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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 (¹³C) and nitrogen (¹⁵N) 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
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 (δ\(^{13}\)C and δ\(^{15}\)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\(_3\)N\(_2\)O Mw = 60, C = 20%, N = 46%), using certified isotopic compositions (δ\(^{13}\)C = -39.89‰ and δ\(^{15}\)N = -0.73‰). Analytical control was done for every 10 samples using a certified isotopic standard (Elemental Microanalysis Protein Standard OAS): δ\(^{13}\)C = -26.98‰ and δ\(^{15}\)N = +5.94‰. Analytical reproducibility was based on triplicates for every 10 samples: ± 0.3‰ for δ\(^{15}\)N and ± 0.2‰ for δ\(^{13}\)C.

Quantitative metrics of the isotopic niche based on individuals’ position in δ\(^{13}\)C-δ\(^{15}\)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

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.
Isotopic niche of shrimp stocks. 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 δ¹⁵N and δ¹³C), 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 δ¹³C–δ¹⁵N 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 δ¹³C–δ¹⁵N 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, $F = 7.49, df = 3, p = 6.53e-05$) (Table 1). The MNND values that show the similarities in trophic ecology within stocks were low, and did not differ among the stocks (ANOVA,
We can state that the isotopic niche approach allowed the discrimination of *X. kroyeri* stocks distributed at 20°S (fishing areas of Espírito Santo State) and 21°5–22°S (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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