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Short Communication

Characterizing trophic ecology of the checkered puffer (*Sphoeroides testudineus*)

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ABSTRACT. *Sphoeroides testudineus* (Linnaeus, 1758), is a common, widely distributed fish in coastal ecosystems. To better understand the trophic niche of *S. testudineus,* we collected individuals from tidal creeks on Abaco Island, The Bahamas, and employed stomach content and stable isotope analysis. Examination of stomach contents showed that mollusks, such as West Indian false cerith snails, cerith snails, and tellin clams, were the most common prey items. Diet data were consistent with stable isotopes data such that *S. testudineus* seem to feed at an intermediate trophic position in the food web. These preliminary data suggest that *S. testudineus* may be a critical intermediate link in these wetland food webs, serving as pathways through which energy is transferred from primary consumers to other predator species.

Keywords: *Sphoeroides testudineus*, diet, food web, mangrove, predator-prey, stable isotopes.

Checkered puffers, *Sphoeroides testudineus* (Linnaeus, 1758), are a common inhabitant of coastal habitats along the eastern United States and throughout the Caribbean (Pauly, 1991; MacDonald *et al.*, 2009; Thiem *et al.*, 2013). *S. testudineus* are common foragers within intertidal areas, often following rising tides to feed. Despite their extensive geographic range, broad habitat use, abundance, and foraging habits, there are relatively few dietary data for this species. Here, we use stomach content data and stable isotopes (δ^{13}C and δ^{15} N) to examine the trophic ecology of *S. testudineus* from Abaco island, The Bahamas. We first address diet composition of *S. testudineus* and the diet of major consumed taxa. Finally, we use previously collected isotope data to offer qualitative comparisons among other common tidal creek fishes to better understand their relative role in tidal creek food webs.

Our study focused on two ecologically similar tidal creeks on Abaco Island: Broad Creek (BC: 26°29'28.23"N, 77°2'40.86"W) and Sandy Point (SP: 26°0'31.05"N, 77°24'8.04"W). Both tidal creeks are fringed by dwarf red mangrove (*Rhizophora mangle*) and have benthic habitats consisting of seagrasses (primarily *Thalassia testudinum*), green macroalgae (*Batophora oerstedii, Halimeda discoidea, Acetebularia* spp.), and barren sand flats (Araújo *et al.*, 2014; Chacín *et al.*, 2015). To assess the taxonomic composition of *S. testudineus* diets we examined the stomach contents of 11 fish from BC and 15 from SP. Fish were captured with traps and hook-and-line in July 2014. Stomach contents were identified to the lowest taxonomic resolution possible (usually to genus) and volume of each prey item determined by water displacement following Winemiller (1990). Unidentified prey was grouped as shell fragments or unidentified tissue.

Tissue samples (muscle) for isotope analysis were collected from each fish. Samples were dried at 60°C for 48 h, ground to fine powder, and analyzed at the stable isotope/Soil Biology Laboratory at University of Georgia, Athens, GA. Source contributions to prey were estimated as consumer-specific means of posterior distributions generated in SIAR (Fig. 1a). Trophic discrimination values were set at 3.4‰ δ^{15}N and 1‰ δ^{13}C for *S. testudineus* prey following Post (2002). Isotope values (prey, and primary producers: *T. testudinum*, *R. mangle*, and *B. oerstedii*) included samples collected from Abaco tidal creeks.

For a community-level understanding of *S. testudineus* trophic ecology in our study system, we use previously collected (from 2009) isotope data for a range of fish species often coexisting with *S. testudineus* in Bahamian tidal creeks (Layman *et al.*, 2004). Given that these data were not collected at the

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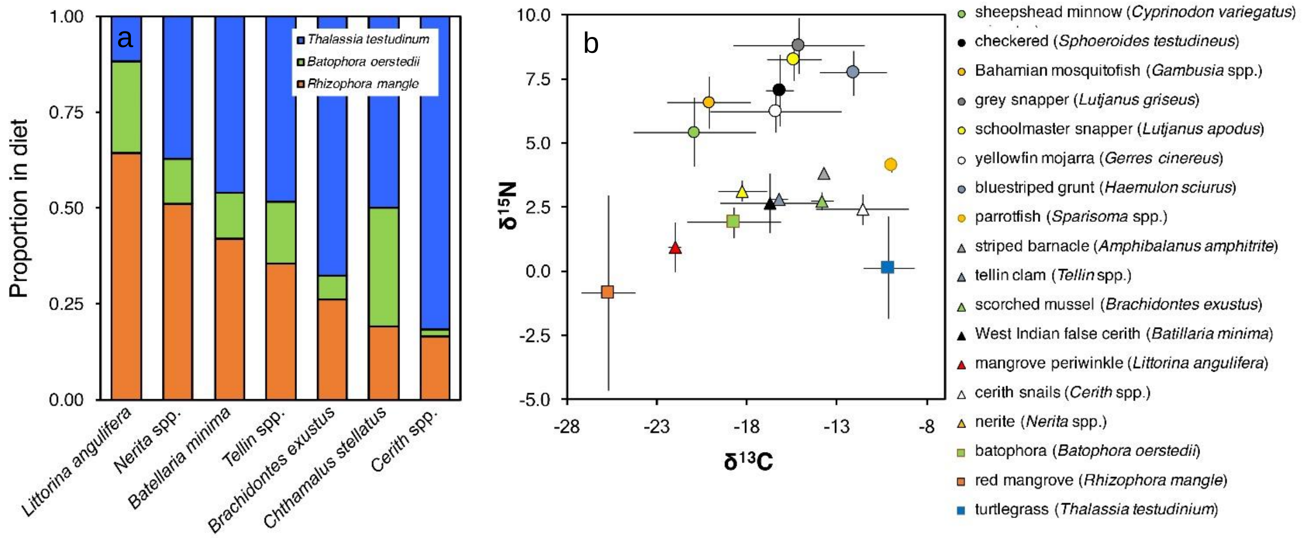

Figure 1. a) Proportion of three resource pools that may support prey of pooled *S. testudineus* samples was based on simple stable isotope mixing models among - red mangrove (*R. mangle*; orange), batophora (*B. oerstedii*; green), and turtlegrass (*T. testudinum*; blue). The isotope signatures for basal resources were inputted to models as: red mangrove (n = 129, δ^{13}C = -25.7, SD ± 1.5 and δ^{15}N = -0.9, ± 3.8), batophora (n = 18, δ^{13}C = -18.7, ± 3.4 and δ^{15}N = -1.9, ± 1.2), and turtlegrass (n = 25, δ^{13}C = -10.1, ± 1.4 and δ^{15}N = 0.1, ± 2.0), b) comparison of δ^{13}C and δ^{15}N values between *S. testudineus* and other common species in the sampled creek systems. Error bars are standard deviations.

same time, and often from different tidal creek systems, we do not offer a quantitative comparison of trophic position. Rather, we simply display these data together with pufferfish prey to highlight areas of dietary overlap among these common fishes.

Our stomach content analysis showed that *S. testudineus* diet was composed of ten benthic invertebrate taxa, the vast majority of which are mollusks (*Tellin* clams, *Batillaria* and *Cerith* snails; Table 1), and to a lesser extent, crustaceans. However, there were some obvious differences between sites. For example, SP fish consumed more *Tellin* clams (63%), and fewer *Batillaria* snails (38%) than BC fish. BC fish also consumed taxa associated with mangroves: *Littorina anguilfera*, *Aratus pisonii*, *Brachidontes exustus*, and *Amphibalanus amphitrite*, while SP fish did not (Table 1). This bias towards mangrove consumers in BC pufferfish may explain the slightly more depleted δ^{13}C signatures they exhibit (BC = -17.1 ± 1.1, SP = -15.4 ± 1.4). Indeed, isotope data show that prey taxa rely on different combinations of basal resource pools (Fig. 1a). For example, *L. anguilfera* (arboreal grazers) shows the most depleted δ^{13}C values (δ^{13}C = -22‰), suggesting strong trophic linkages to red mangrove-derived carbon (δ^{13}C -25.7, Fig. 1a). At the opposite compositional extreme, *Cerith* snails (benthic herbivores) showed the most enriched δC^{13} values (δ^{13}C = -11.6‰), suggesting strong reliance on seagrass-derived carbon (δ^{13}C = -10.1, Fig. 1a). Nevertheless, most prey taxa seemed to incorporate moderate-to-low amounts of mangrove-derived carbon which is not surprising given that most species are primarily benthic grazers or filter-feeders.

While there was substantial interspecific variation in resource pools used by the various prey taxa, there is little variation in the δ^{15}N axis among the prey taxa assessed (mean δ^{15}N = 2.6 ‰), again suggesting that all feed primarily on basal resources.

To help change to illustrate general food web structure in these systems, we provide stable isotope values for other species common in tidal creek systems on Abaco (Layman *et al.*, 2007, Layman & Allgeier, 2012; Araújo *et al.*, 2014; Giery & Layman, 2015). We find that *S. testudineus* appears to occupy an intermediate trophic position, like common benthic invertivores such as yellowfin mojarra (*Gerres cinereus*), schoolmaster snapper (*Lutjanus apodus*), and grey snapper (*L. griseus*; Fig. 1b). Our data also suggest relatively high fractionation rate of δ^{15}N (~5‰) between the two main prey items (*Tellin* spp. and *Batillaria* spp.) and *S. testudineus*. This is slightly greater than the mean reported fractionation rate of 3.4‰ (Post 2002). However, there is often variation in fractionation rates. For example, any single trophic transfer could range between 2-5‰ (Post, 2002). It is also possible that *S. testudineus* consumed higher trophic level prey in time periods earlier than we sampled.

Table 1. The proportion of prey items by volume in *S. testudineus* diets from each tidal creek. The proportion of prey items was calculated by dividing the sum of the volume of each prey type by the sum of the volume of all prey items in the diet of each individual specimen.

Taxa		Stomach contents		Isotope values		
		Broad creek (BC)	Sandy point (SP)	n	δ^{13}C	δ^{15}N
West Indian false cerith	*Batillaria minima*	37.9	8.9	10	-16.7	2.6
Striped barnacle	*Amphibalanus amphitrite*	13.6		2	-13.7	3.8
Nerite snail	*Nerita* spp.	11.6	1.8	9	-18.3	3.1
Cerith snail	*Cerith* spp.	8.2	22.6	29	-11.6	2.4
Mangrove periwinkle	*Littorina anguilfera*	8.0		3	-22.0	0.9
Scorched mussel	*Brachidontes exustus*	7.8	0.7	11	-13.8	2.7
Algae		5.8	3.3			
Mangrove tree crab	*Aratus pisonii*	3.7				
Tellin clam	*Tellin* spp.	3.4	62.8	4	-16.2	2.8
Amphipod	*Amphipoda*		0.1			

S. testudineus diets are almost exclusively composed of small gastropods and bivalves in Bahamian tidal creeks, which is like *S. testudineus* diets from Brazil, the Yucatan and Florida (Targett, 1978; Barros *et al.*, 2010; Chi-Espínola & Vega-Cendejas, 2013). *S. testudineus* from the Brazil sites relied more on gastropods than bivalves, similar to *S. testudineus* from the BC tidal creek in our study. Macrophytes and Brachyuran crabs also composed a large portion of *S. testudineus* diet in the Yucatan and Florida, respectively. The apparent preference of benthic mollusks such as *Tellin* clams and *Battilaria* snails in Bahamas tidal creeks might be related to their high abundance in these systems (Valentine-Rose *et al.*, 2007).

As predators, they feed on durable, well-protected prey such as mollusks and gastropods, an abundant resource unavailable to many other fishes. *S. testudineus* also forage in upper reaches of intertidal habitats on rising tides, accessing prey that other aquatic consumers cannot. In general, we know less about *S. testudineus* as prey. Presumably defended by powerful tetrodotoxins and their unique inflating antipredator behavior, pufferfish appear unlikely to be widely consumed. Their use of shallows and hypersaline habitats may also alleviate predation risk to some degree (Rypel *et al.*, 2007). Nevertheless, documented predators include herons (Ardeidae) and other bony fishes (Randall, 1967; Recher & Recher, 1968). And it is reasonable to expect larger consumers such as juvenile lemon sharks that also enter tidal creeks to feed on *S. testudineus* (Murchie *et al.*, 2010). In these ways, *S. testudineus* may act as a unique and under-appreciated link in shallow coastal food webs and their trophic role deserves further study.

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REFERENCES

Araújo, M.S., R.B. Langerhans, S.T. Giery & C.A. Layman. 2014. Ecosystem fragmentation drives increased diet variation in an endemic livebearing fish of The Bahamas. Ecol. Evol., 4: 3298-3308.

Barros, J.C.N., J. de Arruda-Francisco, A.L. Vasconcelos-Filho & D.d.O. Tenorio. 2010. Moluscos encontrados no trato digestivo de *Sphoeroides testudineus* (Linnaues, 1758) (Teleostei: Tetradontida), no canal de Santa Cruz, Itamraca-Pernambuco, Brasil. Rev. Bras. Engenh. Pesca, 5: 70-80.

Chacín, D.H., S.T. Giery, L.A. Yeager, C.A. Layman & R.B. Langerhans. 2015. Cómo afecta la fragmentación hidrológico comunidades de aves costeras? Un estudio de la isla de Abaco, Bahamas. Wetl. Ecol. Manage., 23: 551-557.

Chi-Espínola, A.A. & M.E. Vega-Cendejas. 2013. Hábitos alimenticios de *Sphoeroides testudineus* (Perciformes: Tetraodontidae) en el sistema lagunar de Ría Lagartos, Yucatán, México. Rev. Biol. Trop., 61: 849-858.

Giery, S.T. & C.A. Layman. 2015. Interpopulation variation in a condition-dependent signal: predation regime affects signal intensity and reliability. Am. Nat., 186: 187-195.

Layman, C.A. & J.E. Allgeier. 2012. Characterizing trophic ecology of generalist consumers: a case study of the invasive lionfish in The Bahamas. Mar. Ecol. Prog. Ser., 448: 131-141.

Layman, C.A., D.A. Arrington, R.B. Langerhans & B.R. Silliman. 2004. Degree of fragmentation affects fish assemblage structure in Andros Island (Bahamas) estuaries. Caribb. J. Sci., 40: 232-244.

Layman, C.A., J.P. Quattrochi, C.M. Peyer, J.E. Allgeier & K. Suding. 2007. Niche width collapse in a resilient top predator following ecosystem fragmentation. Ecol. Lett., 10: 937-944.

MacDonald, J.A., S. Shahrestani & J.S. Weis. 2009. Behavior and space utilization of two common fishes within Caribbean mangroves: implications for the protective function of mangrove habitats. Estuar. Coast. Shelf Sci., 84: 192-201.

Murchie, K.J., E. Schwager, S.J. Cooke, A.J. Danylchuk, S.E. Danylchuk, T.L. Goldberg, C.D. Suski & D.P. Philipp. 2010. Spatial ecology of juvenile lemon sharks (*Negaprion brevirostris*) in tidal creeks and coastal waters of Eleuthera, The Bahamas. Environ. Biol. Fish., 89: 95-104.

Pauly, D. 1991. Growth of the checkered puffer *Sphoeroides testudineus*: postscript to papers by Targett and Pauly & Ingles. Fishbyte, 9: 19-22.

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Post, D.M. 2002. Using stable isotopes to estimate trophic position: models, methods, and assumptions. Ecology, 83: 703-718.

Randall, J.E. 1967. Food habits of reef fishes of the West Indies. Stud. Trop. Oceanogr., 5: 665-847.

Recher, H.F. & J.A. Recher. 1968. Comments on the escape of prey from avian predators. Ecology, 49: 560-562.

Rypel, A.L., C.A. Layman & D.A. Arrington. 2007. Water depth modifies relative predation risk for a motile fish taxon in Bahamian tidal creeks. Estuar. Coast., 30(3): 1-8.

Targett, T.E. 1978. Food resource partitioning by the pufferfishes *Sphoeroides spengleri* and *S. testudineus* from Biscayne Bay, Florida. Mar. Biol., 49: 83-91.

Thiem, J.D., C. Hatry, J.W. Brownscombe, F. Cull, A.D. Shultz, A.J. Danylchuk & S.J. Cooke. 2013. Evaluation of radio telemetry to study the spatial ecology of checkered puffers (S*phoeroides testudineus*) in shallow tropical marine systems. Bull. Mar. Sci., 89: 559-569.

Valentine-Rose, L., J.A. Cherry, J.J. Culp & K.E. Perez. 2007. Floral and faunal differences between fragmented and unfragmented Bahamian tidal creeks. Wetlands, 27: 702-718.

Winemiller, K.O. 1990. Spatial and temporal variation in tropical fish trophic networks. Ecol. Monogr., 60: 331-367.