have been documented to grow beyond the maximum size known for red-bellied turtles (Ernst and Lovich, 2009). Both species utilize aerial basking surfaces for thermoregulation, which is important for nutrient assimilation in reptiles (Ernst and Lovich, 2009). If dietary or basking resources are limited for individuals of either species then overall fitness could be negatively impacted.

Red-bellied turtles are native to the Atlantic coastal plain of the United States between Massachusetts in the north and North Carolina in the south (Ernst and Lovich, 2009). Populations have declined across the northern portion of this species' range and a disjunct, federally threatened population still exists in Massachusetts while the remainder of the species' current distribution is from approximately New York City, NY south to North Carolina (Ernst and Lovich, 2009; Waters, 1962). Findings from recent surveys in Pennsylvania show this species has declined in wetlands across the state, occurring in only 50% of wetlands where it was historically documented (Stone, 2010).

2. Methods

2.1. Experimental design

We conducted experiments with juvenile one year old turtles purchased from The Turtle Shack, a commercial breeder, Port Richey, FL, and imported to Pennsylvania under scientific collecting permits issued by the Commonwealth of Pennsylvania. Turtles were randomly selected and marked with a unique notch code filed into the marginal scutes for future identification. Experiments consisted of six treatments that were designed to test for intra- and inter-specific competition by altering turtle density and species composition while maintaining resource availability. Resource availability was maintained by providing equal amounts of resources (i.e. water [$\sim$710 L], basking space [0.024 m^2] and food [100 pellets/feeding event]) to each group thus manipulating resource availability by altering the density of turtles in each experimental treatment. Treatments with higher turtle density are referred to as low resource groups while those with lower density are referred to as high resource groups.

The experiment was a full factorial design and consisted of treatments composed of resource availability levels and species compositions. Resource availability had two levels (low, high) and species composition had three levels (mixed species, red-eared slider turtle only, red-bellied turtles only). The mixed species group were comprised of a 1:1 ratio of red-eared slider turtles and red-bellied turtles. Each of the six groupings were replicated three times.

2.1.1. Husbandry

Experimental enclosures ($n = 18$) were 1.83 m diameter polyethylene tanks (Dura Life S15595) and contained a single basking platform measuring 13.5 cm $\times$ 18 cm. This size basking platform was designed to enable 100% of the turtles ($N = 6$), within the high resource availability treatments, to bask simultaneously without necessarily interacting but only 50% of turtles ($N = 6$), in low resource availability treatments, to bask simultaneously. Water level was maintained at approximately 27 cm to ensure the basking platform remained just above water. Experimental enclosures were kept outdoors, received morning sun and were shaded in the afternoon. Enclosures were covered with 80% shade cloth at all times except for 4 h periods during feeding/observation periods and during tank cleaning and turtle measuring. Shade cloth kept debris from settling in the enclosures and maintained cooler water. Enclosures were skimmed daily to keep the water free of debris and to ensure that no additional food items were available. Enclosures were emptied and sanitized weekly with bleach and scrubbed clean to eliminate algal growth, a potential food. Weekly water changes also limited waste and kept water temperatures lower which encouraged use of the basking sites. Water temperatures fluctuated with ambient temperature. If water temperature reached 34 °C for a 24 h period it was replaced with cool water. All treatments within a replicate were fed simultaneously on Monday, Tuesday, Thursday and Friday with Zoo Med Natural Aquatic Turtle Food (Item # ZM-55B). Food pellets (100) were placed in an indentation approximately 3.5 cm $\times$ 10.5 cm, centered on the feeding/basking platform, where turtles consumed food for 45 min undisturbed.

All experimental procedures were conducted under an approved protocol by Drexel University Institutional Animal Care and Use Committee.

2.1.2. Acclimatization period

Turtles were placed in their experimental enclosures and acclimatized to the experimental conditions and procedures for a

21 day period. During the first 14 days of acclimatization the amount of food consumed by turtles fed ad libitum was determined by calculating the number of individual pellets consumed during ad libitum 45 min feeding period by each treatment. We used results from the ad libitum feeding trials to determine that 100 pellets were enough to feed high resource groups while ensuring that food resources were not limiting, yet not provide much excess food. Under this feeding regime high resource groups continued to be fed ad libitum, while low resource groups were fed 50% ad libitum amounts.

2.1.3. Individual turtle ingestion

Prior to feeding a digital camera from an eight-Channel Smart DVR security system (SVAT CV301-8CH-008) was suspended directly above the feeding platform and connected to the DVR to record feeding activity which was used to determine the amount of food consumed by each turtle. Each camera's position was checked using an LCD screen attached to the DVR to ensure that the feeding platform and the surrounding water were in view for recording turtle feeding and activity. Food ingestion rates were determined for each turtle by reviewing videos and tallying the number of pellets ingested.

2.1.4. Growth rates and body condition indices calculations

Measurements for each turtle were taken weekly. They included carapace length, carapace width, carapace height, plastron length and mass. All length measurements were to the nearest 0.1 mm using a digital caliper (Control Company Model # 3418). Mass was measured to the nearest 0.01 g (OHAUS Scout Pro digital balance Model No. SP202). All measurements were taken by the same researcher (SHP) throughout the experiment to ensure consistency.

We used weekly measurements to calculate growth rates and body condition indices for individual turtles. We calculated individual turtle growth rates using linear regression on the plastron length and mass over the experimental duration (11 weeks). Body condition indices were estimated using the formula used by Wallis et al. (1999), which divides body mass (g) by the turtle's volume. The volume was calculated as the carapace length cubed. (Wallis et al., 1999).

2.2. Data analysis

2.2.1. Growth rate

We analyzed differences between plastron length, mass and body condition using Linear Mixed Effect (LMER) models. The LMER included Plastron Length (PL), Mass or Body Condition Index (BCI) as the response variables. Treatments, time and their interactions were treated as the fixed effects. Replicate block and individuals were treated as nested random effects, with contributions to both the response variable and its rate of change over time (Gelman and Hill, 2007; Zuur et al., 2009). We determined significant differences and obtained *P*-values between treatments by fitting reduced models that omitted the fixed effects terms of interest and testing, with Analysis of Variance, whether these omissions significantly degraded the predictive power of the model (Quinn and Keough, 2008). All statistical analyses were performed in Program R (R Development Core Team, 2011); Linear Mixed Effect models were run with LMER in the LME4 package (Bates and Maechler, 2009).

2.2.2. Ingestion

Using two-way ANOVAs we determined whether there were significant differences in ingestion rates for each treatment type between replicates and between species. In cases where significant differences existed between replicates we determined which replicates were significantly different from one another through model simplification (Crawley, 2013). Model simplification determined which replicates were significantly different by stepwise omission of replicates from the model. A model with an omitted replicate that is not significantly different implied that the omitted replicate was significantly different from the other replicates. If significant differences existed between replicates we tested those individually using two-tailed student *t*-tests. For results without significant differences between replicates we used the combined means to determine if there were differences between species.

3. Results

3.1. Growth rates

Mean growth rates (plastron length) ranged from 0.2 mm/wk for red-bellied turtles housed alone in the low resource availability treatment to 0.58 mm/wk for red-bellied turtles and red-eared slider turtles housed in the mixed species high resource and single species high resource treatment, respectively (Table 1). Mean growth rates (body mass) ranged from 0.79 g/wk for red-bellied turtles housed in the low resource treatment to 1.79 g/wk for red-bellied turtles housed in the mixed species high resource treatment. Changes in Body Condition Index (BCI) throughout the experiment ranged from $-0.0005\ g/cm^3$ for red-bellied turtles housed with red-eared slider turtles in the low resource treatment to $0.0007\ g/cm^3$ for red-eared slider turtles housed with red-bellied turtles in the low resource treatment.

3.1.1. Comparisons between resource availability groups

Growth rates of red-bellied turtles were significantly greater in high resource treatments than in low resource treatments in mixed species groups (Tables 1 and 2; Fig. 1a, c, e). In contrast, there were no statistically significant differences in growth rates between red-eared slider turtles in low resource or high resource treatments in mixed species groups (Tables 1 and 2; Fig. 1a, c, e).

When housed with conspecifics, both red-bellied turtles and red-eared slider turtles grew significantly faster in high resource treatments than in low resource treatments, (PL and body mass; Tables 1 and 2; Fig. 1b and d). There were no significant differences in body condition indices change over time between red-bellied turtles or red-eared slider turtles housed with conspecifics in low resource vs. high resource treatments (Tables 1 and 2; Fig. 1f).

3.1.2. Comparisons within resource availability groups

Under low resource availability, red-bellied turtle body conditions increased significantly faster when housed with conspecifics than when housed with red-eared slider turtles (Tables 1 and 3; Fig. 1e and f). Under the same low resource conditions, red-eared slider turtles grew faster when housed in mixed species groups than when housed with conspecifics (body mass and body condition; Tables 1 and 3; Fig. 1c and e). For all metrics, red-eared slider turtles changed significantly faster than red-bellied turtles when housed together under low resource conditions (PL, body mass, and body condition; Tables 1 and 3; Fig. 1a, c, e).

Under high resource conditions there were no significant differences in growth metrics in red-bellied turtles or red-eared slider turtles when housed with conspecifics (Tables 1 and 3). Red-bellied turtles grew significantly faster than red-eared slider turtles when housed together under high resource conditions (plastron length and mass; Tables 1 and 3; Fig. 1a and c).

Table 1
Mean changes over time in plastron length, mass and body condition index ± standard error of the mean (S.E.M) of red-bellied turtles (*Pr*) and red-eared slider turtles (*Ts*) grown in experimental mesocosms under low resource mixed species (LRMS), low resource single species (LRSS), high resource mixed species (HRMS) and high resource single species (HRSS) conditions.

	LRMS		LRSS		HRMS		HRSS	
	Pr	*Ts*	*Pr*	*Ts*	*Pr*	*Ts*	*Pr*	*Ts*
Plastron length ± S.E.M (mm/wk)	0.28 ± 0.02	0.41 ± 0.04	0.20 ± 0.02	0.40 ± 0.02	0.58 ± 0.1	0.50 ± 0.13	0.38 ± 0.11	0.58 ± 0.05
Mass ± S.E.M (g/wk)	0.79 ± 0.07	1.09 ± 0.16	0.79 ± 0.06	0.99 ± 0.02	1.79 ± 0.17	1.20 ± 0.29	1.29 ± 0.32	1.45 ± 0.15
Body condition index ± S.E.M (g/cm^3)	−0.00053 ± 0.0001	0.00075 ± 0.0001	0.00015 ± 0.0001	0.00046 ± 0.0001	0.00065 ± 0.0002	0.00067 ± 0.0002	0.0002 ± 0.0002	0.00073 ± 0.0002

3.2. Ingestion rates

Two-way ANOVA comparisons indicated that red-eared slider turtles consumed more food pellets than red-bellied turtles when they were housed together in low resource conditions ($F = 24.12$, $p < 0.001$, $df = 1$). However, red-bellied turtles ate more pellets than red-eared slider turtles when they were housed together in high resource conditions ($F = 8.14$, $p = 0.005$, $df = 1$, Fig. 2). There were no significant differences between the number of pellets consumed by red-bellied turtles or red-eared slider turtles housed with conspecifics in either high resource groups ($F = 1.9$, $p = >0.1$, $df = 1$) or low resource groups ($F = 0.194$, $p = 0.66$, $df = 1$), (Table 2, Fig. 2).

4. Discussion

In controlled feeding experiments red-eared slider turtles negatively impacted the growth rates of red-bellied turtles. When food resources were limited red-eared slider turtles ingested more food, gained mass faster, and maintained body condition compared to red-bellied turtles which exhibited a decline in body condition. Thus, when food resources were limited red-eared slider turtles outcompeted red-bellied turtles for food. When housed with conspecifics, red-eared slider turtles grew slower than when housed with mixed species groups, which suggests that for red-eared slider turtles intraspecific competition is more important than interspecific competition.

In high resource conditions red-bellied turtles grew faster than red-eared slider turtles when housed together. This suggests that under the experimental conditions red-bellied turtles have an inherent ability to grow faster than red-eared slider turtles when food is not limited and interspecific competition is reduced.

Juvenile red-bellied turtles may grow up to 0.78 mm/wk plastron length (Graham, 1971; Haskell et al., 1996) and red-eared slider turtles may grow up to 1.2 mm/wk plastron length (Avery et al., 1993; McRobert and Hopkins, 1998). For both species the maximum experimental growth that we measured (0.58 mm/wk plastron length) was below their maximum potential growth rates. Thus, the experimental growth rates we documented were due to experimental conditions and not inherent differences in the growth rates of each species.

Our results suggest that interspecific competition may limit the growth of juvenile red-bellied turtles because red-bellied turtles grow faster than red-eared slider turtles in mixed species groups when resources are abundant, but grow slower than red-eared slider turtles in mixed species groups when resources are limited. Our results, coupled with previous research on interactions of red-eared slider turtles and native turtle species in Europe (Cadi and Joly, 2003, 2004; Polo-Cavia et al., 2009a), indicate that the global red-eared slider turtle invasion may negatively impact turtle populations in regions where red-eared slider turtle populations have become established by outcompeting native species for limited food resources.

4.1. Mechanism for impacting native species

Under experimentally controlled conditions red-eared slider turtles are better competitors than red-bellied turtles, European pond turtles, and Spanish terrapins (Cadi and Joly, 2003, 2004; Polo-Cavia et al., 2011). In our experiment and those of Polo-Cavia et al. (2011), red-eared slider turtles ingested more food than native turtle species when competing for food with other species than with conspecifics. In our experiment and those of Cadi and Joly (2003) red-eared slider turtles in mixed species groups continued to gain mass and maintain body condition while the native turtle species lost mass and body condition. In Cadi and Joly's

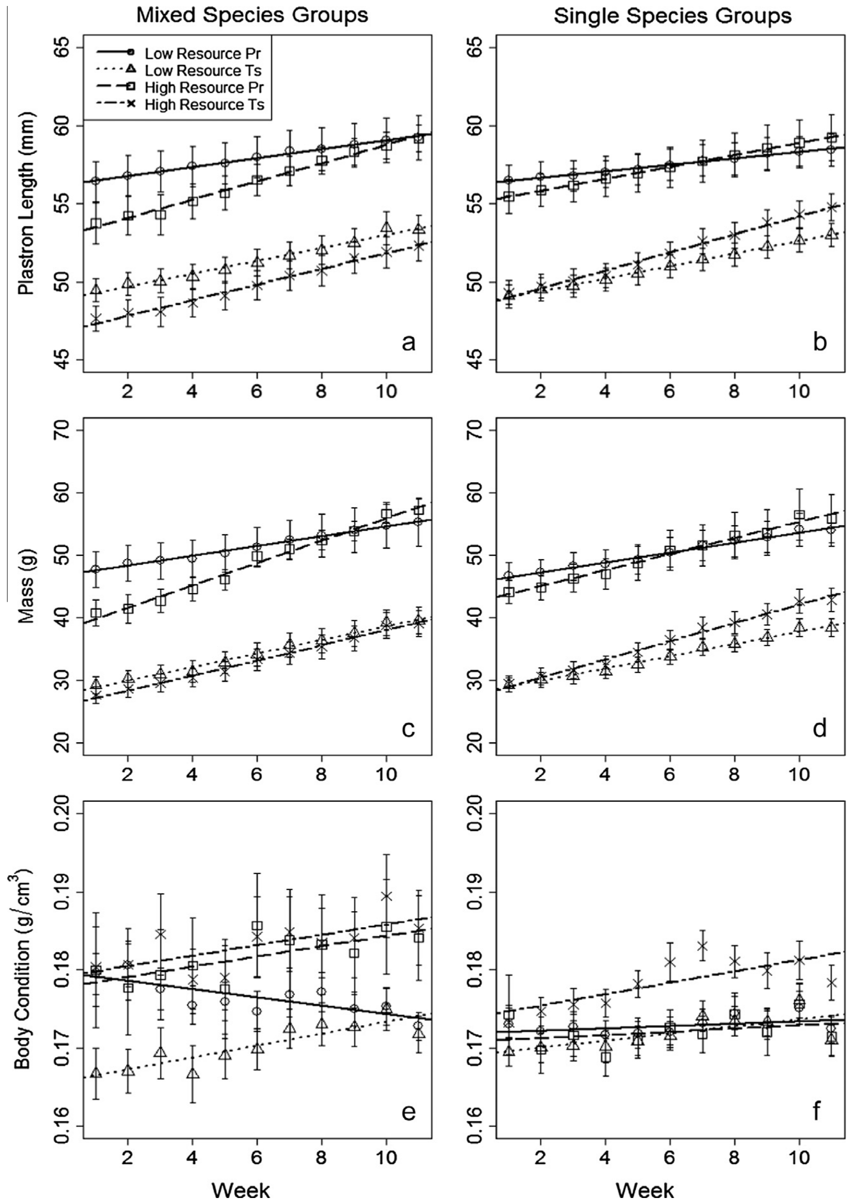

Fig. 1. Mean weekly measurements of plastron length, mass and body condition for each experimental treatment. Mixed species group's are shown in the left column and single species group's in the right. Linear regressions indicate each experimental group's mean growth rate. Low resource red-bellied turtles (*Pr*) are shown with open circles and high resources red-bellied turtles are indicated by the open squares. Low resource red-eared slider turtles (*Ts*) are shown with open triangles and high resource red-eared slider turtles are indicated by the *x*. Error bars indicate the standard error of the mean.

Table 2
Results of comparisons between low and high resource groups for all three metrics. *P*-values were obtained through comparisons between Linear Mixed Effect Models and reduced models which omitted the fixed effects interaction terms. Results shown are for Plastron Length (PL), Mass and Body Condition Index (BCI) for low resource groups (LR) and high resource groups (HR) in mixed species red-bellied turtle (MS-*Pr*), mixed species red-eared slider turtle (MS-*Ts*), single species red-bellied turtle (*Pr*) and single species red-eared slider turtle (*Ts*) treatments. Statistically significant results are highlighted in bold.

	LR-MS*Pr* – HR-MS*Pr*	LR-MS*Ts* – HR-MS*Ts*	LR-*Pr* – HR-*Pr*	LR-*Ts* – HR-*Ts*
PL	**0.007**	0.297	**0.013**	**0.005**
Mass	**0.002**	0.593	**0.049**	**0.002**
BCI	**<0.001**	0.767	0.808	0.163

(2003) extended duration experiments these interactions resulted in decreased survivorship of the native species. These findings support the hypothesis that red-eared slider turtles are superior competitors for limited food compared to native species and suggest a mechanism for how red-eared slider turtles may negatively impact native species throughout their introduced range. Decreased growth rates of native species may result in decreased recruitment rates, reduced population sizes and reduced population viabilities of impacted species (Congdon et al., 1993).

In wetlands of southeastern Pennsylvania, where populations of native red-bellied turtles and introduced red-eared slider turtles are sympatric, many wetlands have been fragmented, and dietary

Table 3
Results of comparisons within low and high resource groups for all three metrics. *P*-values were obtained through comparisons between Linear Mixed Effect Models and reduced models which omitted the fixed effects interaction terms. Results shown are for Plastron Length (PL), Mass and Body Condition Index (BCI) for growth rates between red-bellied turtles (*Pr*) housed in low resource mixed species groups and single species groups, red-eared slider turtles (*Ts*) housed in low resource mixed species groups and single species groups, red-bellied turtles and red-eared slider turtles raised together in low resource conditions, red-bellied turtles housed in high resource mixed species groups and single species groups, red-eared slider turtles housed in high resource mixed species groups and single species groups and red-bellied turtles and red-eared slider turtles raised together in high resource conditions.

	Low resource			High resource		
	Within species		Between species	Within species		Between species
	Pr mixed/single	*Ts* mixed/single	*Pr* & *Ts* mixed	*Pr* mixed/single	*Ts* mixed/single	*Pr* & *Ts* mixed
(PL)	0.17	0.73	**0.007**	0.13	0.32	**0.008**
(Mass)	0.97	**0.03**	**<0.001**	0.23	0.19	**<0.001**
(BCI)	**<0.001**	**0.004**	**<0.001**	0.22	0.80	0.76

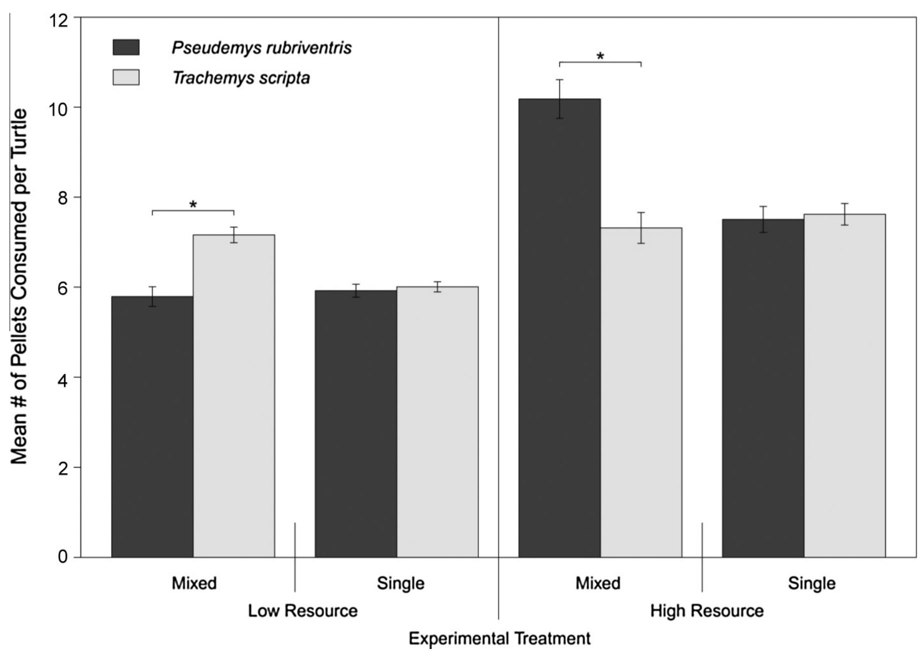

Fig. 2. Mean number of pellets consumed per turtle during feeding periods. Red-bellied turtles are shown in dark grey and red-eared slider turtles are shown in light grey. The $*$ and brackets indicate significant differences found between experimental treatments. Error bars indicate the standard error of the mean.

overlap between these two species has increased (Pearson et al., 2013; Stone, 2010). In southeastern Pennsylvania wetlands, the ratio of red-bellied turtles to red-eared slider turtles varies across the gradient of having either only one of the two species to having an equal number of both species (Stone, 2010). Ephemeral resources (e.g. fruit from trees) may be important components of turtle diets and occur as point sources while other resources may be more widely distributed in the environment. In wetland environments interference and exploitative competition for ephemeral resources may occur and provide similar competitive conditions to those provided during these experiments while more broadly dispersed dietary resources are more likely to result in exploitative competition. We hypothesize that red-eared slider turtles are negatively impacting red-bellied turtles in highly fragmented wetland landscapes in which resource limitations occur. Further studies of wild populations are needed to determine the broad scale implications of our findings in Pennsylvania and across the globe.

4.2. Effects of differences in resource availability

In our experiments we found that juvenile red-eared slider turtle growth rates did not respond to the alteration of available dietary resources. In high resource groups that contained red-eared slider turtles and in the low resource mixed species groups the mean number of pellets consumed per red-eared slider turtle remained the same. This suggests that juvenile red-eared slider turtles were more efficient consumers than juvenile red-bellied turtles when resources were limited. Our results differ from other studies in which red-eared slider turtles experienced differential growth rate under different resource regimes and environmental variables (Aresco, 2010; Avery et al., 1993; Dunham and Gibbons, 1990; Gibbons, 1970; Gibbons et al., 1981; Webb, 1961). These differences were likely due to differences in experimental design and environmental conditions.

The similar growth rates between red-eared slider turtles in high resource and low resource mixed species groups suggest that red-eared slider turtles outcompete red-bellied turtles in limited resource environments. In contrast, the different growth rates between red-eared slider turtles in low resource and high resource single species groups suggests that intra-specific competition retards red-eared slider growth in the presence of conspecifics.

5. Conclusion

The continued introduction and expansion of invasive species across the globe is of concern to researchers, conservationists and managers worldwide (Lockwood et al., 2007; Pimentel et al., 2005). Red-eared slider turtles represent one example of a globally distributed species which may impact native species within their introduced range (Cadi and Joly, 2004; Lever, 2003; Ng et al., 2005; Outerbridge, 2008; Ramsay et al., 2007). Red-eared slider turtles may be negatively impacting the growth of individual native turtle species, which may reduce the viability of native turtle populations where they have been introduced. Competition for resources, as seen in this study, may lead to reduced fitness rates for native species, potentially leading to long term, persistent declines in populations (Byers, 2000).

The results of our research in combination with findings of other researchers (Cadi and Joly, 2003, 2004; Polo-Cavia et al., 2009a; Polo-Cavia et al., 2009b; Polo-Cavia et al., 2011) clearly show that red-eared slider turtles can negatively impact native species and should be considered as an invasive species to be controlled. Globally, red-eared slider introductions continue to occur and the stability of native turtle communities may be threatened. Management efforts should be made to reduce the number of introductions and sizes of naturalized populations of red-eared slider turtles in order to conserve native turtle species. Without reductions in the introduction rates and sizes of naturalized populations of red-eared slider turtles, ecologically similar turtle species are potentially at risk of extirpation due to competition in wetlands worldwide.

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