REPRODUCTIVE STRATEGIES OF THE LEAST TERN *STERNULA ANTILLARUM* AT TROPICAL ISLA CONTOY, MEXICO

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ABSTRACT

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The Least Tern *Sternula antillarum* is a small seabird species that nests on sandy substrates near wetlands and coastal plains. Although the International Union for Conservation of Nature (IUCN) classifies it as Least Concern, the authorities in Mexico have listed it as Subject to Special Protection due to threats such as habitat loss, human disturbance, and predation. In this study, we documented Least Tern reproductive ecology at Parque Nacional Isla Contoy, Quintana Roo. During weekly sampling in 2023 and 2024, we located and marked active nests and recorded the number of eggs and chicks. Using these data, we estimated colony size, reproductive chronology, and hatching success. Nests were concentrated in open areas of sparse halophytic vegetation and sandy substrate, similar to where the species nests elsewhere in the Gulf of Mexico. In 2023, we recorded 162 nests at three sites: Laguna Norte (150), Cruces (seven), and Dunas (five). Most nests had two eggs (62.4%), and hatching success was 23.6%. Laguna Norte had the largest number of nests, possibly because of its natural protection against wave action and wind. In 2024, the number of nests decreased to 89, most of which were observed at Cruces (29) and Dunas (28); El Faro and Laguna Norte had 18 and 14 nests, respectively. In this year, hatching success decreased to 17%. The primary causes of reproductive failure were flooding caused by intense rainfall, wave action, predation by wading birds, and competition with sea turtles. We observed both site fidelity and plasticity in habitat selection. This study provides baseline information about the reproductive ecology of the Least Tern in the Mexican Caribbean and highlights the need to implement continuous monitoring and management strategies.

Key words: seabirds, Least Tern, reproductive ecology, Caribbean, Contoy

INTRODUCTION

The Least Tern *Sternula antillarum* nests on the ground on sandy and/or shell substrates near wetlands or in coastal plains (Burger & Gochfeld, 1996; Howell & Webb, 1995). Clutches of one to three eggs are incubated for 20–22 d (Canales-Delgadillo et al., 2024). This species is listed as Subject to Special Protection under the Official Mexican Standard (Secretaría de Medio Ambiente y Recursos Naturales [SEMARNAT], 2019), and although it is classified as Least Concern by the International Union for Conservation of Nature (IUCN) 2025, its global population is decreasing. Despite being adapted to dynamic habitats, the Least Tern faces multiple threats, including loss of nesting sites (Canales-Delgadillo et al., 2024), human disturbances, and predation (Rodríguez et al., 2009).

The Least Tern breeds along most of the North American coast, except for Alaska and Canada, as well as along the northern coasts of Central America and South America. In central North America, it also nests on inland river sandbars (Alleng, 1993; del Hoyo et al., 2014) and breeds in Belize, Honduras, and Caribbean islands, the latter including the Bahamas, the Cayman Islands, Puerto Rico, San Martín (France), and the U.S. Virgin Islands (Atwood, 2023). In Mexico, the Least Tern occurs along both coasts of Baja California and the Pacific Coast from Sonora to Oaxaca. Along the Gulf of Mexico and the Caribbean coasts, it nests in northern Tamaulipas, Veracruz, Campeche, Quintana Roo, and Yucatán (Atwood, 2023; Howell & Webb, 1995).

Several studies in Mexico have investigated the reproductive ecology of the Least Tern, especially in the Gulf of California and the Mexican Pacific coast (Fleishman & Blinick, 2011; García & Ceballos, 1995; Giner, 2012; Mellink et al., 2009; Palacios & Mellink, 1996; Rosemartin & Riper, 2012; Ryan et al., 2025). Although this species is considered abundant along the Atlantic, Gulf of Mexico, and Mexican Caribbean coasts, insufficient information is available to estimate its actual population size, and its conservation status remains elusive (Brooks et al., 2013; González-Zuarth et al., 2016). However, studies in the Mexican Caribbean and Gulf have documented aspects of its distribution and reproduction. For example, Paynter (1955) reported the species' first occurrence on the coast of Yucatán, where he found small colonies of 5–15 pairs, including at Boca Paila and Bahía de la Ascensión within the Sian Ka'an Biosphere Reserve. Subsequently, López-Ornat et al. (1989) observed the species in Cancún, where it arrived in the third week of April and departed in the third week of September.

González-Zuart et al. (2016) studied the Least Tern in Laguna de Términos, in the southern Gulf of Mexico, where they found 240 nests. Mellink et al. (2007) first documented the nesting of this species in Tantálamos, within the Laguna de Tamiahua, Veracruz. They recorded 10 pairs with active nests (five nestlings) on La Draga Islet 1, while several pairs nested on Islet 2, where 16 chicks and fledglings were observed. In Laguna de Chacmuchuk in Quintana Roo, Venegas-Muñoz and Hernandez-Vázquez (2016) recorded 60 nests on a sandy beach, nesting alongside Roseate Terns

Sterna dougallii. At Playa Norte, Ciudad del Carmen, Campeche, during the COVID-19 lockdown in 2020, Canales-Delgadillo et al. (2024) observed 250 nests. This number was comparable to those recorded in previous years; however, in the absence of human disturbance, a significant increase in reproductive success was evident. In our study, we describe for the first time the reproduction of the Least Tern at Isla Contoy, Quintana Roo, during the 2023 and 2024 breeding seasons.

MATERIALS AND METHODS

Study Area

Isla Contoy is located in the municipality of Isla Mujeres, in the state of Quintana Roo, Yucatán Peninsula. At 21°29′N, 086°47′W, this island is situated at the western end of the Canal de Yucatán, on the border between the Gulf of Mexico and the Caribbean Sea, 50 km north of Cancun and 13 km from the Yucatan Peninsula (Ramsar, 2024) (Fig. 1). The island covers an area of 51.26 km^2, is 8.7 km long, and ranges from 20 to 700 m in width.

The island is mostly flat, with some coastal dunes reaching up to 12 m in height. The Ixlaché Reef, considered the starting point of the Mesoamerican Reef System, the second largest barrier reef in the world, is located in the southern portion of the island. Seven bodies of brackish water occur in the island's interior: Laguna Norte, Pajarera Norte, Laguna Muerta, Laguna Puerto Viejo, Pajarera Central, Laguna de las Garzas, and Pajarera Sur. Together, they cover 0.08 km^2 (Instituto Nacional de Ecología [INE], 1997) (Fig. 1). The regional climate is warm subhumid, with a mean annual temperature of 27.4 °C and little monthly variation. The rainy season extends from May to October, with an average annual precipitation of 380.9 mm; October is the rainiest month, with a mean precipitation of 275 mm (Comisión Nacional de Áreas Naturales Protegidas [CONANP], 2015).

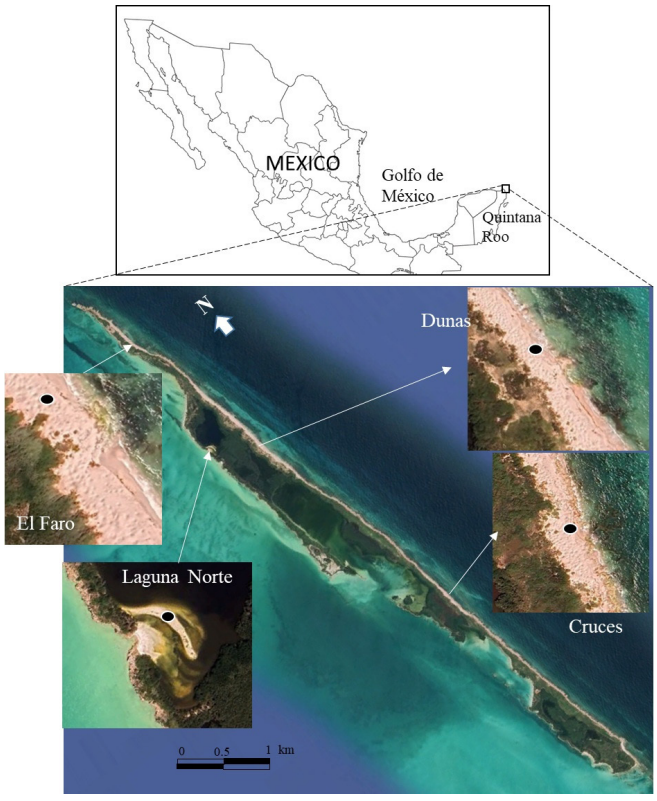

Fig. 1. Location of Isla Contoy, Mexico, and the nesting sites of Least Tern *Sternula antillarum*.

On 08 February 1998, the decree establishing Isla Contoy as a Protected Natural Area with the status of Parque Nacional was published in the *Diario Oficial de la Federación* (DOF, 1998). In the same year, the island was designated as an Important Bird Area (IBA) due to its significance for bird conservation (Commission for Environmental Cooperation [CCA], 1999). This uninhabited island is managed by the CONANP, under the SEMARNAT. In 2003, the island was designated as a Ramsar site (number 1323) by the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar, 2024).

Study Efforts

We visited the Parque Nacional Isla Contoy (PNIC) between June and August 2023 and between May and August 2024. During the first visit of each year, we searched for nests throughout the island. Once active nests were located, we conducted weekly visits until the end of the breeding season. During each visit, we marked newly detected nests with a wooden stake, which we consecutively numbered according to their date of detection.

We estimated colony size (number of nests) and recorded the number of eggs laid throughout the breeding season. We determined breeding phenology based on the dates on which nests, eggs, and chicks were first detected. Using these data, we calculated hatching success, expressed as the percentage of hatched eggs relative to the total number of eggs laid. We compared clutch size between sites in 2023 and 2024 using a Kruskal-Wallis test and between years using a Mann-Whitney test (U). We evaluated hatching success between years with a Z-test for proportions, and between sites using a χ^2 test. All analyses were conducted at a significance level of .05, using the program Statistica 7.

RESULTS

Description of the Nesting Sites

In 2023, we found Least Tern nests at three sites: Cruces, Dunas, and Laguna Norte. The first two sites are on the eastern side of the island and share similar characteristics: small sandy beaches, rocky areas, dunes, and coastal halophytic vegetation. Located at the extreme points of the island, these sites are exposed to strong winds and waves that directly impact the beach strip, especially during high tide. The third nesting site is a sandy islet of 12 × 120 m (1,440 m^2) within Laguna Norte. It is protected by mangroves and, unlike Cruces and Dunas, faces the mainland, where wave action is considerably weaker. In 2024, we again observed nesting activity at Cruces, Dunas, and Laguna Norte. In addition, we found nests on a small beach on the northern side of the island at El Faro, an area exposed to wind and strong wave action (Fig. 1).

Colony Size and Clutch Size

During 2023, we found 162 Least Tern nests on Isla Contoy, with an average of 1.7 ± 0.58 eggs per nest (mean ± standard deviation; range: 1–4 eggs). Nests with two eggs predominated (62.4%), followed by those with one egg (30.3%). Laguna Norte

had the largest colony, with 150 nests, and a mean clutch size of 1.7 ± 0.58 (range: 1–4 eggs). At this site, nests with two eggs were the most frequently observed (65.3%) (Fig. 2A). In Dunas (five nests) and Cruces (seven nests), mean clutch sizes were 1.6 ± 1.03 and 1.3 ± 0.48 eggs per nest, respectively. At both sites, nests with one egg predominated, representing 71.4% of nests in Cruces and 60% in Dunas (Figs. 2B, 2C). The Kruskal-Wallis test revealed significant differences in clutch size among the three sites ($H_{(2)}$ = 6.53, p = .038), with the largest clutch size observed at Laguna Norte.

In 2024, we found 89 nests, with clutches ranging from one to three eggs and a mean of 1.6 ± 0.56 eggs per nest. Two eggs were found in 61.8% (55) of nests, whereas 34.8% (31) had only one egg. Nests were found at four sites on the island: Laguna Norte (14 nests), Dunas (28 nests), Cruces (29 nests), and El Faro (18 nests). In Laguna Norte and El Faro, clutch sizes ranged from one to two eggs (Figs. 2D, 2G), whereas in Cruces and Dunas, clutches ranged from one to three eggs (Figs. 2E, 2F). There was no significant difference in clutch size among the four sites ($H_{(3)}$ = 1.48, p = .68). Most nests had two eggs, with mean clutch sizes of 1.4 ± 0.51 eggs per nest in Laguna Norte, 1.7 ± .44 in Dunas, 1.6 ± 0.65 in Cruces, and 1.6 ± 0.50 in El Faro. Mean clutch size did not differ significantly between 2023 and 2024 (U = 6720.0, p = .33).

Breeding Phenology

During the 2023 breeding season, we started inspections in early June, when active nests were already present, and continued monitoring them until early August. Although reproductive activity occurred at three sites, the largest number of nests was recorded at Laguna Norte. We observed the largest number of nests and eggs during the first week of June and between 21–28 June (Figs. 3A, 3B). In contrast, we recorded relatively few chicks, with the highest number of chicks recorded in early June and July (Fig. 3C).

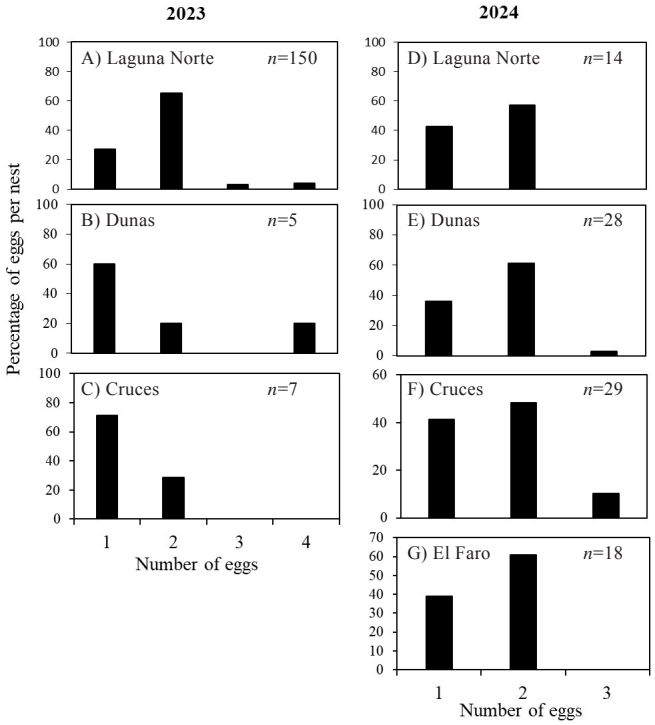

Fig. 2. Number of Least Tern *Sternula antillarum* eggs per nest observed at the nesting sites on Isla Contoy, Mexico, during the 2023 and 2024 breeding season.

In 2024, we found fewer nests and eggs compared with the previous year. The highest numbers of nests and eggs were recorded on 04 June at Cruces (12 nests, 19 eggs) and Dunas (22 nests, 38 eggs), whereas at El Faro, the maximum was recorded in May, with 11 nests and 18 eggs. We detected few chicks in Cruces and Dunas, and we observed no chick activity in El Faro (Figs. 3D–F). At Laguna Norte, unlike the previous season, we recorded only 14 nests, none of which had hatched eggs (Figs. 3D–F). After 19 June, we recorded no active nests at any of the sites.

Hatching Success

There were significant differences in hatching success between years (Z = 3.68, p = .0002). During the 2023 season, hatching success was 23.5% (69 of 294 eggs), whereas in 2024 it was only 16% (24 of 150 eggs). When analyzed by site, hatching success in 2023 was 22.2% at both Dunas and Cruces (two to nine eggs at both sites) and 23.6% (65 of 276 eggs) at Laguna Norte. There were no significant differences in hatching success between sites (χ^2 = 0.94, gl = 2, p = .6). In 2024, hatching success was relatively low, ranging from 4.1% (two of 49 eggs) at Dunas to 48.3% (14 of 29 eggs) at El Faro, with significant differences between sites (Z = −4.67, p = .00002). At Laguna Norte, hatching success decreased markedly between seasons. In 2024, in addition to a decrease in the total number of eggs, none of the 22 eggs recorded hatched (Table 1).

DISCUSSION

Nesting Sites

On PNIC, Least Terns nested in open areas with sparse vegetation near sea level, consistent with reports from other regions of the Gulf of Mexico (Burger & Gochfeld, 1991; González-Zuarth et al., 2016; Mazzocchi & Forys, 2025; Mellink et al., 2007) and the Mexican Pacific (Palacios & Mellink, 1996). At all sites, nests were established on sandy substrates. Unlike silt or clay substrates, sandy substrates retain less moisture, thereby reducing the risk of waterlogging. Consequently, heavy rain events are less likely to affect eggs and chicks (Palacios & Mellink, 1996).

The nesting sites in Cruces, Dunas, El Faro, and Laguna Norte differed markedly in their geomorphology and exposure to wave action, which likely influenced their suitability as nesting habitat. Cruces, Dunas, and El Faro, located in the eastern sector of the island, have narrow beaches composed of sand, rocky areas, low dunes, and halophyte vegetation. These areas are also highly exposed to wind and wave action, particularly during high tides and storms. Such conditions may contribute to the lower density of nests observed at these sites. Previous studies have reported that terns tend to avoid areas with high physical disturbance due to the increased risk of nest loss or damage (Burger & Gochfeld, 1991).

Unlike the other sites, Laguna Norte, located on the continental side of the island, contains a sandy islet (1,440 m^2) that provides more stable conditions for breeding. The islet has reduced exposure to wave action and greater protection from prevailing winds. In addition, the presence of vegetation, such as mangroves, helps reduce erosion in the nesting area. This natural protection could explain the high concentration of nests

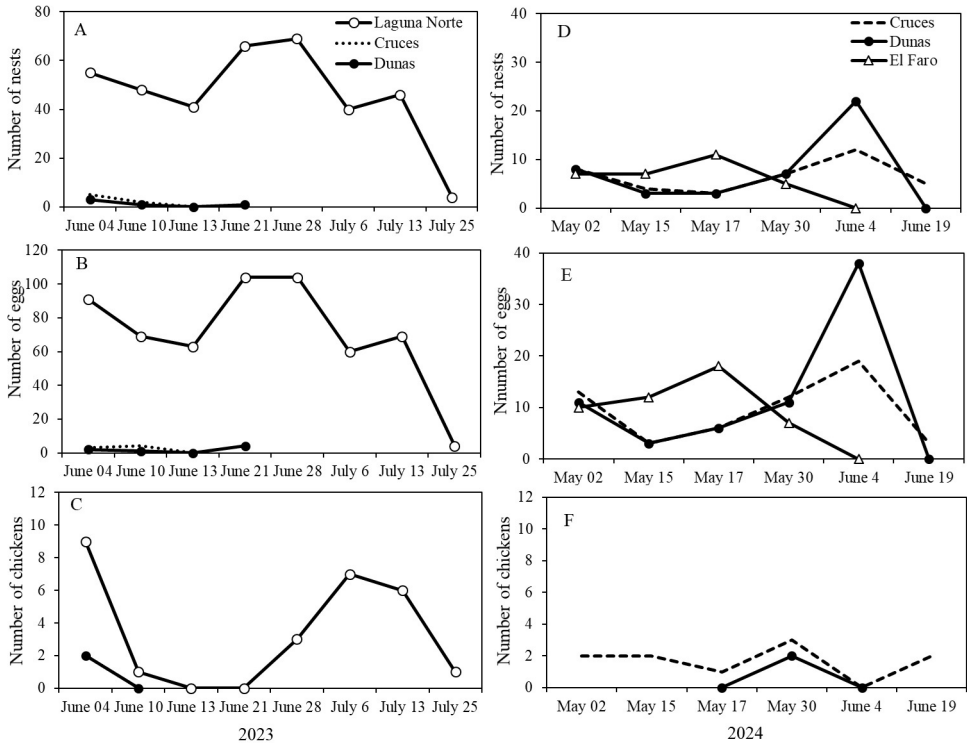

Fig. 3. Number of nests, eggs, and chicks recorded by nesting site and year for Least Tern *Sternula antillarum* on Isla Contoy, Mexico.

recorded in Laguna Norte during 2023 compared with the other nesting sites on the island. However, in 2024, we observed a notable decrease in the number of nests at this site (14 nests). This decrease may be related to the effects of tropical storms and hurricanes (Alberto, Barry, and Beryl) that impacted the area. The significant increase in rainfall and tidal activity due to tropical storms altered the morphology of the sandbar. In 2023, the sandbar was surrounded by water and separated from the beach, limiting the direct effects of waves during high tides and strong winds. In 2024, however, the sandbar had disappeared, leaving only a large mound directly connected to the small beach and more exposed to tidal effects. These changes in sandbar morphology may have reduced the quality and availability of suitable nesting habitat. Collectively, these changes may have affected site fidelity, as has been documented in other Least Tern populations (Darrah, 2024).

TABLE 1
Number of eggs and hatching success of Least Tern *Sternula antillarum* recorded by year and location on Isla Contoy, México

	2023			2024		
	Eggs	Hatching success		Eggs	Hatching success	
Location		%	Number		%	Number
Laguna Norte	276	23.6	65	22	0	0
Dunas	9	22.2	2	49	4.1	2
Cruces	9	22.2	2	50	16.0	8
El Faro				29	48.3	14
Total	**294**	**23.5**	**69**	**150**	**16.0**	**24**

The frequent occupation of Cruces and Dunas sites in both breeding seasons, as well as in previous years, suggests a pattern of site fidelity, a behavior widely documented in this and other tern species (Atwood & Massey, 1988; Spendelow et al., 1995, 2002). However, the exploration and use of new areas, such as the El Faro site in 2024, indicate some flexibility in habitat selection (Thompson et al., 1997). At Cruces and Dunas, the Least Terns coexisted with nests of American Oystercatcher *Haematopus palliatus* (three nests) and Wilson's Plover *Anarhynchus wilsonia* (four nests), an association reported by other authors at different sites (Giner, 2012; Venegas-Muñoz & Hernández-Vázquez, 2016).

Colony Size and Clutch Size

At different sites on Isla Contoy, Least Tern nesting groups were relatively small, except in Laguna Norte in 2023, consistent with observations from other locations in Mexico (García & Ceballos, 1995; Mellink et al., 2007; Palacios & Mellink, 1996; Venegas-Muñoz & Hernández-Vázquez, 2016) and various regions of the Caribbean (Atwood, 2023; Jackson, 2000; McGowan et al., 2006; Stimmelmayr et al., 2013). Nevertheless, the total number of nests across all sites on Isla Contoy, particularly in 2023, exceeded that of nearby colonies, such as Laguna de Tamiahua, Veracruz (Mellink et al., 2007). However, the total number of nests was lower than that reported for Laguna de Términos, Yucatán, where 240 nests have been documented (González-Zuarth et al., 2016).

On a regional scale, Jackson (2000) analysed the distribution of Least Tern nesting sites in the western Caribbean Islands, with colony sizes ranging from 4–10 nests on Long Island to 250–300 nests on Great Inagua and Little Inagua. He estimated a total population of 1,500–3,000 breeding pairs across the region. In this context, the 162 nests recorded on Isla Contoy in 2023 exceeded

the size of some colonies recorded in Mexico (Palacios & Mellink, 1996), the Gulf and Florida (Mazzocchi & Forys, 2005), and the Caribbean (Jackson, 2000; McGowan et al., 2006) but represented 10.8% (2023) to 5.4% (2024) of the estimated breeding population for the West Indies. This value gives Isla Contoy significant relative importance as a breeding site for the Least Tern in the Caribbean and adjacent areas of the Gulf of Mexico.

During both breeding seasons, nests with two eggs predominated on Isla Contoy. Several studies have reported that Least Terns lay one or two eggs, with two-egg clutches occurring more frequently in coastal environments (Atwood & Massey, 1988; González-Zuarth et al., 2016; Marschalek, 2009; Thompson et al., 1997). The occasional occurrence of single-egg clutches in 2023, particularly in Dunas and Cruces, may be associated with factors such as female age and experience, physical condition, food availability, and late-season laying, which can result in smaller clutches. Although two to three egg clutches are most common in this species, single-egg clutches are occasionally recorded under these conditions (Thompson et al., 1997).

Breeding Phenology

During the first visits to Isla Contoy on 04 June 2023 and 02 May 2024, we observed active nests with eggs and chicks less than one week old, indicating that first egg-laying had occurred in early April, at least in 2024. Thus, the breeding season began before the first monitoring visit. Consequently, the total number of nests was likely underestimated, particularly in 2023, when monitoring began later in the breeding season. Some nests established during the first few weeks of breeding may have gone undetected because the eggs had already hatched, failed to develop, or structural evidence of eggs was lost by the time of the first visit. Therefore, the recorded numbers should be considered minimum estimates of the total number of nests present during the breeding season.

The breeding season at Isla Contoy followed a pattern similar to that reported at other sites, such as Laguna de Términos in the southern Gulf of Mexico and along the west coast of the Yucatan Peninsula (González-Zuarth et al., 2016). A similar pattern has been reported in Texas (Thompson, 1982) and South Carolina (Brooks et al., 2013), where the Least Tern begins breeding in April, with laying extending into July or even August. In contrast, in California, the first nests have been reported in early May (Marschalek, 2009; Massey & Atwood, 1981), approximately one month later than observed on Isla Contoy. These temporal discrepancies could be related to latitude and site-specific environmental characteristics, including food availability and nesting habit quality.

Hatching Success

In the reproductive colonies of Isla Contoy, hatching success was relatively low compared with reports from other sites (Brooks et al., 2013; Nefas et al., 2018). In particular, the nesting areas of Cruces, Dunas, and El Faro were also used by Green Turtles *Chelonia mydas*, Loggerhead Turtles *Caretta caretta*, and Hawksbill Turtles *Eretmochelys imbricata*. In addition, these sites were exposed to adverse environmental conditions, including intense winds and rough waves, which resulted in spatial competition and nest destruction on several occasions during the two-year study period. These factors were the primary causes of nest and egg loss in Least Terns and likely contributed to the low hatching success observed (Table 2).

On Laguna Norte islet, the decrease in hatching success in 2023 was associated with increased lagoon water levels resulting from precipitation and tidal activity, which led to the destruction of 33.3% of the nests (Table 2). Flooding was particularly problematic for nests located at the edges of the colony and near water, resulting in direct egg loss. During the first monitoring visit, conducted on 21 June 2023, we counted submerged eggs, providing direct evidence of the immediate negative impact of rainfall on reproductive success.

In addition, incidents of predation and destruction of eggs and chicks by wading birds such as the Yellow-Crowned Night Heron *Nyctanassa violacea*, Great Egret *Ardea alba*, Great Blue Heron *Ardea herodias*, and American Flamingo *Phoenicopterus ruber*, as well as by American Crocodile *Crocodylus acutus*, were recorded. These incidents represented an additional source of pressure on colony reproductive success (Table 2). Post-hatching monitoring of chicks was not possible because they leave the nest two to three days after hatching and take refuge among vegetation and other objects available in the immediate surroundings (Thompson et al., 2020).

CONCLUSION

The results obtained on Isla Contoy highlight its importance as a breeding site for the Least Tern in the Caribbean, with the number of nests recorded representing a significant proportion of the regional breeding population. However, exposure to adverse climatic conditions and variations in habitat quality strongly influence the reproductive success of colonies. From a management and conservation perspective, these findings highlight the need to identify and prioritize the protection of nesting sites with stable conditions and low exposure to waves and wind, such as Laguna Norte, where higher nesting activity was observed. The presence of protective coastal vegetation, such as mangroves, plays a fundamental role in mitigating the impacts of extreme climatic events and should be considered in conservation planning.

TABLE 2
Percentage of nests of Least Tern *Sternula antillarum* on Isla Contoy, Mexico, destroyed by cause and location in the two breeding seasons

	Total number of nests	Destroyed nests				
		Tides/ rain %	Turtles %	Crocodiles %	Wading birds %	Unknown %
2023						
Laguna Norte	150	33.3	0.0	2.0	2.7	9.5
Cruces	7	28.6	71.4			
Dunas	5	28.6				
Total	**162**					
2024						
Laguna Norte	14	57.1				
Dunas	28	89.3	10.7			
Cruces	29	100.0				
El Faro	18	16.7	44.4			
Total	**89**					

In addition, the plasticity exhibited by the species in site selection suggests that continuous monitoring and evaluation of potential new nesting habitats are essential, especially in the context of climate change and the potential alteration of traditionally used beaches. Coexistence alongside other coastal species, as well as competition with sea turtles for space on narrow beaches, presents additional challenges that must be addressed through the integrated management of coastal ecosystems.

Given limited knowledge of the population status of the Least Tern in the Gulf of Mexico and the Mexican Caribbean, long-term monitoring programs are necessary to accurately assess the population status of Least Terns in these regions. A standardized, long-term monitoring program should be implemented before the start of the breeding season, beginning in late March or early April, to detect the first nesting attempts and reduce underestimation of the total number of nests. Periodic colony visits during the breeding season are also recommended to record the number of active nests, the abundance of breeding adults, and reproductive success. Applying consistent protocols across multiple colonies throughout the region would allow estimation of population size and evaluation of interannual trends, providing essential data for assessing the conservation status of Least Tern populations and informing management decisions by environmental authorities.

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AUTHOR CONTRIBUTIONS

SHV: Project management, data collection, data analysis, writing—original draft. CGP: Project management, fundraising, writing—review & editing. LBEO: Data collection, writing—original draft, writing—review & editing.

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