



Feeding habits of the sea anemone *Telmatactis panamensis* (Actiniaria: Andvakiidae) from the Coiba National Park, Panama

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Abstract: Research on sea anemones in Coiba National Park, located in the Pacific region of Panamá, has recently begun, with two species of this cnidarian group being recorded for the first time. One of these species, *Telmatactis panamensis*, is also common in other regions of the Eastern Tropical Pacific. However, despite its abundance, there are no studies on various aspects of its biology and ecology. The aim of this research is to investigate the feeding habits of *T. panamensis* in the Coiba National Park, Panama. The specimens were collected by hand or with a spatula during snorkeling excursions on February 2023 on Isla Canales Afuera and Isla de las Tortugas. They were fixed in 7 % formaldehyde saline solution for subsequent dissection and examination. Prey items found within their gastral cavities, as well as the organisms found in the surrounding area of each sea anemone, were identified to the lowest taxonomic level possible. Using the collected data, the following trophic parameters were calculated: vacuity index (V), frequency index of prey (f), percentage of prey (Cn) and index of relative importance (IRI). The diet of *T. panamensis* consists primarily of zooplankton (copepods, eggs, fish larvae), with a lesser contribution from benthic crustaceans and mollusks. The most frequent prey is zooplankton (f = 0.5), followed by benthic crustaceans (f = 0.19) and mollusks (f = 0.13). Zooplankton comprises the highest percentage of prey (Cn = 88.9 %), being a major prey. Benthic crustaceans and mollusks are occasional prey items (Cn < 10 %). Zooplankton also has the highest index of relative importance (IRI = 44.4 %) while benthic crustaceans and mollusks have an IRI of less than 1 %. The prey composition of this actinarian does not differ from the adjacent community. The sea anemone *T. panamensis* is an opportunistic polyphagous, primarily consuming the most abundant prey in its environment, including both the surrounding zooplankton and the benthos. These findings coincide with the vast majority of previous studies on other species of sea anemones from various regions worldwide.

Key words: Actiniaria; diet; trophic parameters; subtidal; Panama.

Hábitos alimenticios de la anémona de mar *Telmatactis panamensis* (Actiniaria: Andvakiidae) del Parque Nacional Coiba, Panamá. Resumen: Recientemente se ha iniciado el estudio de las anémonas de mar del Parque Nacional Coiba, en el Pacífico de Panamá; registrándose por primera vez dos especies de este grupo de cnidarios. Una de las especies,

Telmatactis panamensis, es también común en otras regiones del Pacífico Tropical Este, pero a pesar de su abundancia no hay estudios sobre diversos aspectos de su biología y ecología. El objetivo de este trabajo es estudiar los hábitos alimenticios de *T. panamensis* en el Parque Nacional Coiba, Panamá. Los especímenes fueron recolectados a mano o con espátula mediante incursiones de snorkel en febrero de 2023 en la Isla Canales Afuera e Isla de las Tortugas, y fijados en solución salina de formaldehído al 7 % para su posterior disección y examinación. Las presas encontradas en el interior de sus cavidades gástricas y los organismos observados en el ambiente circundante a las anémonas fueron identificados al más bajo nivel taxonómico posible. Usando los datos recolectados, se calcularon los siguientes parámetros tróficos: índice de vacuidad (V), índice de frecuencia de ocurrencia (f), porcentaje de presa (Cn) e índice de importancia relativa (IRI). La dieta de *T. panamensis* consiste principalmente de zooplancton (copépodos, huevos, larvas de peces), y en menor medida en crustáceos bentónicos y moluscos. La presa más frecuente es el zooplancton ($f = 0.5$), seguido por los crustáceos bentónicos ($f = 0.19$) y moluscos ($f = 0.13$). El zooplancton presenta el mayor porcentaje de presas ($Cn = 88.9$ %), siendo una presa mayor. Los crustáceos y moluscos bentónicos son presas ocasionales ($Cn < 10$ %). El zooplancton también presenta el mayor índice de importancia relativa ($IRI = 44.4$ %). Los crustáceos y moluscos bentónicos tienen un IRI inferior al 1 %. La composición de presas de este actinario no difiere de la comunidad adyacente. La anémona de mar *T. panamensis* es un polífago oportunista que se alimenta mayormente de las presas más abundantes de su entorno, tanto del zooplancton circundante como del bentos. Estos datos coinciden con la gran mayoría de estudios previos sobre otras especies de anémonas procedentes de diversos sitios de nuestro planeta.

Palabras clave: Actiniaria; dieta; parámetros tróficos; submareal; Panamá.

Introduction

The study of the feeding behaviours of marine organisms, their diverse strategies obtaining food, and their role in food webs, is one of the most interesting topics in marine biology and ecology. Among the invertebrate groups, cnidarians can be found with great abundance in a variety of benthic communities, both in temperate and tropical waters. They play an important ecological role due to their multiple life cycles and their great adaptive plasticity, which allows them to live on diverse substrates, including other organisms (Erralde & Acuña 2020).

The Anthozoa is the largest class in the phylum Cnidaria in terms of numbers of species (Daly *et al.* 2007). A comprehensive bibliographical review of the scientific literature on feeding in Anthozoa was conducted by Santos *et al.* (2020). It was observed that, within Anthozoa, feeding studies have primarily focused on species in the orders Actiniaria (sea anemones *sensu stricto*), Scleractinia (stony corals), and Alcyonacea (soft corals). Understanding the diet, trophic levels, and feeding behaviors of Anthozoa, including sea anemones, is essential for a better comprehension of the ecology and evolution these species, as the energy and nutrients derived from their feeding habits are vital

for reproduction, development and growth (Leibold 1995, Rossi *et al.* 2004).

The diverse feeding habits of sea anemones have led them to be classified as opportunistic polyphagous predators (Acuña & Zamponi 1995a, Erralde & Acuña 2020), which ingest a wide variety of organisms from the community, and may occupy different levels in the trophic web. Some studies suggest that the diet of anemones reflects the structure of the community where they live (Chintiroglou & Koukouras 1992, Acuña & Zamponi 1996, Tsurpalo & Kostina 2003). However, most studies have focused on the diet of temperate sea anemones, and little is known about the trophic ecology of tropical species and their role in tropical ecosystems. Only one study has been conducted in the Tropical Eastern Pacific, analyzing the diet composition of the sea anemone *Anthopleura nigrescens* on Costa Rica's Pacific coast. This species primarily feeds on juvenile bivalves and zooplankton, such as cyprids and copepods, while insects are occasional prey items, reflecting the opportunistic nature of this species. The mentioned study also tested the differences in prey items captured during daytime and nighttime high tides (Quesada *et al.* 2014). The sea anemone *Telmatactis panamensis* Verrill 1869 is a common species widely distributed in the eastern tropical

Pacific (Fautin *et al.* 2007, Acuña *et al.* 2012, Acuña *et al.* 2022, Ramirez-Orellana *et al.* 2024), but no studies have been conducted regarding its ecology or biology. In this study, we analyze for the first time the feeding habits of *T. panamensis* by examining the gut contents of specimens collected from two islands in Coiba National Park, Panama.

Materials and Methods

A total of 16 specimens of *Telmatactis panamensis* were sampled in two different locations in Coiba National Park (Panama) during field surveys conducted on February 7th and 9th 2023. The first location, Canales de Afuera Island (7°41'49.3" N & 81°37'30.8" W), yielded 13 individuals with wet weights ranging from 0.0233 g to 21.3526 g. The second location, Tortugas Island (7°42'20.6" N & 81°38'02.5" W), provided three specimens with wet weights ranging from 0.0389 g to 0.9268 g. The two locations are similar environments and more information about these zones can be consulted in Camilli *et al.* 2007. The individuals were collected by hand or with a spatula from the subtidal zone during snorkeling excursions and were preserved in 7% formaldehyde. Water samples surrounding each individual were collected in the same plastic sampling container as the anemone for further processing in the research facility.

Once in the laboratory, each sample was weighted before and after dissection to assess any significant changes in weight due to stomach contents. Each specimen was dissected using a scalpel, which was cleaned between samples with tap water, distilled water and 70% ethanol to avoid any cross-contamination. The same cleaning procedure was applied to the Petri plates, tweezers, sieves, and any other reusable materials used during the process. To access the gastrodermis of each specimen, a vertical incision was made, and the stomach contents were aspirated using a plastic disposable pipette. It is important to emphasize that a new disposable pipette was used for each individual. The collected contents were placed on a Petri plate, which was divided into quadrants. Distilled water was then added to the crevices of the gastrodermis and collected with the pipette into a separate Petri plate. Both petri dishes were examined under a stereoscopic microscope for possible identification and to count all the prey found.

The water sample containing formaldehyde, in which the anemone was preserved before processing, was also divided into different Petri

plates and studied under the stereoscope. Prey items large enough to be seen with the naked eye were separated using a sieve column, with the smaller sieve being 1.0mm and the larger one 8.0mm. The sieve column was not used for all the water samples, as most of the prey present in the liquid were too small (<1.0mm) and passed through all the meshes, increasing the likelihood of loss with minimal benefit in size classification. When the column was used, it was rinsed with distilled water, and a collection bowl was placed at the bottom to capture any stray prey. The more complete prey items were collected and examined under the microscope for potential identification.

The following trophic parameters were calculated according to Acuña & Zamponi (1995a): vacuity index (V), frequency index of prey (f) and percentage of prey (Cn). Prey items were categorized based on their percentage of occurrence as major (Cn > 50 %), minor (10 % < Cn < 50 %) and occasional (Cn < 10 %). To estimate the relative importance of each prey, the Index of Relative Importance (IRI) was calculated according to Erralde & Acuña (2020) as follows:

$$IRI = \frac{(N_i \times M_i)}{(N_t \times M_t)} \times 100, \text{ where:}$$

N_i = the number of individuals of the i item

M_i = the number of samples containing the i item

N_t = the total number of individuals of all the identified items

M_t = the total number of samples

We calculated and compared the richness and the Shannon-Weaver diversity index between the prey community of *T. panamensis* and the community present in the surrounding environment using the Mann-Whitney-Wilcoxon test. We also compared the composition of these two communities with a permutation test (PERMANOVA), using Bray-Curtis dissimilarity (the data were previously transformed by applying the fourth root). All statistical analyses and graphics were made on R software (R Core Team, 2022).

Results

The diet of *Telmatactis panamensis* in Coiba National Park (Panamá) is mainly composed of zooplankton (Fig. 1A). From the 64 zooplanktonic organisms found in the gastral cavities of this sea anemone, we identified two as belonging to the order Cyclopoida and one to the order Harpacticoida, two were fish larvae and nine were eggs (two fish eggs and seven eggs from undetermined organisms).

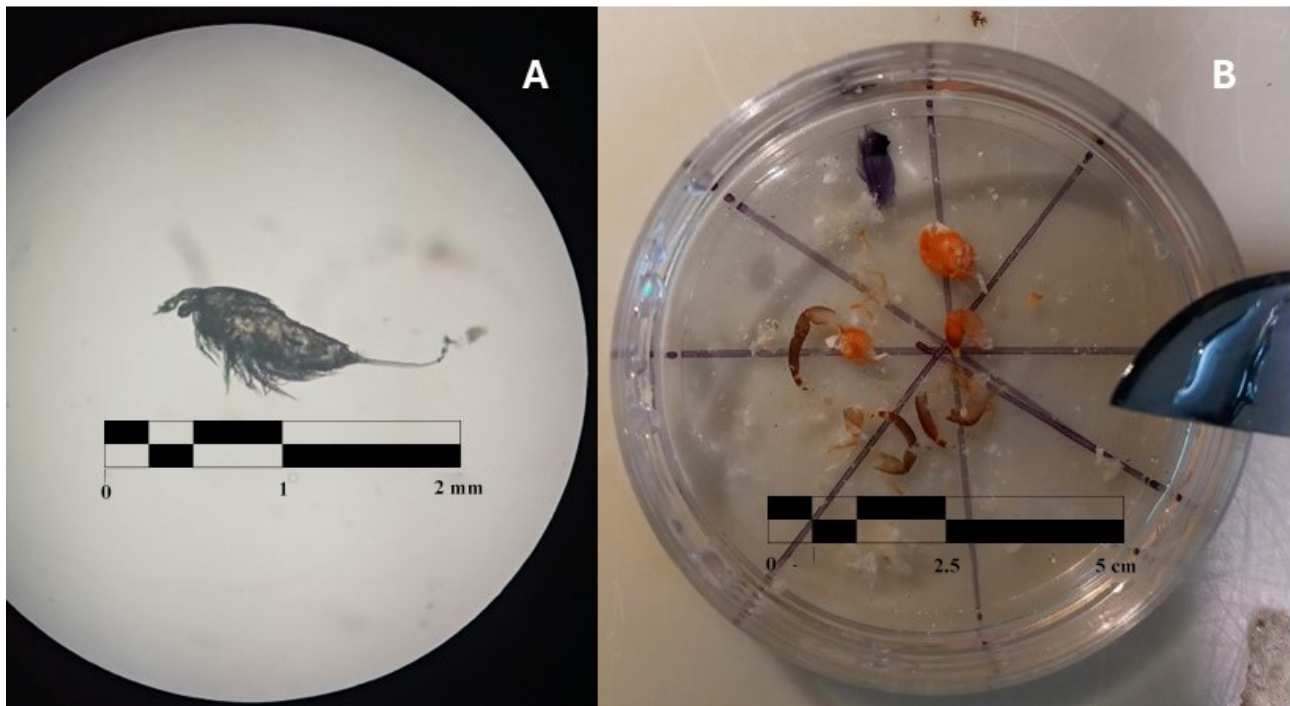


Figure 1. Example of prey organisms found inside some of the *Telmatactis panamensis* specimens dissected. A: Zooplankton; B: Benthic crustaceans.

However, most of them could not be identified due to the advanced state of digestion in which they were found. Other prey items ingested by *T. panamensis* are benthic crustaceans (Decapoda and other unidentified Crustacea; Fig. 1B) and mollusks (Bivalvia and Gasteropoda). A large amount of digested tissue was also found, which could not be identified. From the 16 individuals of *T. panamensis* examined, four had their gastral cavity empty. This gives a vacuity index of 25 %. This is a rather low value compared to others obtained by several authors on other sea anemone species (Quesada 2013).

In Figure 2 is shown the frequency index of each prey item for *T. panamensis*. The most frequent prey is zooplankton ($f = 0.5$), followed by benthic crustaceans ($f = 0.19$) and mollusks ($f = 0.13$). The unidentified digested tissue was very frequently found in the examined gastral cavities ($f = 0.31$). Zooplankton has the highest percentage of prey (Cn = 88.9 %), being a major prey. Benthic crustaceans and mollusks are occasional prey items (Cn < 10 %; Fig. 3). Zooplankton has also the highest index of relative importance (IRI = 44.4 %), while benthic crustaceans and mollusks have an IRI lower than 1 % (Fig. 4).

In the 16 samples of the surrounding water, we found a total of 95 organisms, of which 88 were zooplanktonic, two were benthic crustaceans (a decapod and an amphipod), four were mollusks (Bivalvia and Gasteropoda) and one was a hydrozoan

polyp. From the zooplanktonic organisms we were able to identify eight Harpacticoida, one Cyclopoida, nine eggs and three fish larvae; the others could not be identified due to their advanced state of digestion. We compared the prey community ingested by *T. panamensis* with the community available in the surrounding environment and found that they do not differ in richness (Mann-Whitney: $Z = 1.72$, $p = 0.086$), diversity (Mann-Whitney: $Z = 0.21$, $p = 0.835$) or composition (PERMANOVA: $df = 1$, $F = 0.60$, $p = 0.601$).

Discussion

Sea anemones are sessile feeders characterized as predatory behavior machines (Shick 1991), that obtain their food from different sources such as mobile preys that inadvertently enter the area of the tentacular crown (e.g. crabs), zooplanktonic organisms or sessile preys dislodged by wave action (e.g. bivalves). The diet of most species is varied, comprising mostly marine organisms, although many can include terrestrial organisms such as insects and mites (Möller 1978, Ayre 1984, Acuña & Zamponi 1995a, Quesada *et al.* 2014). Although these invertebrates are clearly consumers, some species may slightly shift their position within trophic levels, as demonstrated by Sun *et al.* 2022 in their study using stable isotope analysis of the trophic ecology of the sea anemones

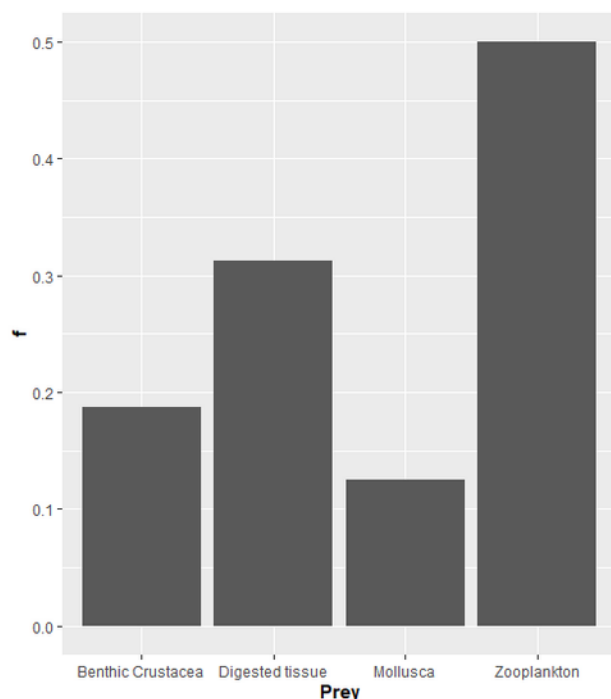


Figure 2. Frequency index of prey (f) of the different food sources (Prey) in the total gastral cavities of *Telmatactis panamensis* analyzed.

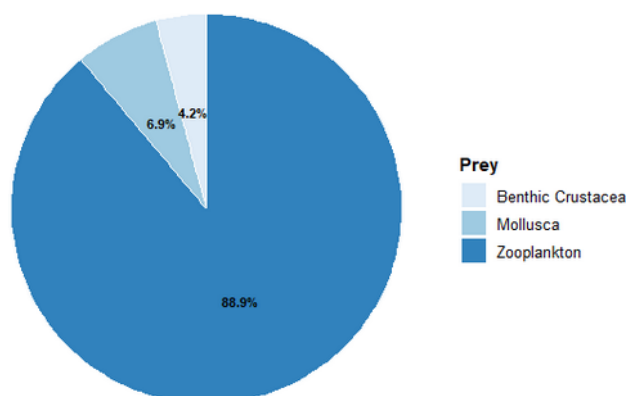


Figure 3. Percentage of the different prey items for *Telmatactis panamensis*. Only those prey in which the number of individuals could be quantified were taken into account.

Actinostola callosa, *Actinauge cristata* and *Urticina* sp. Many species, mainly tropical, complement their nutrition through their association with unicellular algae constituting polytrophic systems (Schlichter 1973), while others have the ability to absorb organic substances dissolved in seawater (Schlichter *et al.* 1987).

In the present study, the diet of *T. panamensis* is primarily composed of copepods, the most abundant zooplankton group in the northern part of Coiba National Park (Brugnoli Olivera *et al.* 2023)

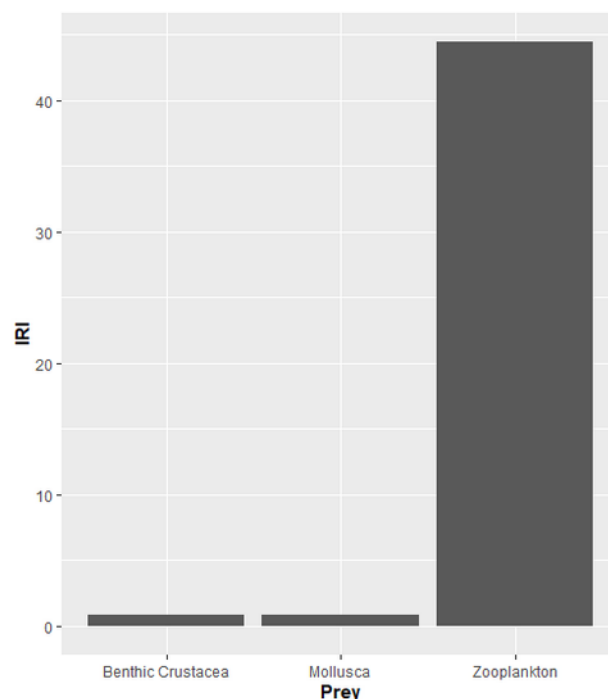


Figure 4. Index of Relative Importance (IRI) of the different prey items for *Telmatactis panamensis*. Only those prey in which the number of individuals could be quantified were taken into account.

confirming its classification as zooplanktivorous species. This is further supported by the observed Index of Relative Importance (IRI). However, it can occasionally ingest benthic organisms as well. Prey capture involves the action of the tentacles, as is typical for most sea anemones. Although, in the case of *T. panamensis* its tentacular crown cannot fully retract and close, which poses a disadvantage when it comes to retaining captured prey. Many of the prey items found in the gastric cavities of *T. panamensis* were in an advanced state of digestion and could not be identified, likely due to the rapid action of digestive enzymes. Thus, the diet of *T. panamensis* is likely underestimated, and future studies using metagenomics analysis could enhance our knowledge about its feeding habits. Clearly, the composition of its diet reflects the availability of prey in the surrounding environment, consistent with observation made for other species of sea anemones (Chintiroglou & Koukouras 1992, Acuña & Zamponi 1996, Tsurpalo & Kostina 2003). Unlike other tropical species of Actinaria, *T. panamensis* does not host symbiotic algae, relying solely on prey capture as its only food source. It could be interesting to study the prey found in the gastric cavities of *T. panamensis* collected at different times of the day and night to determine whether it exhibits

a more active or preferred hunting period, similar to what has been observed in other marine invertebrates (Larson 1997).

Other zooplanktivorous species with similar diet, where copepods are the main prey item, include *Metridium senile* in Monterey, California (Purcell 1977); *Diadumene* (= *Haliplanella*) *lineata* in Norfolk (Williams 1972), *Nematostella vectensis* in Nova Scotia (Frank & Bleakney 1978) and *Anthopleura nigrescens* on the Pacific coast of Costa Rica (Quesada *et al.* 2014). The number of captured prey items is closely related to the feeding surface of the anemone (Sebens 1981). This factor, combined with their polyphagous opportunistic behavior, could explain the variation in the types and quantities of prey consumed by different sea anemones species in various locations (Erralde & Acuña 2020).

Highlighting the feeding plasticity of Cnidarian species, their opportunistic trophic habits (Gregorin *et al.* 2024) and their characteristics as voracious predators of mesozooplankton (Gili *et al.* 2006, Houlbrèque & Ferrier-Pagès 2009) including eggs, juveniles and larvae of several organisms—these invertebrates can be considered important components of marine food webs. The ecological relevance of sea anemones lies in their diverse feeding strategies. Zooplanktivorous species, such as *T. panamensis*, may serve as facilitators of benthic-pelagic coupling. This coupling is crucial in aquatic ecosystems, enabling nutrient cycling and energy transfer between the benthic and pelagic domains (Agnetta *et al.* 2019). Future studies using stable isotopes (Zabala *et al.* 2013) and metagenomics (Santos *et al.* 2023) could provide more precise insights into their role in marine food chains.

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Ethical statement

Collection of sea anemones were conducted following all applicable ethical regulations regarding collection of biological samples. Investigation was performed under permit ARG-120-2023 issued by Ministerio de Ambiente, Panama

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