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First Report on the Presence of Epibiotic Fauna on Orcas (Family: Delphinidae) in Costa Rica

Primer Reporte de Presencia de Fauna Epibiótica en Orcas (Family: Delphinidae) en Costa Rica en Costa Rica

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Abstract

Interactions between cetaceans and their epibiotic fauna provide valuable insights into ecological dynamics, helping us understand ecosystem responses to climate change and species displacement. Data from the Orcas en Costa Rica project (1997-2024) was analyzed, the number of orcas with barnacles and remoras, and their specific body parts involved were determined. Orcas were classified by sex and age (male, female, juvenile, or calf), and the species of barnacles and remoras presented were identified. Among observed orcas, 25% had attached barnacles or remoras, with no adult males presenting visible barnacle associations. In 2022, 36% of reports indicated epibiosis, suggesting potential impacts of global warming on orca populations. This is the first report of epibiotic fauna on orcas in Costa Rica, establishing a baseline for using cetacean-epibiont interactions as bioindicators of environmental health, enhancing our understanding of ecosystem responses.

Keywords: *Xenobalanus globicipitis*, *Remora australis*, ecological dynamics, killer whales, keystone species.

Resumen

Las interacciones entre cetáceos y su fauna epibiótica proporcionan valiosas perspectivas sobre la dinámica de los ecosistemas, ofreciendo herramientas para entender cómo reaccionan a factores como el cambio climático y el desplazamiento de especies clave. Se analizaron datos del proyecto Orcas en Costa Rica (1997-2024), el número de orcas con percebes y rémoras, y sus partes del cuerpo involucradas fueron determinadas. Las orcas fueron clasificadas por sexo y grupo de edad (macho, hembra, juvenil o cría) y se identificaron las especies de percebes y rémoras presentes. El 25% de las orcas observadas tenían percebes o rémoras adheridas, sin asociaciones visibles de percebes en machos adultos. En 2022, el 36% de los informes presentaban epibiosis, lo cual podría indicar efectos del calentamiento global en las orcas. Este es el primer informe de fauna epibiótica relacionada con orcas en Costa Rica, estableciendo una base para usar las interacciones cetáceo-epibionte como bioindicadores de la salud ambiental permitiendo mayor comprensión de las respuestas dentro del ecosistema.

Palabras clave: *Xenobalanus globicipitis*, *Remora australis*, dinámicas ecológicas, ballenas asesinas, especies clave.

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Introduction

Epibiotic organisms are defined as organisms that live on the surfaces of other organisms (El Bour, 2016). They can be used as biological markers for cetacean biology (Matthews et al., 2020; Ten et al., 2022a), allowing a deeper understanding of cetacean immune mechanisms and health status (Lehnert et al., 2023; Baum et al., 2020). In addition, this relationship has been used to determine migratory routes and population structures (Iwasa-Arai et al., 2018; Kaliszewska et al., 2005). Barnacles and remoras are commonly found in epibiotic relationships with cetaceans (Ten et al., 2022).

Barnacle is the common name for over 1000 marine species of the subclass Cirripedia (Fertl et al., 2018). Authors refer to the large numbers of barnacles associated with cetaceans as “infestations” (Siciliano et al., 2020). The correlation between elevated barnacle presence and sick cetaceans may be attributed to their attractiveness as hosts due to their decreased mobility in compromised health states (Scarano, 2016). Thus, the presence of barnacles could be associated with several adverse environmental and physiological factors, and not as a cause for the decline in cetacean health (Flach et al., 2021). Barnacles have been observed to elicit an immune response during the attachment process, implying that healthy cetaceans are likely to resist barnacle implantation (Hall, 2020). Other authors have suggested that this relationship could be better described as commensalism (Kane et al., 2008).

Remoras are marine fish belonging to the Echeneididae family (Fertl et al., 2009). They use suction disks to attach to sharks, rays, bony fish, sea turtles, cetaceans, and sirenians (O’Toole, 2002). Remoras have low mobility and must be associated with large animals to cover significant distances (Fertl y Landry, 1999). They have been reported in tropical orcas in Mexico (Guerrero-Ruiz & Urbán, 2000) and the Eastern Tropical Pacific (ETP) (Kane et al., 2008).

Climate change has wide-ranging effects on cetaceans, affecting their habitats, food sources, migration patterns, and overall health (van Weelden et al., 2021; Kebke et al., 2022). This underscores the importance of establishing a novel framework for the active monitoring of cetaceans. Epibionts, as sentinels of cetacean health status, can be a valuable tool for modeling ecosystem health and potential threats (Ten et al., 2022b).

Research on orcas is a growing field in Costa Rica (Castro-Azofeifa, 2021). This study presents the first documented report of epibiotic fauna on orcas in Costa Rica. Given that these interactions did not exhibit any observable detrimental effects on the studied orcas, they were not classified as parasitic. This study aimed to establish a baseline to illustrate the ecological interactions between orcas and their epibiotic fauna. This will establish a foundational reference that will be invaluable for future investigations on the ecological and biological aspects of orcas in the Pacific.

Materials and Methods

The Orcas en Costa Rica Project is a pioneering initiative committed to researching tropical orcas in the Costa Rican Pacific. Working with tour operators, fishermen, citizen science, and research efforts, orca sightings from 1997 to 2024 have been documented. Creating a comprehensive database that includes the sighting date, sighting coordinates, and sighting

lunar cycle.

Each recorded event was verified using visual evidence from pictures or videos. The number of individuals shown in all sightings was reported and classified by biologists as adult male, female or juvenile, and calf. This classification is based on the morphology of the dorsal fins and the size of the specimen. It is vital to clarify that a distinction between female and male juveniles was not made. Events with barnacle and remora presence were selected as our dataset. The number of orcas that presented this relationship was noted and the sightings were divided into the presence of remoras or barnacles. The number of adult males, females/juveniles, and calves that presented epibiotic fauna were reported. The year of sightings, temporal season, and geographic location were checked to identify trends. The number and size of the remoras and barnacles in each cetacean were estimated. When quantification was too difficult to establish, a minimum number of individuals was reported. The areas of attachment of each epibiotic organism on the cetacean surface were classified as the dorsal fin, the dorsal area, pectoral fins, eye patch, or fluke.

The limitations of this research pertain to the quality of the images and videos analyzed and the nature of the encounters. The use of opportunistic data derived from citizen science presents certain challenges, primarily due to the quality issues inherent in the material. The majority of the videos and images are of poor quality, with many having been captured on cell phones. Nevertheless, the access to pictures, videos, and reports from fishermen is invaluable, offering avenues for expanding the project and extending the reach of environmental education efforts.

The 37 videos obtained for this research, in which epibiotic fauna was observed, were transformed into sequences of images that could be used to identify the epibiotic fauna on the killer whales using the Python programming language. The most high-quality images were selected and incorporated into the existing images from the sightings with epibiotic fauna. In total, 204 images were selected and subjected to analysis. The database was constructed based on the observations made on these images. It is noteworthy that only a small proportion of images (21) had ventral images, yet no epibionts were observed in any of them.

An independent chi-square test was performed to determine whether there was a statistically significant association between the presence of epibiotic fauna and specific parts of the orcas.

To identify the species of the epibiotic fauna presented, a graphic analysis of the best available images was carried out combined with a comparison with similar articles (Guerero-Ruiz

Table 1. Epibiotic fauna associated with killer whales in Costa Rica obtained from the Orcas in Costa Rica database.

Date (dd/mm/yyyy)	Group size	Orcas with epibiotic fauna	Age group of orcas with Barnacles or remoras	Presence of Xenobalanus globicipitis (Number for each cetacean)	Presence of Remora australis (Number for each cetacean)	Body part involved
29/01/03	7	2	F/J	2 ; 5	-	Dorsal fin
18/06/13	6	1	F/J	2	-	Dorsal fin
05/10/13	10	1	F/J	1	-	Dorsal fin
17/11/16	2	2	F/J	<20 ; <20	-	Dorsal fin and pectoral fins, fluke
28/02/19	3	1	F/J	3	-	Pectoral fins and dorsal fin
08/03/20	6	2	F/J	1 ; <10	-	Dorsal area, fluke
30/04/20	3	1	M	-	<6	Dorsal fin, dorsal area
21/02/22	9	1	F/J	1	-	Dorsal fin
01/06/22	5	2	M	-	<5	Dorsal area, eye patch
17/06/22	10	2	F/J, C	3	<10	Dorsal fin, dorsal area
01/09/22	3	1	C		1	Dorsal area
Total	**64**	**16**	**-**	**8**	**4**	

y Urbán, 2000; Becerril-García et al., 2019). An expert in tropical fish from the University of Costa Rica was consulted to confirm the identification of the remora.

Results

The Orcas en Costa Rica project documented 78 confirmed sightings of orcas from 1997 to 2024, involving 302 individuals. It is important to note that the project does not have a mechanism for identifying individual orcas, therefore the count represents the total number of orcas observed across all sightings, rather than distinct individuals in the region.

Of these, 11 documented the presence of epibiotic fauna (**Table 1**). These cases involved 64 orcas, 16 of which were recorded as having an epibiotic relationship. Barnacles were reported in eight of these 11 cases (**Figures 1 and 2**). In three cases, remoras were documented (**Figure 3**). 11 females/juveniles and a calve presented barnacles. No barnacles were visually observed in adult males. Three adult males, a female/juvenile, and a calve recorded remoras. Notably, one sighting recorded orcas with barnacles and remoras, although on different individuals.

The largest barnacles were observed in larger individuals, possibly females, identified by their size, dorsal fin shape, number of scars, and teeth wear. This relationship was mainly associated with flukes. Previous studies have suggested that epibionts can be passed on from

Figure 1. *Xenobalanus globicipitis* in the tip of the dorsal fin of *Orcinus orca* (Berny Castillo, 2022).

mothers to calves because of their continuous contact (Baird, 2000). The epibiotic organisms were identified as *Remora australis* and *Xenobalanus globicipitis*.

Four of the 11 cases occurred in 2022, representing 36% of the total number of orca sightings reported that year. Five records were in the rainy season, four in the dry season, and two in the transition months. Therefore, a specific temporal seasonal link was not apparent. From a geographical perspective, there were no clear trends regarding sightings that involved orcas with barnacle or remora interactions (**Figure 4**), as the reports covered most of the Costa Rican Pacific coast.

When barnacles were placed on the fluke, they usually occupied most of the terminal part in groups of more than 10 individuals. Barnacles were found in seven cases in the dorsal fin, two cases in the pectoral fins, two cases in the fluke, and two cases in the dorsal area. The distribution of the remoras was predominantly on the back, although one was observed on the dorsal fin of a male and one on a male's eyespot (**Figure 3**).

A statistically significant prevalence for certain body parts was observed among the epibiotic fauna, with the dorsal fin being the most frequently observed with epibiotic fauna

(X2 =13.5, df = 4, P = 0.009074).

Discussion

The greater number of epibiotic fauna presented in female and male juveniles in the region could indicate that they are better hosts than adult males. This could be because males compete physically, as evidenced by the large

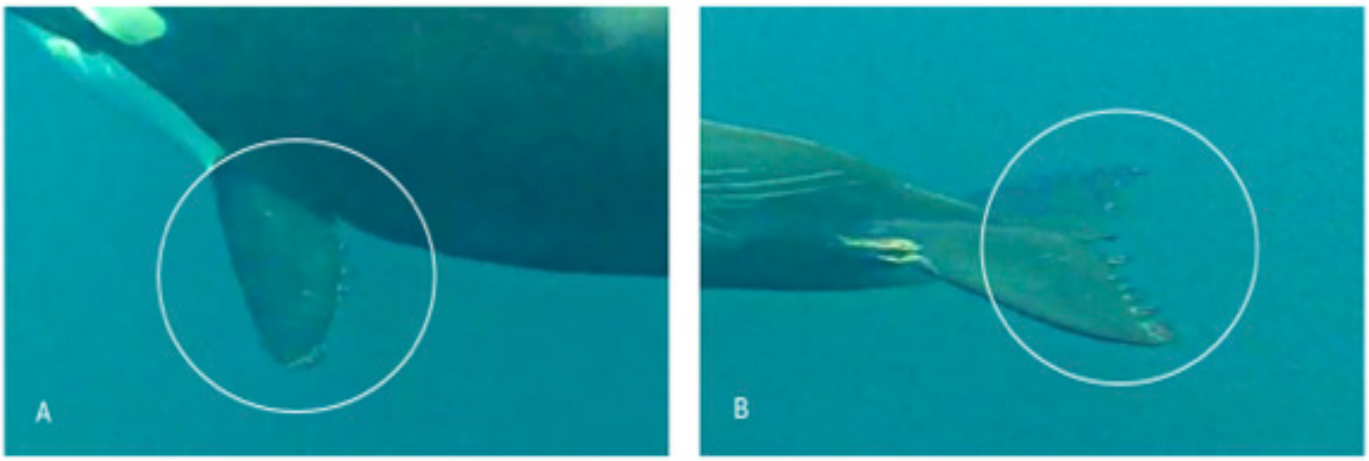

Figure 2. A) *Xenobalanus globicipitis* on the pectoral and B) fluke of a female orca (Shawn Larkin).

Figure 3. *Remora australis* in the eye patch of Orcinus orca (Esteban Morales, 2022).

number of scars they carry and the frequent display of jumps and tail slaps (Robeck et al., 2019). This could hinder the consolidation of sessile ectoparasites such as barnacles (Dolezal et al., 2023). The presence of barnacles in male juveniles may be linked to their reduced physical capability, which may make it less likely for them to remove them through mechanical action. Additionally, their frequent contact with older individuals, who may already have barnacles, may contribute to their presence in juveniles (Weihs et al., 2007; Baird, 2000).

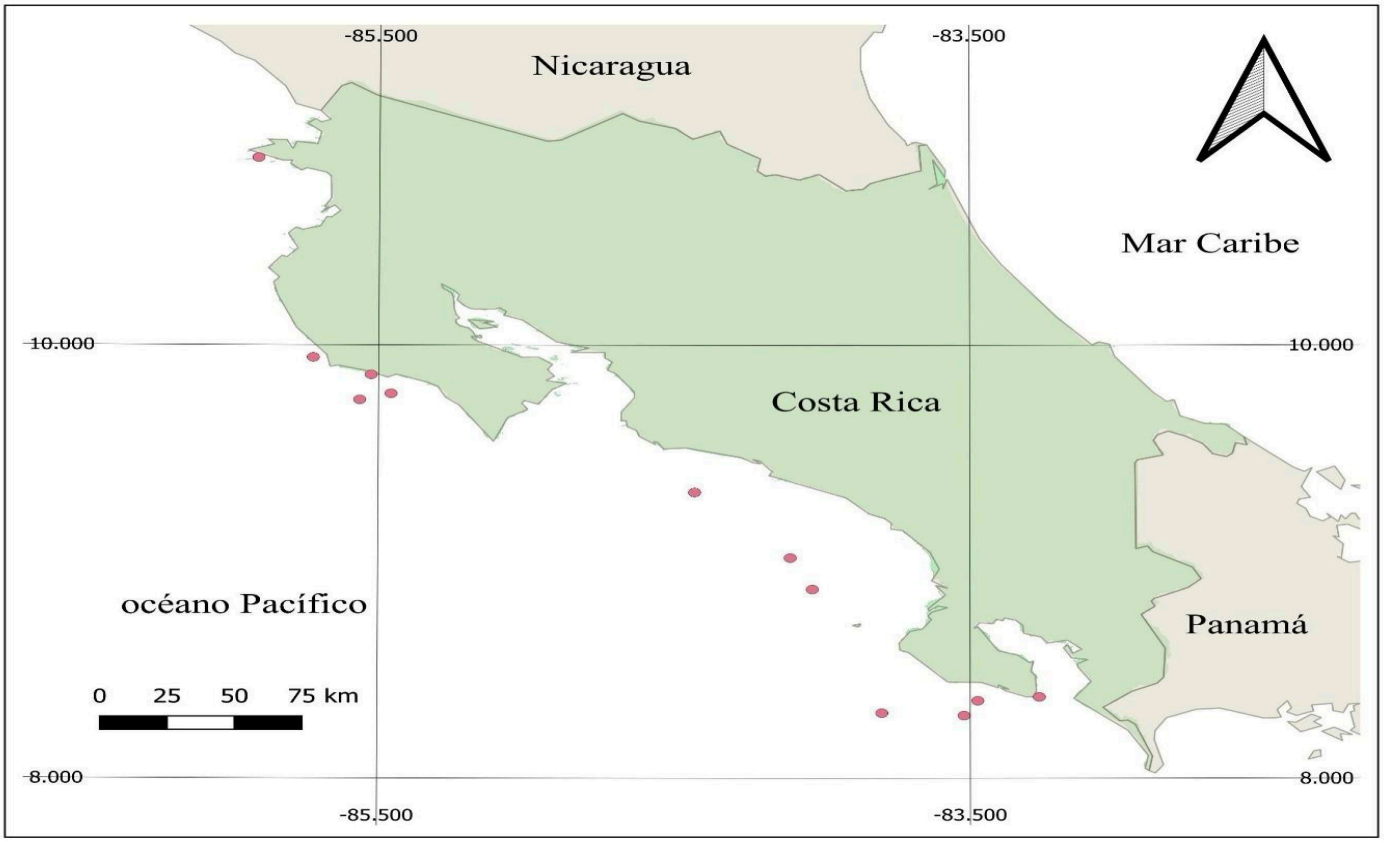

Figure 4. Geographical distribution of orca sightings with epibiotic fauna in the Costa Rican Pacific.

However, remoras can be attracted by other factors, such as space availability (Wingert et al., 2021). By being larger, adult males are more attractive hosts than females or juveniles. They may choose the most stable male areas to settle, such as the eyespot (**Figure 3**) or the dorsal fin (**Table 1**).

The prevalence of epibiotic attachment on the dorsal surface can be attributed to the enhanced surface area it provides and the difficulty of removing them from that specific body part (Weihs et al., 2107).

Xenobalanus globicipitis was the species presented in this report. Described as a barnacle with high specialization in cetacean hosts, it has emerged as a valuable indicator for assessing cetacean health (Dolezal et al., 2023). Kane et al. (2008) found that odontocetes have a low prevalence of this species, while mysticetes were their preferred hosts. *X. globicipitis* has been used as an indicator of the travel patterns of orcas in the Northern Hemisphere (Matthews et al., 2020), and orca population dynamics in the Southern Hemisphere (Whitehead et al., 2015). Additionally, these epibionts have been hypothesized to function as indicators of oceanic warming (Visser et al., 2020).

While *Remora osteochir* originally seemed promising for species identification. There is insufficient supporting literature to firmly establish it as a reliable candidate. *R. australis*, on the other side, has been extensively linked to

dolphins and whales in Central America (Bussing y López, 2005). Other odontocete species have also been documented in the ETP as its hosts (Becerril-García et al., 2019).

There appeared to be no discernible temporal influence on the documentation of epibiotic fauna. However, the notable increase in the proportion in 2022 is a cause for concern. Although some sources suggest a connection between orcas in poor health and the presence of epibiotic fauna, such a correlation does not seem evident in the country's context (Siciliano et al., 2020). Beyond the intrinsic characteristics of the first stages of development, orcas with remoras or barnacles did not have any notable physical problems. In general, the animals appeared healthy. The high number of reports during 2022 could be linked to the cumulative effects of climate change affecting the ETP (Clarke et al., 2021), as the increase in barnacle numbers might be associated with warmer ocean temperatures. Barnacles tend to prefer warmer areas on cetaceans to attach (Dolezal et al., 2023). Nevertheless, it is noteworthy that the number of reported sightings in the Costa Rican Pacific in 2022 was not as numerous as in other regions, such as South Africa (Whitehead et al., 2015).

With the region's adverse climatic projections and the influence of the ENSO phenomenon (Ying et al., 2022), it is crucial to develop new and quick ways to assess the health of cetaceans living in the ETP. The use of epibiotic fauna as a biological marker could be a promising approach because it allows remote monitoring.

A persistent issue in this region is the insufficient available data to address questions related to tropical biodiversity. We propose to create a detailed registry to develop a baseline of epibiotic interactions between orcas, *X. globicipitis* and *R. australis*. Local populations will be trained to identify and report the abundance of barnacles and remoras, thereby providing valuable information to experts and decision-makers. This approach will enhance the influence of citizen science on biodiversity conservation. This baseline serves as a reference for future assessments. Identifying statistically significant changes in the percentage of orcas exhibiting these interactions or in the number of barnacles or remoras per individual, could provide valuable indicators of potentially adverse physiological conditions. In the future, acquiring samples of this epifauna will facilitate precise identification and genetic analyses. These analyses will contribute to a deeper understanding of the role of tropical orcas on ecosystems. Serving as a valuable comparative tool for assessing the relationships between killer whales and epifauna in future studies conducted in different regions worldwide.

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Ethics, Conflict of Interest, and Funding Statement

All authors reviewed and approved the publication of this study. The authors of this manuscript declare that they complied with the ethical and legal requirements at the time of conducting the study and during the writing of the manuscript. There are no conflicts of interest of any kind, and the contributions of the authors to the study are as follows: C.C.A: Data collection. T.R.G.: Data analysis. All co-authors: preparation and final approval of the manuscript.

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