

Nesting Distribution and Conservation of the Brown Booby (*Sula leucogaster*) on the Red Sea Coast of Saudi Arabia

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ABSTRACT

Brown boobies (*Sula leucogaster*) have a wide range throughout the pantropical oceans, with a few exceptions. Even though this species has an extensive distribution range, little is known about its breeding distribution in the Red Sea region. Brown booby populations were surveyed on 16 islands across the Red Sea coast of Saudi Arabia in 2011, 2012, and 2013. This survey aimed to evaluate the breeding populations and conservation of the Brown Booby in the Red Sea of Saudi Arabia. A total of four new colonies comprising of about 33 nests in total were found on three islands. These three islands are flat-surfaced with a height of fewer than two meters; they are covered with sand and have mangrove shrubs. Brown boobies face multiple threats, including human disturbance, the introduction of animals, and predation. Finally, both research and conservation management are vital for ensuring the long-term survival of seabird populations and the Red Sea ecosystems.

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INTRODUCTION

Most seabird species are experiencing population decline; around 28% of them have been classified as globally threatened, making them one of the most threatened group of birds (Votier and Sherley, 2017). Seabird populations are susceptible to environmental shifts and thus are an excellent indicator of changes in marine ecosystems (Nie *et al.*, 2015; Rajpar *et al.*, 2018). The brown booby (*Sula leucogaster*) is a large seabird species that belongs to the family Sulidae (Bird Life International, 2021). This species is extensively distributed across pantropical oceans, with some exceptions (Nelson, 2005; Bird Life International, 2021). They breed in the Caribbean Sea, the Atlantic coasts of Brazil and Africa, the Red Sea, northern Australia, many oceanic islands off Madagascar, the Western and Central Pacific Ocean, and off the coasts of Mexico and Peru (Bird Life International, 2021). Four subspecies have been characterized and are

mainly distinguished by the color of their male plumage: *S. l. leucogaster* which breeds in the Caribbean Sea and Atlantic islands, and it has a darker brown head and neck than the rest of its upper body; *S. brewsteri* which breeds in the Eastern Pacific Ocean, and it has a whitish head and pale neck; *S. lelesiaca* which breeds on the Pacific coasts of Central America and Colombia, and it is similar to the *brewsteri* but its head and neck are less extensively pale than those of the *brewsteri* race; and *S. lplotus*, which breeds in the Red Sea and the Gulf of Aden through the Indian Ocean and the Pacific Ocean (Del Hoyo *et al.*, 1992; Schreiber and Norton, 2002; Redman *et al.*, 2016; Gill *et al.*, 2021). It has a brown head and neck, which is similar to the females. Among the known brown booby subspecies, *S. lplotus* is the largest and *S. lelesiaca* is the smallest (Schreiber and Norton, 2002).

The worldwide population has been considered to include more than 200,000 individuals (Bird Life International, 2021). In the Red Sea and the Gulf of Aden, this species is widespread throughout the entire region (Newton, 2006). Several of the previous studies have shown there to be breeding residents throughout the islands of the Red Sea, the Gulf of Aden, and the Socotra Archipelago (Newton and Al-Suhaibany, 1996; Jennings, 2010). Jennings (2010) found that the number of brown booby breeding populations in the Red Sea and the Gulf of Aden was roughly 15,000, about 3,000 of which were in the Red Sea of Saudi Arabia.

Several studies have reported that the highest

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number of nesting pairs in the Red Sea of Saudi Arabia is in the middle and southern regions (Ormond *et al.*, 1984; Newton and Al-Suhaibany, 1996). Newton and Al-Suhaibany (1996) confirmed the nesting of 590 pairs of brown boobies on 19 islands across the Red Sea of Saudi Arabia. Shobrak and Aloufi (2014) reported 84 nesting pairs on Riykhah Island north of the Red Sea of Saudi Arabia. Several studies have proposed that brown boobies in the Red Sea of Saudi Arabia might breed throughout the year in certain colonies (Shobrak *et al.*, 2002; Ostrowski *et al.*, 2005). This species nests in a wide variety of habitats, such as sandy beaches, open rocky islands, coral atolls, and sometimes even cliffs (Ostrowski *et al.*, 2005; Shobrak, 2007; Jennings, 2010; Shobrak and Aloufi, 2014; Bird Life International, 2021).

The species is currently classified as “least concern” with a declining population trend according to the IUCN Red List (Bird Life International, 2021). Previous studies have shown that there is the possibility that several factors have negatively impacted the breeding population of seabirds in the Red Sea, such as predation, coastal development, egg assemblage, tourism activities, pollution, alien species, introduced animals, overfishing, habitat damage and degradation, and global warming (Del Hoyo *et al.*, 1996; PERSGA/GEF, 2004; De Marchi *et al.*, 2006; Shobrak, 2007). Several studies conducted in different locations across the Red Sea coast of Saudi Arabia demonstrated that disturbance, predation, egg collection, introduced predators, tourism, leisure activities, and global warming were the main hazards that influenced the nesting of seabird species (Al-Rashidi *et al.*, 2012; Shobrak and Aloufi, 2014; Almalki *et al.*, 2014; Almalki, 2021).

Knowledge about the breeding distributions of seabirds in the Red Sea area of Saudi Arabia is limited. A survey of brown boobies in the Red Sea region of Saudi Arabia was motivated for three reasons. First, a comprehensive survey was last conducted in 1996 by the National Commission for Wildlife Conservation and Development to determine the most important islands for nesting seabirds (Newton and As-Suhaibani, 1996). These data needs to be updated. Second, the estimated number of breeding pairs (3000 pairs, Jennings, 2010) does not match the number of non-breeding birds (6000 pairs, Jennings, 2010); therefore, the previous surveys might have represented an underestimated number of breeding colonies in the Red Sea region.

MATERIALS AND METHODS

Surveys were performed across the Red Sea coast of Saudi Arabia to discover the nests of brown boobies over a period of three years: 2011 (May-June), 2012 (May-July),

and 2013 (May-June). Sixteen islands were surveyed at four different locations along the Red Sea of Saudi Arabia (Table 1): (i) Al Wajh Archipelago (two islands), (ii) off Umluj City (seven islands), (iii) off Al-Qunfudhah City (three islands), and (iv) the Farasan Archipelago (Four islands) (Fig. 1). The coastline of the Red Sea of Saudi Arabia stretches 1,840 km from the border of Jordan in the north of Haql (29°30' N) to the border of Yemen, south of the Farasan Islands (16°22' N) (Bruckner *et al.*, 2012). This which represents about 80% of the eastern Red Sea coast (MEPA/IUCN, 1987). Most of this region has a dry and hot climate, especially during the summer, with an annual precipitation of less than 70 mm (PERSGA/GEF, 2003; Bruckner *et al.*, 2012). A boat was utilized to access the islands, and the locations of the visited islands were registered by utilizing a handheld global positioning system receiver (Garmin e-Trex) device. The brown boobies were counted according to the number of active nests in each colony. All discovered colonies were surveyed by foot. In each brown booby that was colony discovered, the number of occupied nests was assessed visually.

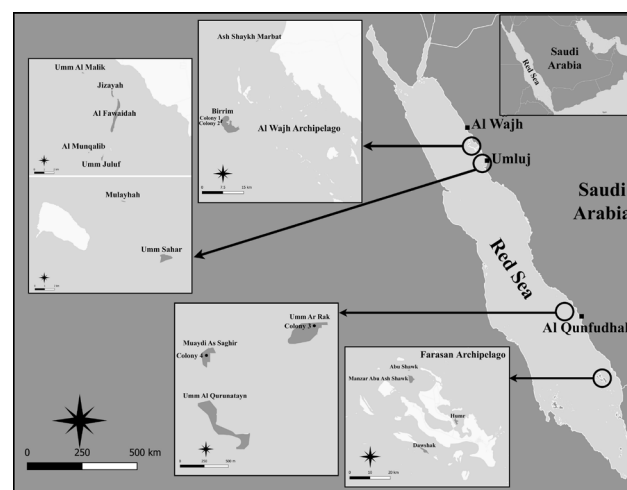


Fig. 1. Map shows visited islands (dark grey) and nesting colonies of brown boobies in the Red Sea region of Saudi Arabia (black dot).

RESULTS

Breeding population

Brown booby nesting was confirmed on only three islands out of the 16 islands surveyed across the Red Sea coast of Saudi Arabia during the survey period. Birrim Island (Al-Wajh Archipelago) is a flat-surfaced island with a height of two meters and covered with sand, especially on its northern and southern edges. Some of its coasts,

Table I. The number of colonies and nests of brown booby on the Red Sea coastline of Saudi Arabia.

City	Islands	Coordinates	Date	No. of colonies	No. of nest
Al Wajh	Ash Shaykh Marbat	25.8800, 36.60167	18-05-2013	0	0
	Birrim	25.6473, 36.48547	18-05-2013	2	15, 9
Umluj	Umm Al Malik	25.23666, 37.1383	14-05-2013	0	0
	Jizayah	25.2133, 37.170	14-05-2013	0	0
	Al Fawaidah (Attaweel)	25.19027, 37.1705	14-05-2013	0	0
	Al Munqalib	25.1583, 37.1433	14-05-2013	0	0
	Umm Juluf	25.15694, 37.1566	14-05-2013	0	0
	Mulayhah	24.9866, 37.1461	14-05-2013	0	0
	Umm Sahar	24.93833, 37.18055	14-05-2013	0	0
Al-Qunfudhah	Umm Ar Rak	19.2727, 40.9861	11-07-2011	1	7
	Muaydi As Saghir	19.2711, 40.9766	11-07-2011	1	2
	Umm Al Qurunatayn	19.2667, 40.9766	11-07-2011	0	0
Farasan islands	Abu Shawk	17.0100, 41.7944	25-05-2012	0	0
	Manzar Abu Ash Shawk	16.9683, 41.8066	15-05-2011	0	0
	Dawshak	16.6500, 41.8694	14-05-2011	0	0
	Humr	16.7747, 42.0136	26-05-2012	0	0
	Total			4	33

especially the eastern, have mangroves, and some bogs are in the middle and west. Umm Ar Rak is a flat sandy island, not exceeding one meter in height, on which mangroves grow densely. Muaydi al Saghir Islands (in the Al-Qunfudhah), a flat-surfaced island covered with sand, is densely covered with mangroves (Table I). These three nesting locations were the first to be identified and reported. The number of nests reported at each breeding site was 3 – 15 nests (Table I). Two active colonies (colony 1 and colony 2) were discovered on Birrim Island, with a total number of 24 nests (colony 1 = 15 nests and colony 2 = nine nests). The distance between them was about 300 m; the distance between the two colonies and the shoreline was 120 m and 40 m, respectively. All nests in colony 1 had chicks, and all the chicks were large, had white feathers, and seemed to be the same age (Fig. 2). In contrast, most of the nests in colony 2 had small chicks with white feathers.

On the Al-Qunfudhah, the total number reported in this survey was nine nests divided between Umm Ar Rak Island (seven nests) and Muaydi al Saghir Island (two nests) (Table I). The distance between the nests and the shoreline ranged between 2–15 meters. All of the nests on these two islands had only eggs (Fig. 2). Four islands in the Farasan Archipelago were visited during the breeding season; however, no nests were discovered (Table I).



Fig. 2. A, Brown booby chicks on Birrim island, which have white feathers and seem the same age; B, incubating an egg in Umm Ar Rak Island.

Breeding season

The brown booby's breeding seasons differed between the northern locations and the central part of the Red Sea of Saudi Arabia. On Birrim Island (Al-Wajh archipelago), brown boobies were observed to raise their chicks in the middle of May 2013. Because the incubation duration of brown booby has been found to be around 42 days (Nelson, 1978; Schreiber and Burger, 2002), it could be concluded that the breeding season may possibly have started in March. On Birrim Island, the majority of the nests in the two colonies had chicks with white feathers. On the Umm Ar Rak; and Muaydi al Saghir Islands (in the Al Qunfudhah), brown boobies were observed to be incubating eggs in the middle of July 2011. Thus, the breeding season may have started in mid- to late May.

Nesting habitat

Brown booby breeding colonies were discovered on Birrim Island (a coral island) and on Umm Ar Rak and Muaydi al Saghir Islands (sandy islands). On Birrim Island, the nesting habitats were hard and sandy with many stones and shells. In addition, colony 1 was close to vegetation. However, no nests were seen in the vegetation area and all nests were exposed. On Birrim Island, colony 2 was discovered in an open area with no vegetation.

On Umm Ar Rak and Muaydi al Saghir, the habitats were soft, sandy beaches. Both islands contained some vegetation, but all nests were in an open site with no vegetation. Moreover, four bird species on Umm Ar Rak Island, the crab plover (*Dromas ardeola*), sooty gull (*Larus hemprichii*), cattle egret (*Bubulcus ibis*), and sooty tern (*Onychoprion fuscatus*) were found nesting at the same site as brown boobies. In addition, vast numbers of the African collared dove (*Streptopelia roseogrisea*) were observed roosting in the trees on the same island.

Threats

Several factors may influence the breeding populations of the brown booby and other seabird species in the Red Sea of Saudi Arabia, such as human disturbance, introduced animals, and predation. Human footprints were recorded on most of the islands visited during the study. These could have been made by fishermen or tourists. No introduced animals were evidenced on the Al-Wajh, Umluj, and Al-Qunfudhah Islands. However, snake tracks (as introduced snakes) were observed on most of the study sites in the Farasan Islands. On Umm Ar Rak Island, the human presence caused the brown booby nests to flush, resulting in eggs leaving the nest and being vulnerable to attack by sooty gulls. Moreover, sooty gulls were observed to prey on the eggs of members of their own species when the parent birds, disturbed by the researchers, left their

nests for a short time.

DISCUSSION

A small number of surveys have been conducted in the Red Sea of Saudi Arabia to determine the distribution of nesting seabirds in which several brown booby colonies were detected. For example, Newton and Al-Suhaibany (1996) discovered nearly 600 nesting pairs on 19 islands across the Red Sea coast of Saudi Arabia. Ostrowski *et al.* (2005) reported 108 incubated nests and 94 chicks in protected areas in the Umm al Qamari Islands. Shobrak and Aloufi (2014) reported 84 nesting pairs on Riykhah Island in the north of the Saudi Arabia Red Sea. In the Farasan Archipelago, an estimated 150 breeding pairs were recorded in 1993 (Bird Life International 2021). This study documented that four new colonies of brown boobies were found on three of the 16 surveyed islands along the Red Sea of Saudi Arabia.

In this study, no colonies were found on the Four islands visited in the Farasan Islands. In 1993, an estimated 150 breeding pairs were recorded in the Farasan Islands (Bird Life International 2021). Ormond *et al.* (1984) and Newton and Al Suhaibany (1996) discovered that most nesting pairs were in the Saudi Red Sea's central and southern regions, indicating that the Farasan Islands and the Al-Qunfudhah areas are the species' most significant nesting grounds. However, the results of the present study support Shobrak and Aloufi's (2014) findings that the species may have declined or been grossly overestimated in previous studies. Jennings (2010) reported that subsequent ground-truthing confirmed that the numbers identified in aerial surveys during June 1996 were underestimated for several reasons. For instance, the species nests on steep broken cliffs or rugged highland areas. It may also nest on the ground covered by dense vegetation. Furthermore, research indicates that the breeding season of this species is earlier in the northern part of the Red Sea (Jennings, 2010; Shobrak and Aloufi, 2014).

The finding in the present study was that the breeding seasons of brown booby populations differed between the central and northern parts of the Red Sea of Saudi Arabia. According to this study, nesting season may begin in March in the north of the Red Sea of Saudi Arabia and in May in the central part of the Red Sea of Saudi Arabia. The brown booby is a seasonal breeder in some regions, but it has been observed to nest in any month in other regions (Ospina-Alvarez, 2008; Bird Life International, 2021). PERSGA/GEF (2003) reported that the nesting season of brown boobies in the Red Sea of Saudi Arabia is diverse, and several breeding waves could occur in specific colonies. In addition, the seasonality of nesting was found

to differ between the northern and southern populations. The nesting season starts in summer in the latter, whereas it most likely begins in April in the former (Shobrak *et al.*, 2002).

Newton and Al-Suhaibany (1996) found that the nesting season of this species in the northern Red Sea of Saudi Arabia began in March. Shobrak and Aloufi (2014) also concluded that the nesting season on the northern islands of the Red Sea of Saudi Arabia may begin in March. However, Ostrowski *et al.* (2005) observed that the nesting of this species occurred throughout the year on the Umm al Qamari protected islands in the middle of the Saudi Arabian Red Sea, and nesting peaks were found in May, July, and October. Furthermore, according to Jennings (2010), chicks were observed in the Farasan Islands in the beginning of February, while most nests with eggs were discovered in early July. According to Shobrak and Aloufi (2014), the species likely started nesting earlier in the northern Red Sea, whereas Boland and Al Suhaibany (2020) revealed that the nesting of brown boobies in the Red Sea might occur throughout the year.

Implications of conservation

Many seabird populations have changed dramatically in recent decades because of the threats to both terrestrial and marine habitats (Lewison *et al.*, 2012). Although they have received little attention, the Red Sea and the Gulf of Aden have been recognized as having 17 species of true seabirds that regularly breed there (PERSGA/GEF, 2004). Seabirds are a primary concern of the managers of preserved marine and coastal regions because they serve as both measures of marine environmental quality and as critical objectives of restoration, protection, and management schemes (Thibault *et al.*, 2019). They are one of the most highly endangered animal groups globally, and they have a higher risk of extinction than any other bird species (Croxall *et al.*, 2012; Inniss *et al.*, 2016; Xu *et al.*, 2016). Seabirds usually nest on distant or inaccessible islands that are rarely disturbed and free of mammalian predators (Walsh *et al.*, 1995; Lewison *et al.*, 2012). Commonly, seabirds nest in colonies, and they are very sensitive to humans and human activities within the colony or in the surrounding area (Chardine and Mendenhall, 1998). One of the main stressors for seabird populations is human access to nesting locations, thus controlling these activities is a serious issue that is part of ensuring their conservation (Inniss *et al.*, 2016). Another issue caused by human disturbance in remote islands, especially in the Farasan Archipelago, is the introduction of predators such as snakes, cats, and mice. Thus, the control of such predators is critical to ensuring the survival of ground-nesting birds on the Farasan Islands. PERSGA/GEF

(2004) and Almalki *et al.* (2014) reported snake tracks on some islands in the Red Sea, particularly in the Farasan Archipelago. Moreover, in recent years, there has been an ongoing armed conflict along the Kingdom of Saudi Arabia's southern border with Yemen. Lawrence *et al.* (2015) and Hanson (2018) reported on the negative effects of war on biodiversity and the ecosystem, such as habitat alteration, pollution, decreasing populations, and declining biodiversity. Thus, the battle on Saudi Arabia's southern border may have a significant influence on the biodiversity and environment of the Farasan Islands.

The Red Sea coastal habitats in Saudi Arabia are among the most vulnerable environments in the region, and they are confronted with several human-created problems, such as demographic growth, habitat deterioration, and coastal development (Sheppard *et al.*, 2010; Sale *et al.*, 2011; Al-Obaid *et al.*, 2017; Khawfany *et al.*, 2017). The current study found human tracks on the majority of the surveyed islands, which is in line with the findings of Shobrak and Aloufi (2014). Moreover, recently, many islands have been exploited and developed to promote tourism in some locations along the Red Sea of Saudi Arabia. Humans have various negative effects on wildlife. For instance, the introduction of exotic species can indirectly affect normal behavior and physiology (Weston *et al.*, 2012). Furthermore, because human-caused disruptions have become increasingly common, researchers have paid greater attention to human interference in fragile coral island ecosystems (Xu *et al.*, 2016).

The purpose of the current study was to provide an update on the nesting distribution and conservation of the brown booby in the Red Sea of Saudi Arabia. This study revealed there to be four new colonies on three islands out of the 16 surveyed across the Red Sea of Saudi Arabia. The study documents several threats that may threaten brown boobies, including disturbances, the introduction of animals, and predation. This research supports the idea that comprehensive surveys are required to discover the most important islands for nesting seabird species and to protect these islands.

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Statement of conflict of interest

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