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Note

The niche of shrimp stocks (*Xiphopenaeus kroyeri* Heller, 1862) from southeastern Brazil: a stable isotope approach

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NOTE

The niche of shrimp stocks (*Xiphopenaeus kroyeri* Heller, 1862) from southeastern Brazil: a stable isotope approach

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The penaeid shrimps are important targets in crustacean fisheries worldwide. The species *Xiphopenaeus kroyeri* Heller, 1862, known as the Atlantic Seabob Shrimp, is a penaeid species with continuous distribution in coastal waters along the western Atlantic Ocean, from 36°N to 30°S, and their stocks are highly exploited by marine coastal fisheries (FAO 2018). In Brazil, this is the second most important species of crustacean in fisheries landings (Boos et al. 2016).

Stable isotopes of carbon (^{13}C) and nitrogen (^{15}N) are applied as chemical proxies to provide complementary data on animals' trophic ecology (Fry 2008). Niche differentiation is the process by which species evolve different forms of food sources use (MacArthur 1984). Layman et al. (2007) introduced metrics from ecomorphological approaches to summarize quantitative information from stable isotopes data. Later, Jackson et al. (2011) developed a Bayesian framework for these metrics comparisons, allowing robust inferences regarding isotopic niche of animal species. Thus, stable isotopes provide quantitative information about the consumer isotopic niche, which is associated with its feeding ecology and ecological niche in the environment.

This study evaluated the niche dimensions of *X. kroyeri* (Image 1) from four stocks in southeastern Brazil through stable isotopes determinations. We hypothesize that the isotopic niche is similar among the four stocks because this shrimp is an omnivorous consumer with high feeding plasticity, consuming a broad spectrum of food sources that are abundant in its home range, such as primary sources and small animals from both benthic environment and water column (Willems et al. 2016).

The shrimps were sampled in four fishing areas from Espírito Santo and Rio de Janeiro States, southeastern Brazil: Vitória (-20.51S & -40.50W), Anchieta (-20.80S & -40.63W), Atafona (-21.61S & -41.00W), and Farol de São Tomé (-22.03S & -41.03W) (Figure 1). In June 2017, 120 individuals were sampled in the local fishing market from each fishing area, totalling 480 individuals. The abdominal muscle of each individual was removed and stored in a dry sterile vial, frozen (-20°C), freeze-dried and homogenized using mortar

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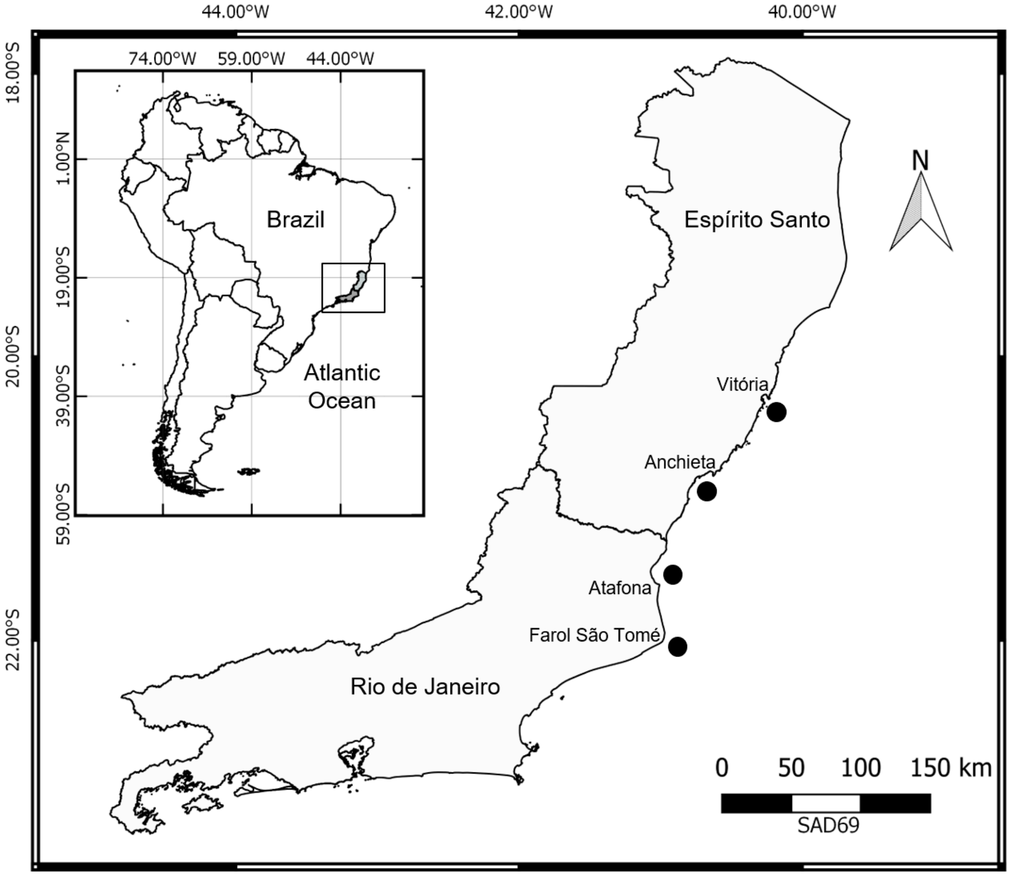

Figure 1. Location of the fishing areas in Espírito Santo (Vitória and Anchieta) and Rio de Janeiro (Atafona and Farol de São Tomé) States, southeastern Brazil.

and pestle. Samples containing 0.4g of muscle (dry weight) of each individual were analysed for Carbon and Nitrogen isotopic determination. The stable isotopes ratios ($\delta^{13}C$ and $\delta^{15}N$) of each shrimp was determined using a Delta V Advantage mass spectrometer (Thermo Scientific, Germany) coupled to an elemental analyser in Laboratório de Ciências Ambientais from Universidade Estadual do Norte Fluminense Darcy Ribeiro. The reference values for Nitrogen and Carbon stable isotopes were atmospheric Nitrogen and Pee Dee Belemnite (PDB), respectively. Samples were analysed using analytical blanks and urea analytical standards (IVA Analysentechnik-330802174; CH_4N_2O Mw = 60, C = 20%, N = 46%), using certified isotopic compositions ($\delta^{13}C$ = -39.89‰ and $\delta^{15}N$ = -0.73‰). Analytical control was done for every 10 samples using a certified isotopic standard (Elemental Microanalysis Protein Standard OAS): $\delta^{13}C$ = -26.98‰ and $\delta^{15}N$ = +5.94‰. Analytical reproducibility was based on triplicates for every 10 samples: ± 0.3‰ for $\delta^{15}N$ and ± 0.2‰ for $\delta^{13}C$.

Quantitative metrics of the isotopic niche based on individuals' position in $\delta^{13}C$-$\delta^{15}N$ bi-plot space were estimated according to Layman et al. (2007) and Jackson et al. (2011). The metrics were calculated using Stable Isotope Bayesian Ellipses in R (SIBER - Jackson et al. 2011; R Core Team 2020). The first two metrics represent the stocks trophic diversity, and the last two represent the stocks trophic redundancy, or the relative position of individuals to each other within their respective

Image 1. *Xiphopenaeus kroyeri*

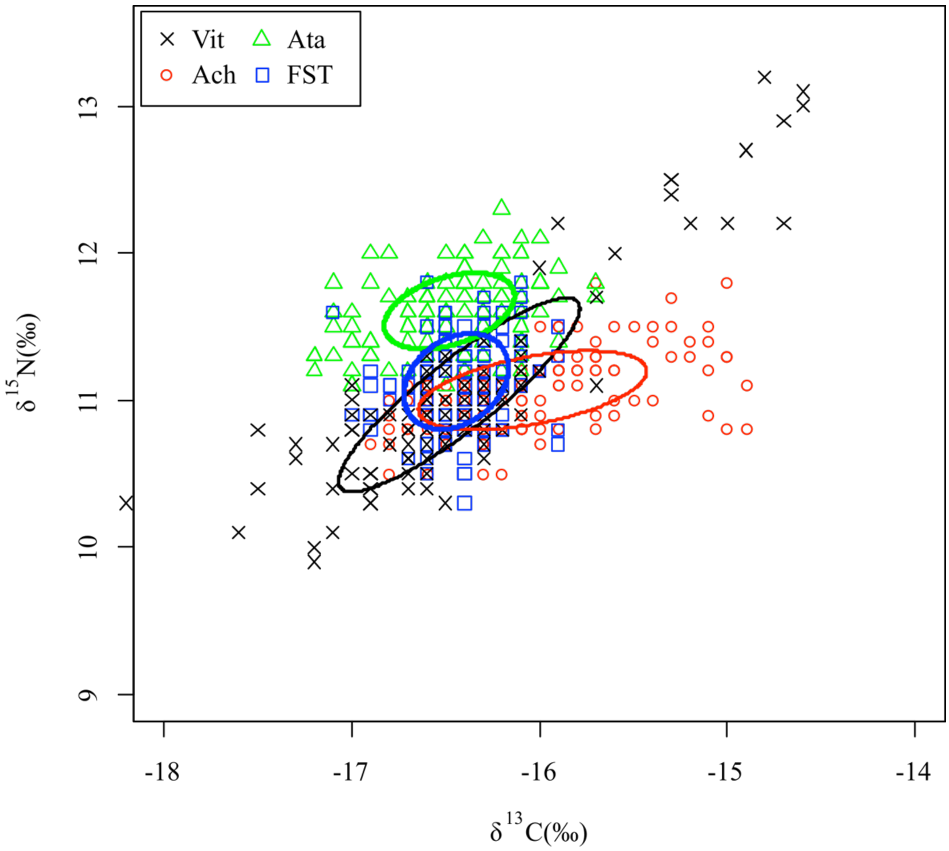

Figure 2. Isotopic values of Xiphopenaeus kroyeri stocks from Espírito Santo (Vitória and Anchieta) and Rio de Janeiro (Atafona and Farol de São Tomé) States. Colored lines represent data ellipses (40% confidence interval) for the isotopic niches. Vit—Vitória | Ach—Anchieta | Ata—Atafona | FST—Farol de São Tomé.

isotopic niches. The standard ellipse area (SEA) is the isotopic niche width of a given stock, based on bivariate distribution ellipses for each stock and sized to include 40% of the data subsequently sampled. The mean distance to centroid (CD) is the mean Euclidian distance from each individual to stock centroid (mean $\delta^{15}N$ and $\delta^{13}C$), which provides average level of trophic diversity. The mean nearest neighbour distance (MNND) is the mean Euclidian distance from each individual to the nearest neighbour in $\delta^{13}C$–$\delta^{15}N$ bi-plot space, indicating similarity in trophic ecology within stocks. The standard deviation of nearest neighbour distance (SDNND) is a measure of stock uniformity in $\delta^{13}C$–$\delta^{15}N$ bi-plot space, or the evenness of individuals' distribution within stocks. One-way ANOVA evaluated differences among stocks considering CD and MNND metrics, as these are means. SDNND metric was compared using *F-ratio* tests because it is a standard deviation. The statistical analyses were done in the R program (R Core Team 2020).

The *X. kroyeri* stocks from Espírito Santo State (Vitória and Anchieta) had highest SEA values when compared to stocks from Rio de Janeiro State (Atafona and Farol de São Tomé) (Table 1, Figure 2); and also highest values for the average level of trophic diversity (CD) (ANOVA, $F = 7.49$, $df = 3$, $p = 6.53e\text{-}05$) (Table 1). The MNND values that show the similarities in trophic ecology within stocks were low, and did not differ among the stocks (ANOVA,

Table 1. Quantitative metrics of isotopic niche of *Xiphopenaeus kroyeri* stocks from Espírito Santo and Rio de Janeiro states.

Stocks/ Fishing areas	SEA‰²			CD	MNND	SDNND
	LQ	Med	UQ			
Espírito Santo State						
Vitória	0.59	0.63	0.67	0.66	0.07	0.10
Anchieta	0.41	0.44	0.47	0.51	0.08	0.27
Rio de Janeiro State						
Atafona	0.24	0.25	0.27	0.37	0.04	0.05
Farol de São Tomé	0.25	0.26	0.28	0.36	0.04	0.12

CD—distance to centroid | MNND—mean nearest neighbour distance | SDNND—standard deviation of nearest neighbour distances | SEA—standard ellipse area | LQ—lower quartile | UQ—upper quartile | Med—Median.

F = 1.74*, df* = 3, *p* = 0.16); however, higher values were recorded for stocks from Rio de Janeiro State (Table 1). Individuals' distribution in the isotopic niche space revealed the highest and the lowest trophic uniformity (SDNND) for shrimps from Atafona and Anchieta stocks, respectively (Table 1). Comparisons using *F* tests showed significant results ($p < 0.01$), except for the comparison between Vitória and Farol de São Tomé stocks ($p = 0.15$).

The results refuted the hypothesis that the four *X. kroyeri* stocks have similar isotopic niche width because of the high feeding plasticity of this species. Shrimp stocks from Espírito Santo State (Vitória and Anchieta) had highest trophic diversity (SEA and CD metrics), indicating greater variety of food sources and wider utilization of the available food sources. The shrimps from Rio de Janeiro State (Atafona and Farol de São Tomé) had highest trophic redundancy (MNND and SDNND metrics), revealing a more homogeneous dietary pattern. In general, shrimps have high feeding plasticity, and variations in diet composition and in the amount ingested can occur among species, genders, maturity stages and seasons, even on a small spatial scale (Carnevali et al. 2012; Gutiérrez et al. 2016). The isotopic composition of the animal tissues derives from the ingested food sources and fractionation processes in these tissues, and the carbon and nitrogen isotopic values can differ both spatially and among the food sources ingested by the consumer (Fry et al. 2003; Fry 2008). Thus, the composition of food sources and availability in each fishing area might explain the variations among the *X. kroyeri* stocks regarding their isotopic niches. Further studies on the local feeding ecology of this species, such as the study conducted by Willems et al. (2016) off the coast of Suriname, are recommended to confirm this assumption.

In Suriname, a combination of stomach content and stable isotope analyses from *X. kroyeri* individuals in different life stages showed that hyperbenthic crustaceans, benthic microalgae and offshore sedimentary organic matter were important food sources, with benthic microalgae contributing up to 64% to the overall diet for all life stages, however, an ontogenetic diet shift was recorded, with adult shrimps positioned higher in the food chain ($\delta^{15}N$ more enriched), preying on larger benthic organisms (Willems et al. 2016). The isotopic data of the four *X. kroyeri* stocks from southeastern Brazil can be combined with future stomach content analysis to verify and compare the feeding preference in this region to the data from Suriname.

We can state that the isotopic niche approach allowed the discrimination of *X. kroyeri* stocks distributed at 20⁰S (fishing areas of Espírito Santo State) and 21⁰S–22⁰S (fishing areas of Rio de Janeiro State). Recognizing the seafood origin allows determining the fishers' fidelity to a given fishing area (geographical origin), besides developing inferences on seafood quality from the environmental quality (Ortea & Gallardo 2015). The results will be helpful to assist fisheries management, delimitating the fishing area of local vessels and helping track the origin of the shrimps commercialized in local markets.

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