



# SEASONAL PATTERNS OF ABUNDANCE AND STOPOVER USE OF *CALIDRIS CANUTUS RUFA* ON THE BRAZILIAN AMAZON COAST

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## ABSTRACT

This study investigated the seasonal abundance of the subspecies *Calidris canutus rufa* and the use of Panaquatira Beach, located on the northern coast of Maranhão, Brazil, as a migratory stopover site. This subspecies is the only one that reaches the southern part of South America and uses various locations throughout its migration, including Panaquatira Beach. Population censuses were conducted using the transect method, with observations along a 1-kilometer stretch of shoreline. Three monthly visits were carried out between March and September 2023. The population peak occurred in April, with an average of 617 individuals, while the lowest averages were recorded in June (85) and July (87). In September, an individual was observed at Panaquatira that had been banded in the United States. Compared to previous studies, population variation was observed. However, it is still premature to affirm a real population decline of the subspecies.

**Keywords:** Rufa red knot, migration, connectivity, habitat use.

## PADRÕES SAZONAIS DE ABUNDÂNCIA E USO DE ÁREAS DE PARADA DE *CALIDRIS CANUTUS RUFA* NA COSTA AMAZÔNICA DO BRASIL

## RESUMO

Este estudo investigou a abundância sazonal da subespécie *Calidris canutus rufa* e o uso da Praia de Panaquatira, localizada na costa norte do Maranhão, Brasil, como ponto de parada migratória. Essa subespécie é a única que alcança a região sul da América do Sul e utiliza diversos locais ao longo da migração, incluindo a Praia de Panaquatira. Os censos populacionais foram realizados utilizando a metodologia de transecto, com observações ao longo de um percurso de 1 quilômetro. Foram realizadas três visitas mensais entre março e setembro de 2023. O pico populacional ocorreu em abril, com média de 617 indivíduos, enquanto as menores médias foram registradas em junho (85) e julho (87). Em setembro, foi registrado um indivíduo anilhado nos Estados Unidos. Em comparação com estudos anteriores, observou-se variação populacional. Entretanto, ainda é prematuro afirmar que há um declínio populacional real da subespécie.

**Palavras-chave:** maçarico-de-papo-vermelho, migração, conectividade, uso de habitat.

## INTRODUCTION

Migratory birds undertake long-distance annual movements, relying on a wide variety of habitats along their routes to complete essential processes such as moulting, foraging, and the accumulation of energy reserves (Rodrigues, 2007). The success of these processes directly influences survival during migration and reproductive performance, as individuals that fail to acquire sufficient resources at stopover sites may reach breeding areas in suboptimal conditions. The Red Knot (*Calidris canutus*) is a long-distance Nearctic migrant that breeds in the Arctic and occupies coastal areas on all continents except Antarctica (Juárez, 2021). Among its subspecies, *Calidris canutus rufa* (Wilson, 1803) is notable for being the only one to migrate as far as southern South America.

Despite being classified as Near Threatened (NT) by the IUCN (BirdLife International, 2018), the subspecies has experienced marked population declines over recent decades, driven largely by its extreme vulnerability to habitat loss and degradation at both wintering and stopover sites (Morrison et al., 2009; Rodrigues, 2007). These pressures are particularly acute along the Amazonian coast of Brazil, where the subspecies' precarious status is reflected by its classification as Critically Endangered in the state of Maranhão (MARANHÃO, 2025), even as it remains listed as Least Concern at the federal level (BRASIL, 2026).

The persistence of *Calidris canutus rufa* across the Atlantic Flyway relies on strong migratory connectivity, where the survival of populations is contingent upon the availability of resources at key stopover sites. One of the most critical stopover sites within the migratory network of *C. c. rufa* is Delaware Bay, where individuals rely on a highly seasonal and energy-rich food resource such as *Limulus polyphemus* eggs to acquire enough nutrients and complete migration (Morrison et al., 2005; Castro and Myers, 1993). This dependence on key sites highlights the vulnerability of the species to changes in resource availability along the flyway, reinforcing the importance of other stopover areas, including those along the Brazilian coast.

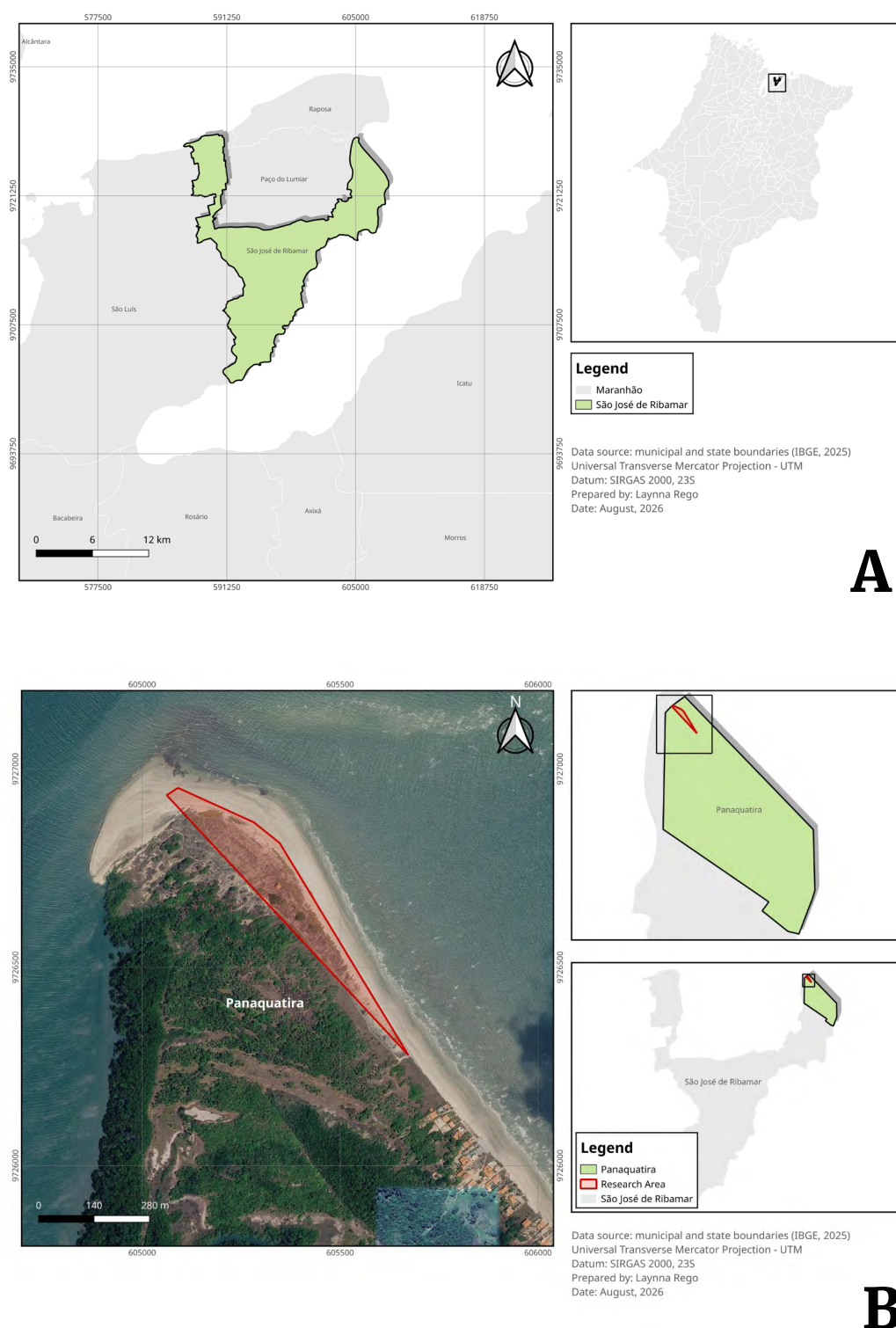
Although knowledge gaps persist regarding the strategies and migratory routes of *C. c. rufa* in Brazil, particularly along the Amazon coast, certain sites have been identified as especially important for the species. On the northern coast of Maranhão, Brazil, Panaquatira Beach has been identified as one of the most important sites for the occurrence of *C. c. rufa* (Rodrigues & Lopes, 2000; Baker et al., 2005).

Given the ecological importance of the Brazilian Amazon coast as a migratory route and stopover area for this subspecies, it is important to understand how *Calidris canutus rufa* uses sites in this region. The present study analyzed the seasonal abundance of *C. c. rufa* at Panaquatira Beach, compared current abundance patterns with records from previous studies, and recorded the occurrence of banded individuals as evidence of population connectivity along the migratory route.

## MATERIAL AND METHODS

The study was conducted at Panaquatira Beach, located on the northern coast of Maranhão, Brazil, northeast of São Luís Island (Figura 1A e 1B). The area is part of the Golfão Maranhense (44°1'40.32"W). It is an estuarine zone influenced by the waters of São José Bay and the Atlantic Ocean. The beach is part of a sandy spur, with a macrotidal regime with amplitudes varying between 6 and 7m, characterized by a sandy substrate which directly influences the availability of habitat for coastal birds throughout the tidal cycle.

**Figure 1. Map of the study area of *Calidris canutus rufa*. A) Highlight to São José de Ribamar city, Maranhão State - Brazil. B) Location of Panaquatira beach, where birds monitoring was conducted.**



The methodology used was based on the transect technique for carrying out population censuses and analyzing the seasonal abundance of *Calidris canutus rufa*. Observations were made along a transect 1 kilometer long, using photographic records and binoculars. The monitoring was carried out between March and September 2023, with three monthly visits, totaling seven months of follow-up.

To analyze the occurrence of ringed individuals, all the flocks observed along the route were counted and photographed. This procedure allowed the rings to be identified visually. The data were collected at high tide, when the birds began to arrive at the resting site.

## RESULTS

The seasonal abundance of *C. c. rufa* at the study site revealed a distinct bimodal pattern driven by the species' migratory phenology. At the onset of the northward migration in early March, initial counts were low ( $n = 70$ ), with individuals exhibiting non-breeding plumage (Figure 2). Population numbers then rapidly increased, peaking between late March and April (mean = 617 individuals - Figure 3), a period characterized by the transition to reproductive plumage and a significant increase in body condition scores (Figures 4). These observations suggest that Panaquatira serves as a vital refueling site where birds optimize their physiological state for the final leg of their migration to Arctic breeding grounds. Conversely, the southward migration was marked by a secondary, less pronounced abundance peak in September, consisting primarily of individuals in winter plumage (Figure 5). The detection of a banded individual from the United States during this period confirms the site's integral role in the Atlantic Flyway connectivity (Figure 6). Finally, the observed numerical differences compared to historical data (Figure 7) suggest shifting local population dynamics, likely reflecting increasing environmental pressures and habitat alterations.

Figure 2. *Calidris canutus rufa* in winter plumage, in March 2023 at Panaquatira Beach, São José de Ribamar, Maranhão.



Figure 3. *Calidris canutus rufa* in breeding plumage and with a higher body score, in April 2023 at Panaquatira Beach, São José de Ribamar, Maranhão.



Figure 4. Seasonal abundance of *Calidris canutus rufa* between March and September 2023 in Panaquatira, São José de Ribamar, Maranhão

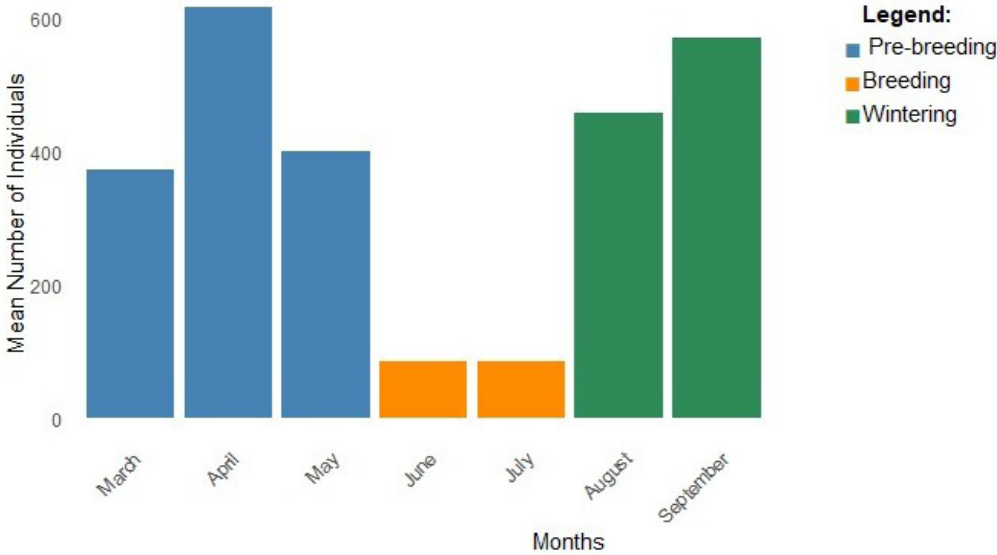


Figura 5. *Calidris canutus rufa* with complete winter plumage, for reproductive rest, September 2023 at Panaquatira Beach, São José de Ribamar, Maranhão.



Figure 6. *Calidris canutus rufa* newly arrived from migration, with breeding plumage. In the photo, an individual with a colored ring from the US in August 2023 at Panaquatira Beach, São José de Ribamar, Maranhão.



Figure 7. Comparison of the temporal variation in the abundance of *Calidris canutus rufa* between data collected in 2011 and 2023 at Panaquatira Beach. The graph illustrates the differences in the presence of the species over the months monitored, showing significant changes in abundance over the study period.



## DISCUSSION

The observed population dynamics of *C. c. rufa* at Panaquatira Beach confirm its role as a critical stopover node within the Atlantic Flyway, characterized by distinct seasonal peaks rather than long-term wintering. The bimodal abundance pattern, peaking in April and September, highlights the site's importance for both northward and southward refueling phases.

The significant interannual shift in abundance, marked by higher counts in March, May and late-migratory months (August–September) in 2023 compared to 2012 (Sousa and Rodrigues, 2015), suggests a potential shift in migratory phenology. Such shifts may indicate an earlier arrival or an extended duration of site use during the northward and southward journeys. This temporal plasticity is documented in long-distance migrants responding to changing climatic conditions and prey availability across their range.

The decrease in peak April counts from 2012 to 2023, coupled with increases in surrounding months, may signal a spatial redistribution of the population along the coast. This redistribution could be linked to changes in the quality of foraging habitats or fluctuations in the abundance of their prey, which are known to dictate stopover duration and site selection.

The detection of a banded individual originating from the United States, consistent with previous observations of individuals banded in Argentina (Sousa and Rodrigues, 2015), confirms that Panaquatira serves as a stopover site for populations moving between different wintering and breeding grounds. While the observation of individuals in winter plumage during the northward window warrants further investigation, these will not be characterized solely as non-migratory juveniles without age-structured field data. Instead, these individuals may represent variation in plumage transition or local population heterogeneity.

Ultimately, these population fluctuations likely reflect a combination of extrinsic factors, including environmental stressors at primary stopover sites and site-specific changes in foraging quality. Future research should prioritize high-resolution monitoring of local food resources and environmental variables to determine whether the observed numerical shifts result from broader regional population trends or localized adjustments in habitat selection.

## CONCLUSION

The temporal patterns of abundance and plumage observed in this study highlight the importance of Panaquatira Beach as a stopover site for *C. c. rufa* during both northward and southward migrations. The presence of individuals in breeding and non-breeding plumage, together with records of banded birds, provides evidence of the species' connectivity within the Western Atlantic Flyway.

Differences in abundance patterns compared to previous studies suggest temporal variation in the use of the area, reinforcing the need for long-term monitoring to better understand changes in migratory dynamics and site use.

Although variation in abundance was evident, the available data do not allow for conclusions regarding population trends over time, emphasizing the need for caution in interpreting these differences.

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