SEABIRDS AND COMMON DOLPHIN (*Delphinus* SP) ASSOCIATIONS IN THE MOCHIMA NATIONAL PARK, VENEZUELA, SOUTH CARIBBEAN

Alimar Molero-Lizarraga [1*], Sergio Cobarrubia-Russo[2], Enrique Quintero-Torres[2], Guillermo R. Barreto[3] & Luis Bermúdez-Villapol[4]

*[1] Laboratorio de Diversidad Biológica, Centro de Estudios de la Crisis Ambiental Global, Instituto Venezolano de Investigaciones Científicas IVIC, 1020-A Caracas, Venezuela. *alimarelena@gmail.com. http://orcid.org/0000-0003-1646-9818*

[2] Laboratorio de Biología de los Organismos, Centro de Ecología, Instituto Venezolano de Investigaciones Científicas, Apartado Postal 20632, 1020-A Caracas, Venezuela. Sergio.cobarrubia@gmail.com. http://orcid.org/0000-0002-3351-1929. equintero1981@gmail.com. http://orcid.org/0000-0002-1589-9157

[3] Laboratorio de Manejo y Conservación de Fauna Silvestre, Departamento de Biología de Organismos, Universidad Simón Bolívar, Apartado 89000, 1080-A Caracas, Venezuela. guibarre@gmail.com. https://orcid.org/0000-0003-0042-7082

[4] Centro de Investigación de Cetáceos, Isla de Margarita, Venezuela. luisbiodiversidad61@gmail.com. http://orcid.org/0000-0002-5091-5861

ABSTRACT: Associations between seabirds and cetaceans are common. To describe the presence of associations among *Delphinus* sp and seabirds in the Mochima national park, from October 2009 to September 2010, observations of groups of this cetacean and seabirds were made on mobile platforms, using a focal group-follow methodology. Data such as dolphins group size, behavior, flock type, flock size, species were collected. univariate chi-square test, contingency tables and the Sperman correlation test were used to analyze the data. Out of 86 dolphin groups observed 54 (62.79%) were associated with seabirds. The most frequent seabird species in these associations was the Brown booby (*Sula leucogaster*) (63%), followed by the Brown Pelican (*Pelecanus occidentalis*) (15%), the Magnificent Frigatebird (*Fregata magnificens*) (8%), the Masked Booby (*Sula dactylactra*) (7%), and the Neotropic Cormorant (*Phalacrocorax brasilianus*) (7%). There were statistically significant associations between dolphin behavior and flock type (χ^2= 14.51, df = 1, p-value = 0.00013). We observed that the size of dolphin-associated bird flocks tended to increase with the size of dolphin schools (Spearman rank correlation = 0.53, p-value = 4.294e-05). These associations often play an important role in foraging success in tropical regions. It has been suggested that these interactions may increase bird foraging efficiency and decrease energy expenditure, although there is no apparent benefit to dolphins.

Key words: common dolphin, seabirds, association, Mochima National Park

RESUMEN: Las asociaciones entre aves marinas y cetáceos suelen ser frecuentes. Con el objetivo de describir la presencia de asociaciones entre *Delphinus* sp. y aves marinas en el Parque Nacional Mochima, desde octubre de 2009 hasta septiembre de 2010, se realizaron observaciones de grupos de delfines y aves marinas en plataformas móviles, utilizando una metodología de seguimiento de grupo focal. Se recolectaron datos de tamaño de grupo de delfines, comportamiento, tipo y tamaño de bandada, especies. Los datos se analizaron con chi-cuadrado, tablas de contingencia y la prueba de correlación de

Sperman. Se registró un total de 86 grupos de delfines, de los cuales 54 (62,79%) estaban en asociación con aves marinas. La boba marrón (*Sula leucogaster*) fue el que más se asoció con el Delfín común (63%), seguido del Alcatraz *Pelecanus occidentalis* (15%), la Tijera de Mar *Fregata magnificens* (8%), Boba borrega *Sula dactylactra* (7%) y la Cotúa *Phalacrocorax brasilianus* (7%). La asociación fue más frecuente cuando los delfines se estaban alimentando. Hubo asociaciones estadísticamente significativas entre el comportamiento de los delfines y el tipo de bandada (χ^2= 14,51, df = 1, valor p = 0,00013). Observamos que el tamaño de las bandadas de aves asociadas a delfines tendía a aumentar con el tamaño de los grupos de delfines (Spearman = 0,53 p = 4,294e-05). Se ha señalado que estas asociaciones desempeñan un papel importante para el éxito de la búsqueda de alimento en las regiones tropicales y que pueden aumentar la eficiencia de forrajeo de las aves y disminuir el gasto de energía, pero no se observa beneficio aparente para los delfines.

Palabras clave: delfín común, aves marinas, asociación, Parque Nacional Mochima.

INTRODUCTION

Interspecific associations can be classified as positive, negative or neutral based on their effect on the species involved (Odum & Barrett 2006). Seabirds are know to associate with various marine vertebrate, including sharks, turtles, whales and dolphins (Pitman 1993; Clua & Grosvalet 2001; Hebshi *et al*. 2008; Vaughn *et al*. 2008). Some authors have characterized these interactions as mutualism while others have classified them as commensalism (Cremer *et al*. 2004). However, there is also evidence of parasitic relationships between Kelp gull (*Larus dominicanus*) and Right whales (*Eubalaena australis*) (Thomas 1988; Marón *et al*. 2015; Sironi *et al*. 2019).

It has been suggested that most associations are likely opportunistic or incidental according to the concentration of common prey (Evans 1982). Interactions between seabirds and cetaceans are frequent (Cremer *et al*. 2004, 2009; Degrati *et al*. 2013). Evolutionary benefits of feeding cetacean aggregate include reduced predation (Bertram 1978; Norris & Schilt 1988) and increased foraging success (Evans 1982; Vaughn *et al*. 2008). Association with dolphins may help seabirds locate their prey and may increase the accessibility of prey that is not accessible to single-foraging birds (Evans 1982; Pierotti 1988; Vaughn *et al*. 2008).

Common dolphins are found in warm temperate and tropical waters around the world. It occurs in coastal and offshore areas (Gaskin 1968). For a time common dolphins were divided into two species – short-beaked common dolphins (*Delphinus delphis*) and long-beaked common dolphins (*D. capensis*). However, in 2015 genetic studies determined that all populations correspond to a single species (*D. delphis*) with four recognized subspecies (Cunha *et al*. 2015).

There is a stock that has been identified for Venezuela that stands out for its long snout. Its taxonomic identity, however, is still up for debate (Esteves & Oviedo 2007; Jefferson *et al*. 2009; Tavares *et al*. 2010; Committee on Taxonomy 2019). Therefore, in the intention that taxonomic identification may be clarified in the future, we refer to the common dolphin studied in this research as *Delphinus* sp.

In Venezuela, they are found mainly in the northeast region and are considered the most common cetaceans of the area (Romero *et al*. 2001; Quevedo 2004; Molero 2005; Acevedo

2007). This area boasts high productivity and some of Venezuela's most important upwellings (Suárez & Bethencourt 1994).

The associations of this genus with seabirds have been reviewed (Evans 1982; Pitman & Au 1992; Pitman & Ballance 1992; Clua & Grosvalet 2001; Neumann & Orams 2003; Schaffar 2004). In Venezuela, bird-dolphin interactions have been used to detect the presence of cetaceans at the site or were indicative of dolphin feeding behavior (CIC 2004; Molero 2005). Little is known about the characteristics of these interactions. The study's goal was to describe the interactions between common dolphins and seabirds. Additionally, we investigated whether dolphin behavior and group size were related to the incidence of seabird associations.

MATERIALS AND METHODS

Study area

Mochima National Park (MNP) is located on the northeastern coast of Venezuela extending from Anzoategui to Sucre state (10°10.31´N - 64°13.4´W and 10°25´N - 64°42.9´W; Fig. 1). Water depths reach 125m with slopes from 0 to 3º (Miró 1974). The climate is semiarid with a dry season between January and May and a rainy season between June and December. The temperature, dissolved oxygen, salinity, pH, and water clarity exhibit cyclical variation associated with coastal zone upwelling (Robaina 1991).

Field methods

From September 2009 to August 2010, we conducted opportunistic surveys in the eastern part of the Mochima National Park using a 5-meter handmade boat equipped with a 40hp outboard motor, traveling at a constant speed of 15 km/h (Fig. 1). The surveys followed a predefined route, and each survey lasted an average of five hours, subject to sea and weather conditions. Observers used 7x50 binoculars to locate dolphins and seabirds. We halted observation efforts in case of low visibility (<5–6 km), precipitation, or a Beaufort scale reading greater than 3.

Upon sighting a group of dolphins, we deviated from the route and followed them for 30 minutes. To reduce autocorrelation bias, we monitored only one group per two hours (Molero-Lizarraga *et al*. 2021).

We applied the focal group method with instantaneous sampling (Altmann 1974; Mann, 1999) to collect data on group size, dolphins behavior, flock composition (proportion of individuals of each species), flock type (monospecific or mixed species) and number of seabirds. Mixed flocks comprised individuals of different species connected by common social behaviors, movements, and foraging (Powell 1985; Hutto 1987, 1994; Arbeláez-Cortés *et al*. 2011; Giselle & Fanjul 2013). Four behavioral states were considered for dolphins: feeding, traveling, socializing, and resting (TABLE 1).

A group of dolphins was defined as any number of dolphins observed in association, moving in a similar direction and usually engaged in a similar behavior (Garaffo *et al*. 2007) and seabird group was defined as an aggregation of two or more individuals of the same or different species

TABLE 1. Description of Behavioral States in Dolphins

Behavior	Description
Feeding	Short and unsynchronized dives, frequent surface events, multidirectional movements, and often the presence of seabirds and schooling fish.
Traveling	The animals moved steadily in one direction and executed synchronized dives.
Socializing	Animals engage in individual interactions within a group, frequently making physical contact, often with vigorous movements and aerial behaviors such as leaping and breaching. This also includes sexual and aggressive behaviors.
Resting	Animals exhibit very slow movements or remain stationary at the surface.

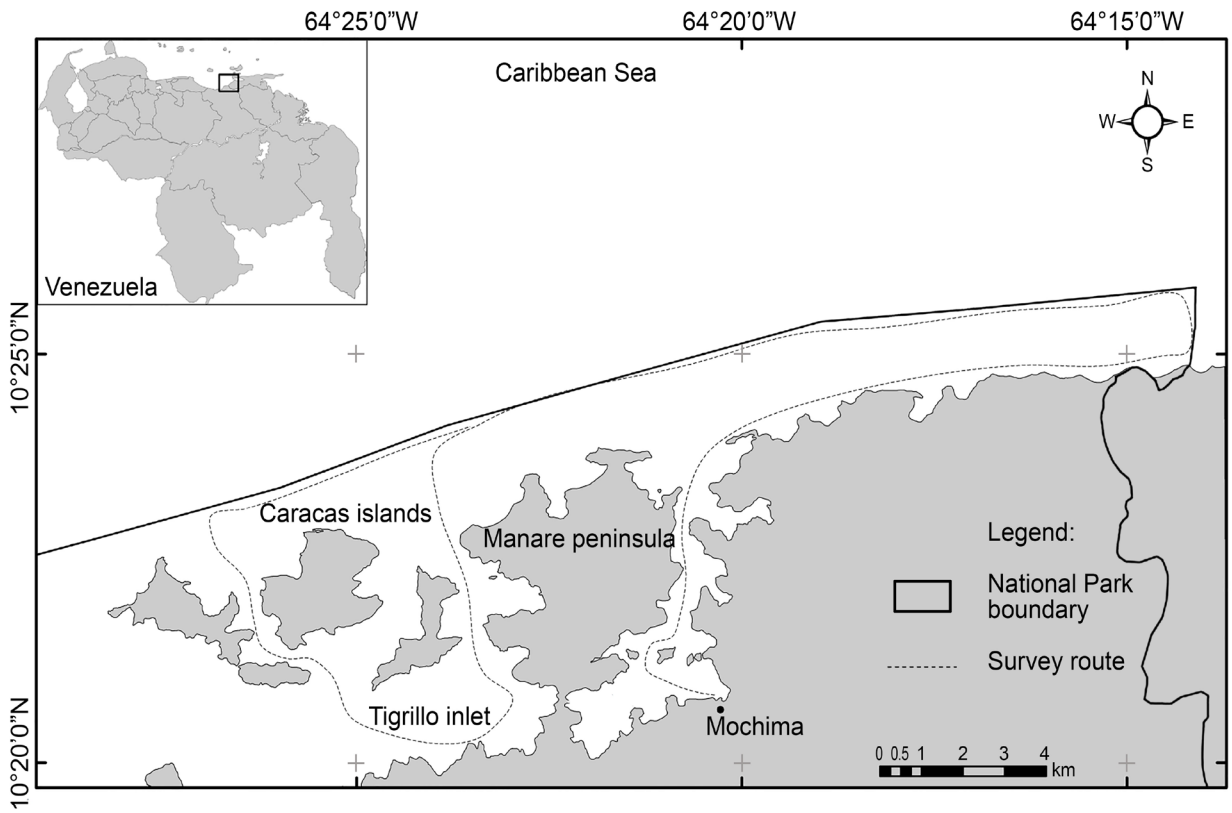

Fig. 1. Map of the study area. Includes park boundary and survey route. Surveys were done from Mochima town.

found in a range of 20–30 m that move together (Hutto 1994). Associations were defined as the presence of seabirds in the immediate vicinity of a cetacean (Hodges & Woehler 1994). Observations of the associations between seabirds and dolphins were recorded every 5 minutes for a total of 30 minutes (Altmann 1974; Mann 1999).

Data analysis

For each seabird species, the frequency and percentage association was calculated. A good-fit Chi-square (χ^2) test was conducted in order to compare observed occurrence of associations with the expected one (Quinn & Keough 2002). All species were assumed to have equal expected frequencies as a null hypothesis. Contingency tables were created to measure the association between dolphin behavior and the presence-absence of birds and the relationship between flock type and dolphin behavior. The Chi-square (χ^2) test of independence and Fisher exact test (when expected cell counts are low, < 5) were calculated respectively (Crawley 2013). Finally, in cases where no significant associations were detected, statistical power was calculated to verify whether the non-significance result is due to lack of relationship between the groups or due to lack of statistical power (Quinn & Keough 2002).

A Spearman correlation was used to examine the relationship between number of dolphins and number of associated seabirds. All analyzes and graphs were performed in R (R Core Team 2021).

RESULTS

From 86 observed groups of *Delphinus* sp., 54 (62.79%) involved interactions with seabirds (Fig. 2). Brown Booby (*Sula leucogaster*) was the predominant associated with common dolphin (63%), four other seabird species were involved: Brown Pelican *Pelecanus occidentalis* (15%), Magnificent Frigatebird *Fregata magnificens* (8%), Masked Booby *Sula dactylactra* (7%) and Neotropic Cormorant *Phalacrocorax brasilianus* (7%) (Fig. 3). These observed frequencies differed significantly from those expected ($\chi^2 = 86.11$, df = 4, p-value = 2.2e-16).

Associations were more common when dolphins were feeding, however no statistically significant relationship was found between dolphin behavior and avian presence ($\chi^2 = 2.95$, df = 3, p-value = 0.39). Statistical power was low (power = 0.260) for an effect size W= 0.18 (low) and a significance level of 0.05, suggesting that a larger sample size is required. Dolphin groups were found to be more frequently associated with monospecific than mixed flocks (Fig. 4). Our observations revealed that the Brown Booby (*S. leucogaster*) was a common participant in both monospecific and mixed species flocks (TABLE 2). There were statistically significant associations between the dolphin behavior and flock type ($\chi^2 = 14.51$, df = 1, p-value = 0.00013).

The size of bird flocks associated with dolphins tended to increase with the size of the dolphin schools (Fig. 5). A correlation was found between the number of birds and the number of dolphins in the group (Spearman rank correlation = 0.53, p-value = $4.294e^{-05}$).

DISCUSSION

Our study provides new insights into associations between seabirds and dolphins in the Mochima National Park. We observed at least 5 seabird species in associating with Common

dolphin groups in this area: *S. leucogaster, P. occidentalis, F. magnificens, S. dactylactra* and *P. brasilianus*. The seabirds were mainly in monospecific flocks, of *S. leucogaster*. According to the literature, boobies like Booby brown commonly feed with cetaceans and other seabirds, which may explain their frequent involvement in our observed interactions (Marchant & Higgins 1990).

Fig. 2. Feeding association between Seabirds and dolphins in the Mochima National Park.

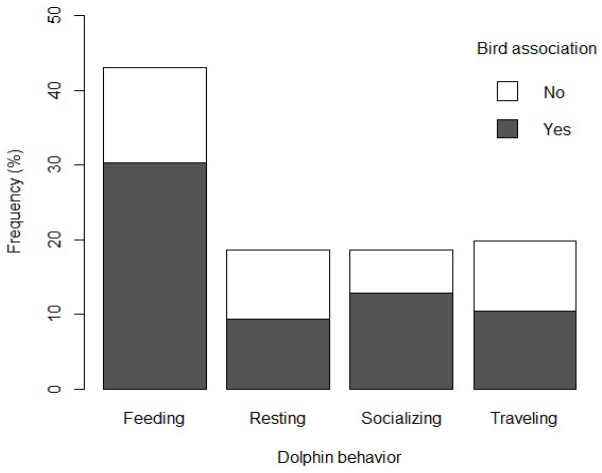

Fig. 3. Association frequencies between common dolphin behaviors and the presence (Yes) or absence (No) of birds.

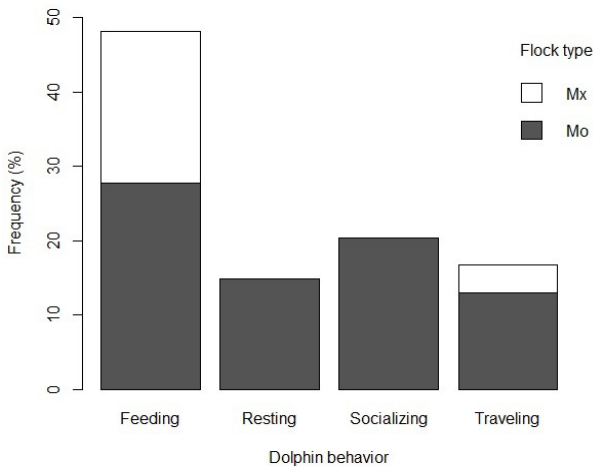

Fig. 4. Association frequencies between common dolphin behavior and flock type.

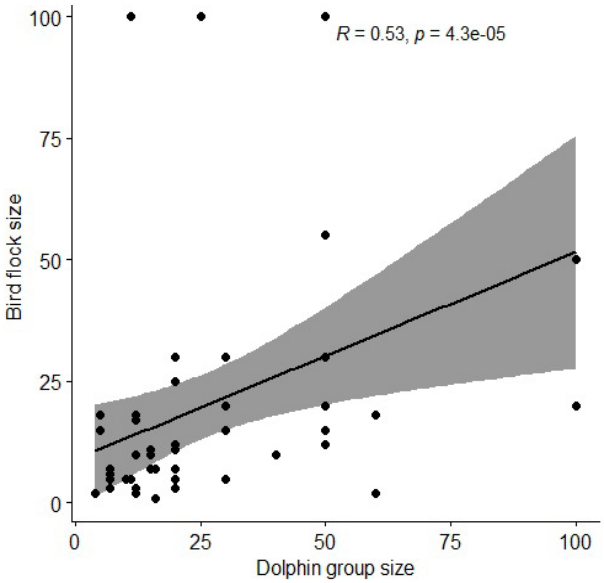

Fig. 5. Scatter plot between dolphin group size and bird flock size. R and p values correspond to Spearman's correlation analysis.

TABLE 2. Seabird species observed in association with Common dolphins (*Delphinus* sp.)

Flock type	Species	N
Monospecific (Mo)	Pb	1
	Po	6
	Sd	1
	Sl	33
Mixed species (Mx)	Po, Sl	2
	Po, Sl, Sd	2
	Pb, Sl	1
	Sl, Fm	3
	Sl, Pb, Fm	2
	Sl, Pb, Po, Fm	1
	Sl, Sd	2

Legend: Sula leucogaster (Sl), *Pelecanus occidentalis* (Po), *Fregata magnificens* (Fm), *Sula dactylactra* (Sd) and *Phalacrocorax brasilianus* (Pb), N (Number of times it was sighted in association with dolphins).

Seabirds are known to associate with marine vertebrates such cetaceans pinnipeds and schooling fish (Ashmole & Ashmole 1967; Evans 1982; Burger 1988; Pierotti 1988; Harrison *et al*. 1991; Pitman & Balance 1992; Burguess 2006; Vaughn *et al*. 2008; Rossi-Santos & Flores 2009).

Several authors have suggested that these associations are important for foraging success in tropical regions, where resources are more patchily distributed (Longhurst & Pauly 1987; Ballance *et al*. 1999).

In our study dolphin behavior and group size appeared in seabird prey detection. Associations primarily occurred when dolphins were feeding and formed large groups. Larger dolphin groups are likely easier for birds to spot from farther away, as noted Degrati *et al*. (2013). Similar findings have been reported for several dolphin species, including Common dolphin (*D. delphis*) Guiana dolphins (*Sotalia guianensis*) Spotted dolphins (*Stenella frontalis*) and Dusky dolphin (*Lagenorynchus obscurus*) (Clua & Grosvalet 2001; Burguess 2006; Degrati *et al*. 2013, Espinoza-Rodriguez *et al*. 2015; Stockin *et al*. 2022).

Subsurface marine predators can facilitate prey detection by seabirds especially in deep water environments (Correia *et al*. 2019). These interactions have been suggested to increase bird foraging efficiency and decrease energy expenditure (Dinsmore 1973; Grubb 1976; Evans 1982; Pierotti 1988; Vaughn *et al*. 2008). However, it is unclear whether these associations provide any direct benefits to the dolphins (Orgeira 2004)

Several mechanisms have been proposed to explain how multispecific feeding groups can benefit individuals. The "feeding efficiency" hypothesis suggests that different species

take on complementary roles based on their unique foraging strategies, reducing interspecific competition and maximizing utilization of patchy resources (Diamond 1981; Anderwald *et al*. 2011; Gostischa *et al*. 2021).

One potential mechanism is that predators with different feeding techniques can exploit prey unavailable to other species (Sealy 1973; Camphuysen & Webb 1999). Additionally, some participants may benefit through opportunistic scavenging of leftovers or prey stealing from other species (Diamond 1981). In ephemeral associations between seabirds and cetaceans, different species may simply aggregate around a common food resource without directly interacting or conferring reciprocal benefits (Evans 1980, 1982).

The seabird-dolphin associations observed in this study likely assisted the seabirds in locating prey patches, though no clear foraging benefit was evident for the dolphins. While these joint feeding aggregations may appear to be random co-occurrences around a common food resource, recent research indicates dolphin-seabird relationships can provide greater mutual benefits than previously thought (Gostischa *et al.* 2021; Stockin *et al.* 2022). Although the current analysis did not directly examine the drivers and mechanisms of these interactions, we offer potential explanations for the patterns found between common dolphins and seabirds in Mochima National Park. Further research is required the causal factors and reciprocal nature of these interspecific foraging associations.

CONCLUSIONS

Our researcher conducted in Mochima National Park found they frequently associated with seabirds, particularly brown boobies (*S. leucogaster*). These associations occurred mainly while dolphins were feeding in large groups, likely helping seabirds locate prey. These relationships can be considered commensalist, providing energetic benefits to seabirds but no clear benefit to dolphins. The specific facilitative foraging mechanisms remain uncertain. Further research on these dolphin-seabird associations is needed to understand mutual benefits and synergistic strategies.

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