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# **Seabirds of Madagascar: Update on Population Trends and Threats at Poorly Known Breeding Sites**

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**ABSTRACT:** Our study conducted from July 2020 to September 2023 showed that Nosy Manampaho is home to the largest seabird colony in Madagascar, with approximately 71,000 pairs and seven breeding species (sooty tern, great crested tern, roseate tern, caspian tern, white-tailed tropicbird, brown noddy, and red-tailed tropicbird). The island holds the largest colony of sooty tern birds in Madagascar, increasing from 21,800 pairs in 2008 to 70,400 pairs in 2023, thanks to the definitive cessation of egg harvest since 2015. The colony of 1,174 pairs of roseate tern discovered during this study at Nosy Bataiza in 2021 could be the largest colony of this species in Madagascar. The colonies of 65 pairs of caspian terns and 160 pairs of greater crested terns in 1946 at Nosy Tsara have disappeared locally, probably due to poaching. The white-tailed tropicbird and the caspian tern breed in small numbers on the islets off the east coast of Antsiranana, probably due to cumulative threats such as rat predation and poaching. Nosy Ankivonjy still supports a small colony of brown boobies (16 pairs), naturally protected from poaching because all the birds breed on vertical cliffs. The large colony of bridled terns (4,300 pairs) at Nosy Manjaboaka is the largest of this species in Madagascar and one of the largest in the Indian Ocean. Overall, seabird colonies on protected islands are stable or growing, while unprotected colonies, threatened by multiple threats (rats, egg harvest and poaching), are declining or have disappeared. Protecting seabird breeding islands by integrating them into marine protected areas is an effective solution. Sustainable seabird ecotourism must be developed to limit extractive activities (poaching or egg harvesting).

**KEY WORDS:** seabirds, islands and islets, conservation, MPA, ecotourism

## **I. INTRODUCTION**

Madagascar is surrounded by more than 270 islands and islets [1], many of them being potentially very favourable for breeding seabirds. However, the current diversity and abundance of breeding seabirds in Madagascar is low compared to the other islands of the Western Indian Ocean (WIO). The islands and islets of Madagascar hold only eleven breeding species totalling less than 80000 pairs, out of the 30 species (and >6 million pairs) that breed in the Western Indian Ocean [2]. Furthermore, most data on seabirds are old, preventing accurate estimate of current population size and trends, and many islands have never been visited by seabird biologists. [2, 3, 4, 5]. Seabirds are threatened in the world. The main threats are invasive species, destruction of breeding habitats and mortality due to industrial fishing gears [6]. In Madagascar, seabirds are known to be threatened by rats, egg harvest and hunting (2, 3, 5, 7, 8). Lack of knowledge is one of the factors limiting seabird conservation in Madagascar. Therefore, acquiring knowledge about breeding seabirds, particularly in lesser-known areas, is crucial for implementing effective conservation measures. In



this article, we present new data obtained from 2020 to 2023 on breeding seabirds in lesser-known areas of the country, located in the northeast, northwest, and southwest of Madagascar.

## II. MATERIALS AND METHODS

### Study sites

The study was conducted on islands and islets of Nosy Manampaho (12°48'39.59"S, 49°52'7.64"E, in Loky Manambato Protected Area) and nearby islets, at Nosy Bataiza (12°22'2.83"S, 49°31'49.39"E, in Ambodivahibe Marine Protected Area (MPA), on islets of the Bay of Sakalava (12°15'54.00"S, 49°23'60.00"E) and Cap Miné (12°13'57.61"S, 49°21'56.82"E), of "Mer d'Emeraude" (Nosy Antaly-Be : 12°07'58"S, 49°21'59"E, 128ha), of Ankivonjy MPA (13°30'13.84"S, 47°57'3.19 "E) and at Nosy Manjaboaka (22°23'38.44"S, 43°14'52.08 "E) (Fig. 1).

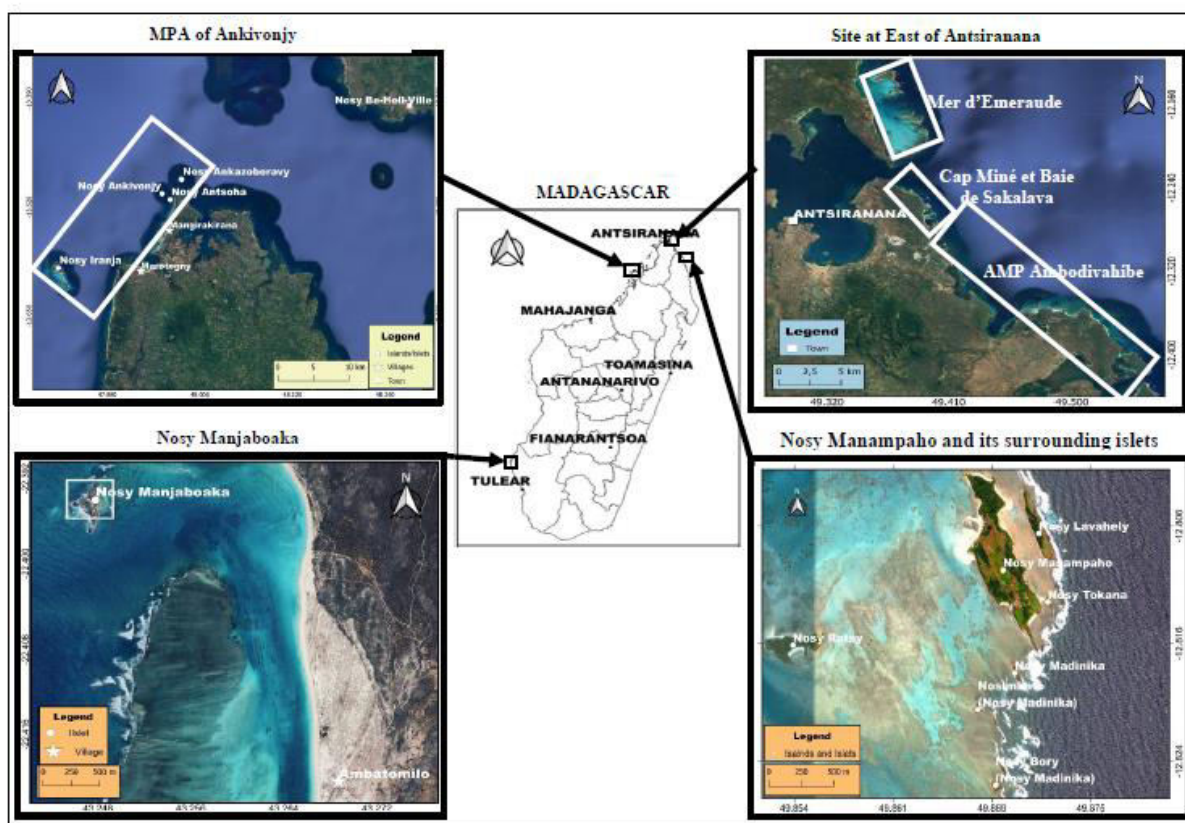


Fig. 1. Geographic location of study sites

### Data collection

We visited and prospected entirely all the islands and islets. The nests of seabird species that breed solitarily (tropical tropicbirds and Caspian terns) were described and geolocated by GPS. Larger tern colonies were counted using quadrat sampling (10 m<sup>2</sup>) : the area of each colony was estimated using a GPS in polygon mode, and all nests within the quadrat were counted. The contents of each nest were recorded (empty nest, egg, chick). To study breeding phenology, we measured the chicks' wing length to calculate their age, based on growth rates observed in the region.

We opportunistically observed birds exhibiting specific behaviors (courtship display, prospecting) during field visits. We also noted any signs of human hunting or harvesting (remains of clipped wings, carcasses of chicks or adults potentially killed by hunters, piles of collected eggs, hunting tools). We also discussed with our local guides to have further information on seabird hunting or harvest. In addition to this, we also conducted individual or group interviews with coastal villagers to have information on the uses of seabirds by local people and to know more about their knowledge of seabirds and islands.

### III. RESULTS

#### Species diversity, population size and breeding phenology

All sites combined, we found nine breeding seabird species, out of the eleven species that are known to breed in Madagascar : Sooty tern (*Onychorhion fuscatus*), Great crested tern (*Thalasseus bergii*), Roseate tern (*Sterna dougallii*), Caspian tern (*Hydroprogne caspia*), Brown noddy (*Anous stolidus*), White-tailed tropicbird (*Phaethon lepturus*), Red-tailed tropicbird (*Phaethon rubricauda*), Bridled tern (*Onychorhion anaethetus*), Brown booby (*Sula leucogaster*).

#### Nosy Manampaho and its surrounding islets

Nosy Manampaho hosts currently the largest colonies of seabirds in Madagascar. Nosy Manampaho and its surrounding islets hold seven seabird breeding species such as Sooty tern, Great crested tern, Roseate tern, Caspian tern, White-tailed tropicbird, Red-tailed tropicbird and Brown noddy. Red-tailed tropicbird was discovered breeding on the island the first time in October 2021. The first main colony on Nosy Manampaho is the population of sooty terns (7043pairs, in 2023), and the second is Great crested tern (850 pairs in 2022). The details of size of all population of all species (Table 1). Based on available data of population of sooty terns from 2008, we have the numeric evolution of this population (Fig.2). Some individuals of Lesser noddy *Anous tenuirostris* were recorded roosting with Brown noddy at Nosy Manampaho area during all survey.

For the phenology breeding of the sooty terns (Fig. 3), 277 chicks have been measured in 2021, and the laying has been estimated between 25 may and 26 July with big peak from 30 may to 03 June. In 2022, out of the 505 chicks measured, the laying started from 18 may with a peak from 28 June to 06 July. In 2023, 98 chicks of sooty terns were measured, and the laying was estimated between 31 may and 26 July with a peak from 15 to 24 June.

The laying of population of Great crested tern was estimated between 1 June to 28 July in 2021 (51 chicks measured), and started from 18 may in 2022 (63 chicks measured). For the Roseate tern, the last laying has been estimated around 20th July (last chick close to flying found 15th September) in 2021, and was estimated from 8 June to 16 July (12 chicks measured) in 2022.

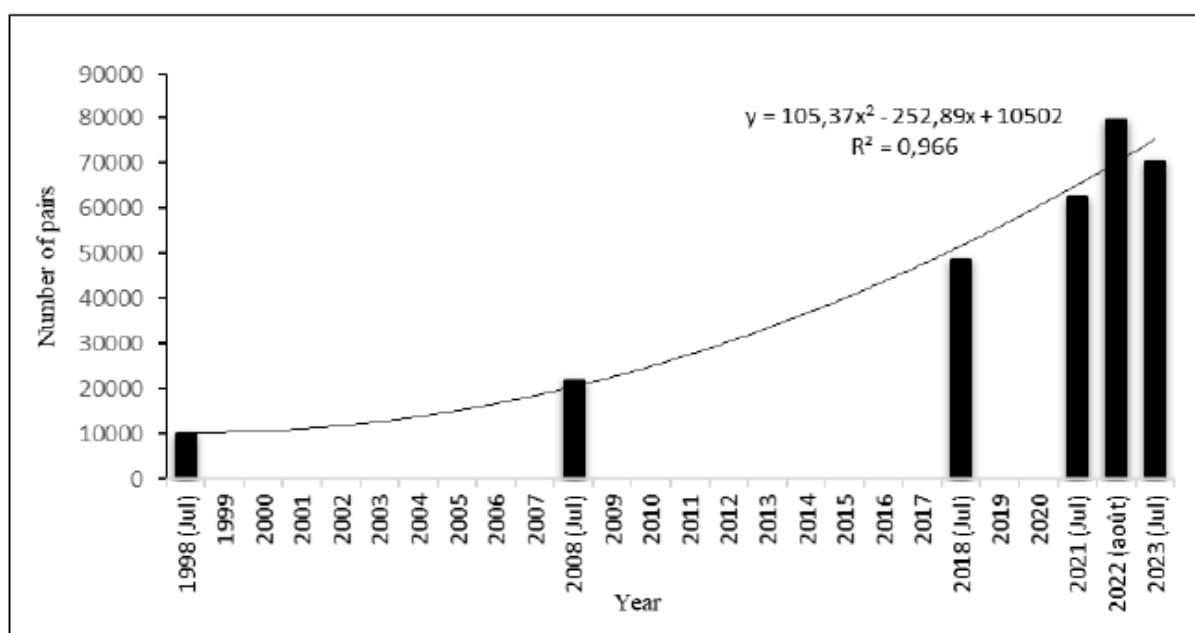


Fig. 2. Numeric trend of population of *Onychorhion fuscatus*, Nosy Manampaho

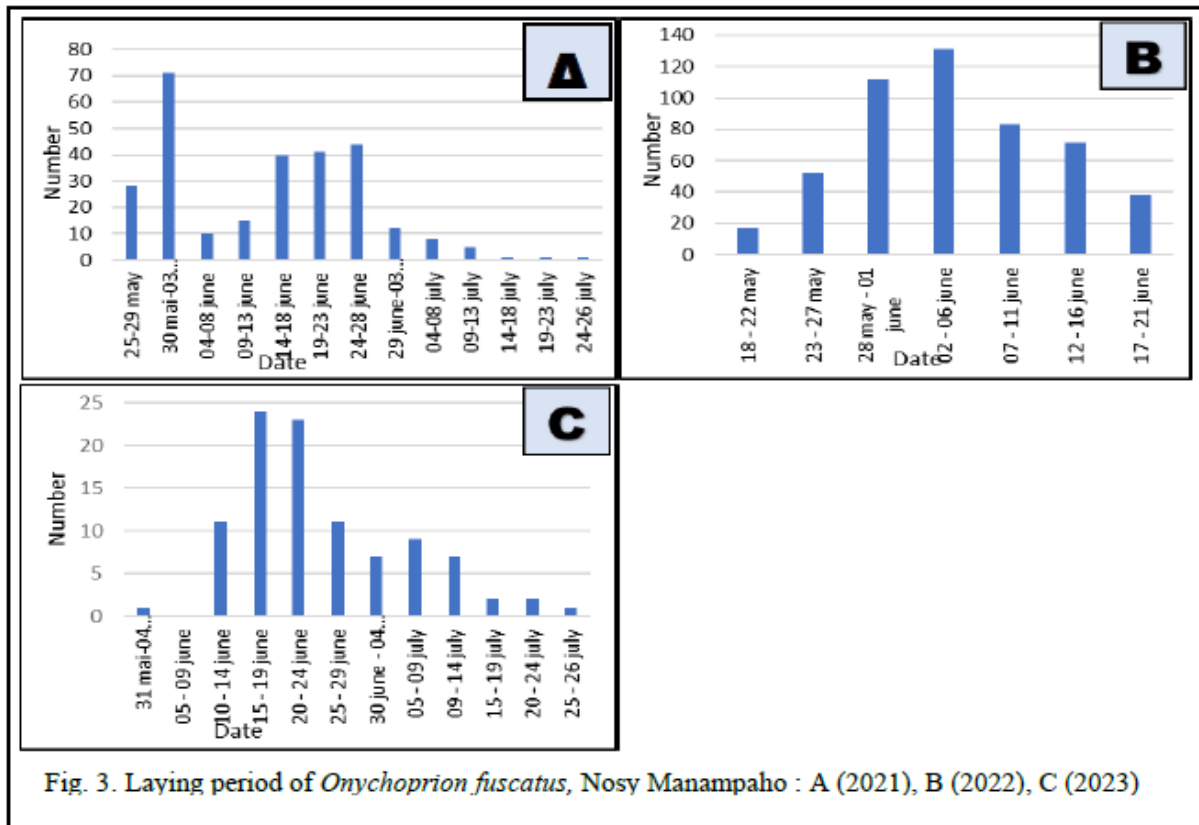


Table 1. Seabird species and population size at Nosy Manampaho

Species	2021	2022	2023
Sooty Tern	62500pairs	79581pairs	70403pairs
Great Crested tern	750pairs	850pairs	289pairs
Roseate Tern	300pairs	300pairs	280pairs
Caspian tern	1pair	1pair	??
White-tailed tropicbird	1pair	1pair	??
Red-tailed tropicbird	1pair	-	01 adults
Brown noddy	100pairs	100pairs	5 adults
Total	63653pairs	80833pairs	70978pairs

Islets of the Ambodivahibe MPA

1000 pairs of Great crested terns were counted on 16th July 2020, 3439 pairs at 2021 at Nosy Bataiza. In 2020, all nests contained eggs, no chicks were found, suggesting that the breeding season was starting, however the colony was mainly occupied by incubating adults (66%), few chicks (6%), then empty nests (28%).

On 2nd August 2021, we discovered 1174 pairs of Roseate Tern at Nosy Bataiza. For the colony of Roseate terns, the nests were occupied by eggs (59%), empty nests (33%) and few chicks (8%).

Ten chicks of Roseate terns were measured, which the laying was estimated begun 7th July 2021 and the most were laid 9th July (Fig. 4). On 10 September 2021, we revisited the islet but we did not find any roseate terns (no adults, no chicks, no eggs) on the islet. At this time, we measured 60 chicks of great crested terns which the laying was estimated

from 18 June 28 July. The eggs of great crested terns observed during of this time were probably the replacement eggs or because of breeding failure.

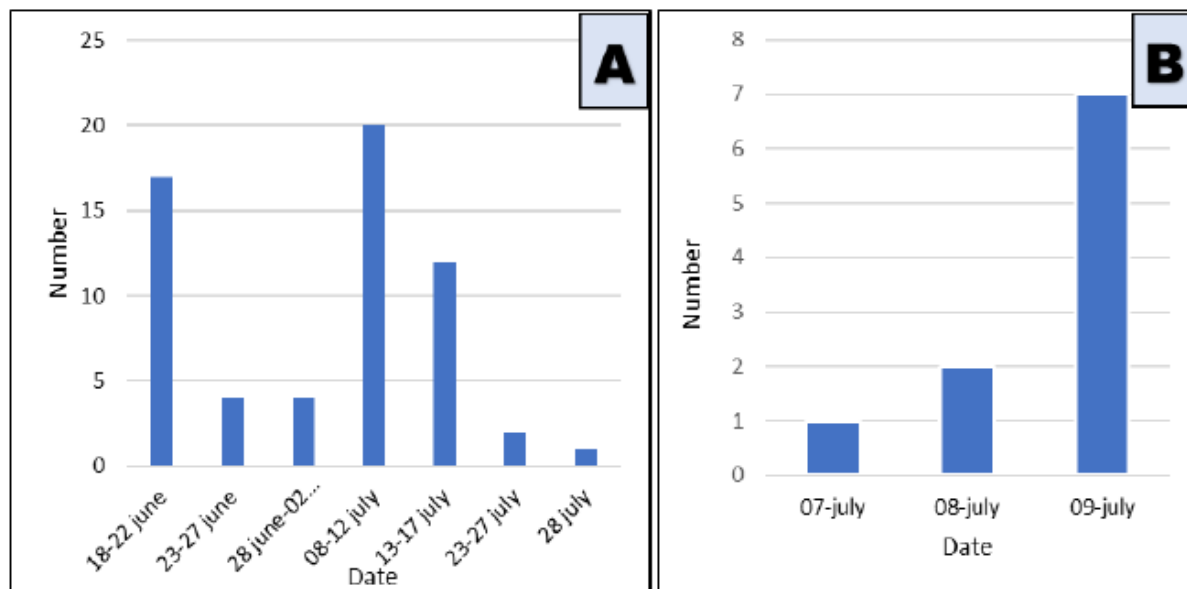


Fig. 4. Laying period of *Thalasseus bergii* (A) and *Sterna dougallii* (B), Nosy Bataiza in 2021

Islands and islets of Sakalava Bay and “Mer d’Emeraude”-Cap Miné

White-tailed tropicbird and Caspian Tern were recorded breeding in few pairs there, with some individuals noted flying on the islets in the area (Table 2).

For white-tailed tropicbirds, at least 14 pairs were counted in the area, mainly at Nosy Antaly Be, Cap Miné and Nosy Tsara (Table 2). This species breeds all time of year in this region but the number was noted important in June-July than other period, at Nosy Antaly of “Mer d’Emeraude”.

For the Caspian Tern, 4 pairs have been counted to breed in secluded pairs spread across the islets of Sakalava Bay and “Mer d’Emeraude”. The laying dates were estimated between 14 April and 24 May, for the two years of monitoring studies (2020 and 2021).

According to the local informant, a coral islet locally called Nosimbato, difficult to access, exists in north of Nosy Tsara, but we could not visit the small islet due to bad weather conditions.

Table 2. Seabird species and population size on the islets of the East coast of Antsiranana, July 2020 to June 2021

	White-tailed tropicbird (pairs)	Caspian tern (pairs)	Date of Field work
Nosy Kafontsa	-	1	July 2020
Nosy Tsara	2	-	July 2020
Cap Miné	3	-	July 2020
Nosy Diego	2	1	July 2020
		1	June 2021
Nosy Suarez	-	-	July 2020
		1la	June 2021
Nosy Antalikely	-	1	June 2021
Nosy Antaly Be	6	-	July 2020



	5	-	Feb. 2021
	9	1	June 2021
Kalanosin'Andranotsimaka	-	1	July 2020
	-	1	June 2021
<b>Total</b>	<b>14</b>	<b>5</b>	

la : landed adult

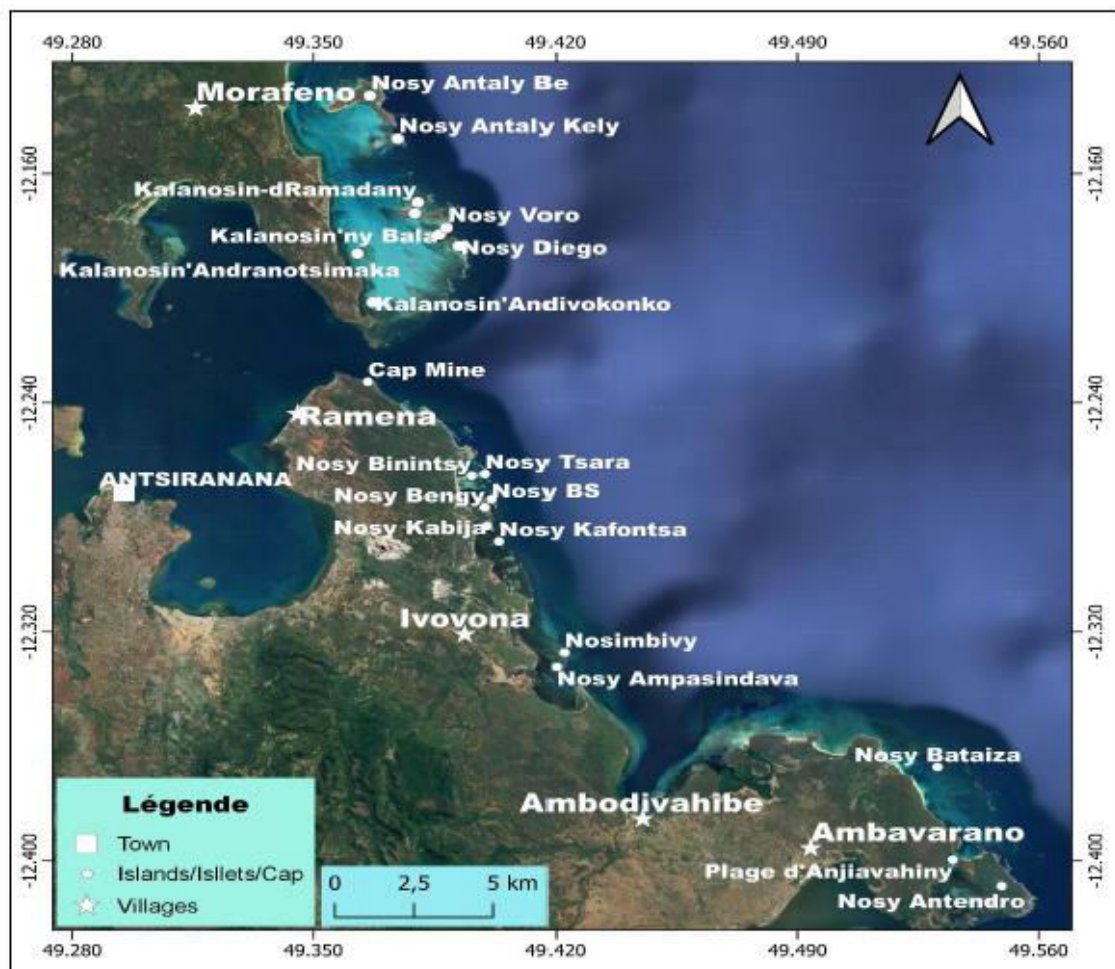


Fig. 5. Visited islands and islets in East coast of

#### Islets of Ankivonjy MPA

At Ankivonjy Marine Protected Area, two species of breeding seabird were recorded such as Brown booby and White-tailed tropicbird.

At Nosy Ankivonjy we recorded sixteen pairs of Brown Booby all perched on cliffs. All nests were on the cliffs, and we did not observe any eggs or chicks. For observation, we used binoculars while remaining just below the cliffs in base of the islet.

White-tailed tropicbird was recorded at Nosy Ankivonjy and at Nosy Iranja. At Nosy Ankivonjy, they were observed flying around the islet but we did not find any nests because of difficulty to climb on this mountainous islet. The characteristics of the habitats is potential of breeding for this species. At Nosy Iranja, they were noted displaying

constantly circling around cliffs (7 adults). That suggests probable breeding of this species in the hole of the cliff at least ten pairs.

An adult of Lesser Frigatebird *Fregata ariel* and 30-50 individuals Great crested terns were observed at MPA of Ankivonjy.

#### Nosy Manjaboaka

Bridled Terns is a tropical seabird, which a new colony was discovered in December 2021 at Nosy Manjaboaka, off the coast of Ambatomilo in the southwestern Madagascar [20]. During our survey in January 2023, 4330 pairs were counted on the islet. The colony were occupied by nests with eggs (22.2%) and empty nests (77.8%), and we did not record any chicks in the colony during our visit. 270 individuals were roosting on the surrounding emerged rocks.

We also found two corpses of wedge-tailed Shearwater *Ardenna pacifica* probably poached by local villagers. The villagers know very well the species and name it "Vorontomany", which means "crying bird" in Malagasy, which is obviously because of its voice.

#### Threats and human pressures

Depending on the site, the main recorded threats to breeding seabird species in the study sites are rats, egg harvest, poaching. Many of study sites, seabirds are threatened by the presence of rats, but the human pressures (hunting, egg harvest and human disturbance) depend on different sites (Table 3). We did not observe the degradation of breeding habitat or erosion.

Also, during the interview with local informants, they offered the information about threats generally similar to those above listed. The colony of bridled terns on Nosy Manjaboaka is highly impacted by egg harvest. The poaching of seabird breeding species is important on Cap Miné, islets of Sakalava Bay and the "Mer d'Emeraude". Seabirds could be impacted also to natural threats as climate change (temperature variations, storms, etc.). However, human pressures are among the most significant threats to biodiversity and leading to population decline or extinction [9].

Table 3. Threats and human pressures to seabird breeding species on the sites, based on this study and previous publications

Site	Poaching (adult or chick)	Egg harvest	Rat	Sources
Nosy Manampaho and islets	no	no	yes	[5, 10, 16, 17], and This study
Nosy Bataiza (MPA of Ambodivahibe)	no	no	yes	[18], and This study
Islets Bay of Sakalava	yes	yes	yes	[3, 7, 19, 34], and This study
Cap Miné	yes	yes	??	[3, 19, 34 ], and This study
Ilets of Mer d'Emeraude	yes	yes	yes	[3, 5, 10, 16, 34], and This study
Nosy Ankivonjy (MPA of Ankivonjy)	no	no	??	This study
Nosy Iranja (MPA of Ankivonjy)	yes	yes	yes	This study
Nosy Manjaboaka	yes	yes	??	[23] and This study

#### Uses of seabirds and islets by coastal villagers and conservation status

All study sites combined, coastal villagers use seabirds and their eggs as food, except on protected sites (Nosy Manampaho, Nosy Bataiza and Nosy Ankivonjy).

Nosy Manampaho and its tern populations are legally protected, included in the Loky Manambato Protected Area, under the management of the "Fanamby Association" after the settling of protection in 2014 (Fanamby). And, since 2015, "Rangers" have been put on the islet up regularly to ensure the control, during the period of breeding terns



(Fanamby and MIAVANA by Time&Tide Foundation). Terns of Nosy Bataiza are protected in the MPA of Ambodivahibe and naturally protected by difficult access on Nosy Bataiza. The seabirds of Nosy Ankivonjy is managed in MPA of Ankivonjy and benefit a naturally protection on cliffs with no access. For the islands and islets of Bay of Sakalava, of “Mer d’Emeraude”, and of Nosy Manjaboaka are legally unprotected.

Most of islands and islets where seabirds breed is used by coastal villagers like a place of rituals for the blessing request to the ancestors, fishermen's camp, seaside tourism (and/or picnic). Numerous “Fady = interdiction by beliefs” exist on almost of the islands and islets of studied sites, but these “Fady” concern on the non-practicing of defecating on the islet. The practices of hunting, egg harvest, and the disturbance of seabirds are not included in the “Fady”. Only the colony of seabirds at Nosy Manampaho is valued for ecotourism, MIAVANA by Time and Tide Foundation. This latter offers its customers a visit ecotouristic to Nosy Manampaho during terns breeding season.

#### **IV. DISCUSSION**

Recovery of the seabird community of Nosy Manampaho after total cessation of egg harvest

In July 2008, Nosy Manampaho held a colony of 21,800 pairs of sooty terns, and 5 non-breeding species of seabirds have been observed such as Roseate Tern (135 birds), Brown Noddy and Lesser Noddy (05 birds for each species), Great Crested Tern (03 birds), and Caspian Tern (02 birds)), but none of them were breeding. It was the largest known colony of breeding seabirds in Madagascar. At that time, the egg harvest of sooty tern was important, with up to 5000 eggs collected per day during the peak laying. At that time, the egg harvest of terns was managed by municipality of Ampisikina [10].

Since 2010, Nosy Ankaos archipelagos and Nosy Manampaho included, have been managed by Ibis Madagascar company by its initiative, and there was a regional decree to forbid the egg harvest. From that time, the establishment of the management of the island commenced. Thus, two new species were recorded breeding on Nosy Manampaho, Great crested tern in 2012, and Roseate tern in 2013 [11, 12]. The establishment of “Plan d’Aménagement et de Gestion (PAG) 2014-2018” of Protected Area (PA) of Loky Manambato by Fanamby was the beginning of legal protection of Nosy Manampaho and populations of terns. The collaboration between Fanamby and MIAVANA by Time and Tide Foundation (replaced Ibis), strengthened the protection of the island and make total cessation of egg harvest in 2015 [13].

In 2018 (July), Sooty Terns, Great Crested Tern, and Roseate Tern were recovered to breed on Nosy Manampaho, and counted 48,600 pairs, 500 pairs, and 250 pairs respectively. One pair of Caspian Tern was also observed in Nosy Lavahely (a tiny islet just 50 m from Nosy Manampaho) [2, 14].

Regarding to the colony of Sooty terns, the population substantially increased, from 21,800 pairs in 2008 [9] to 70,403 in 2023 (Fig. 2), after definitive stopping of egg harvest in 2015. This population can continue growing in the future, based on the size of the island and the area of available breeding habitats. Findings obtained in 2022 (79,580 pairs) and in 2023 (70,403 pairs), could be explained by either the inter-annual variation of breeding, or the census was conducted early (7th July 2023), the fact that all the nests were occupied by eggs or empty (less than 10 small chicks had just hatched found in this large colony). This population can continue growing in the future, based on the size of the island and the area of available breeding habitats.

However, compared to the global population of Sooty Terns in Western Indian Ocean, this population is low, estimated around 1,14% only. Total Western Indian Ocean population estimated at over 6,2 million pairs [15, 16]. The major colonies are in Juan de Nova 2million pairs, Grand ile Cosmoledo 1,14 million pairs, Europa 760 000 pairs, Bird I. 700 000 pairs, Desnoeuvs 500 000 pairs, Aride and Serpent Is 300 000 pairs each, Ile de Lys (Glorieuse) 270 000pairs, Goelette (Farquhar Atoll) 260 000 pairs [15, 16]. Though, the colony of Sooty Terns of Nosy Manampaho is the most important in Madagascar, based on the available data : 2030 pairs in Nosy Foty and Nosy Fasy in 1998 [3]; 50 pairs in the Barren Islands in 2007 [5]; 250 pairs in Nosimboro/Nosy Manitra in 2006 [5]; 300 pairs in 1998 on the islets off Tamatave [3].

The populations of Crested Terns and Roseate Terns have also increased, respectively, from 500 pairs and 250 pairs in 2018 [14] to 850 pairs and 300 pairs in 2021. Furthermore, the breeding of Caspian Terns is confirmed with a nest occupied by two chicks in 2021, if it was just suggested to nest in Nosy Lavahely since 2008. A feathered chick of

Brown Noddy (approximately 100 pairs) was discovered (measured) in September 2021, indicating the breeding of this species for the first time, if this species has been supposed breeding in 2013 [12]. A pair of White-tailed tropicbirds reported by [17] in Nosy Ratsy was also recorded, which indicates the fidelity of the breeding site of this species. A pair of Red-tailed tropicbirds was discovered, with an egg, in Nosy Manampaho in October 2021. Nosy Manampaho is therefore now the 2nd site to hold Red-tailed tropicbird in Madagascar, after Nosy Ve Toliara.

The population growth of Sooty Terns and the new breeding species in this site is certainly thanks to the positive effect of the conservation established, particularly stopping egg harvest. Thus, it would be possible that Lesser Noddy will breed on this islet in the future, as has been observed for roseate tern and brown noddy.

Despite the presence of black rats *Rattus rattus* on the islet [17], in which can have a negative impact on the colony, the Sooty Terns population at Nosy Manampaho has increased and has positive trend. Maybe, this situation could affirm that Sooty Terns can tolerate the existence of black rats population [15, 16].

#### Breeding of Roseate tern *Sterna dougallii* on Nosy Bataiza

Great Crested tern was discovered in June 2012 on Nosy Bataiza, the only seabird species reported nesting on the islet [18]. A new colony of 1174 pairs of Roseate Terns were discovered breeding on Nosy Bataiza, on 2nd August 2021. This colony is probably one of the largest colonies of this species in Madagascar based on available data (Table 4). Because the most of the colony have been reported threatened by human pressures, in which the current situation is unknown (some of them are probably extinct).

During our visit on 09/09/2021, the colony of Roseate Terns was not observed on the islet, suggesting the breeding was finished and the laying was very synchronous. Thus, the short duration of the breeding cycle of this species is noted. Laying was estimated begun from 07/07/2021 and finished around 07/15/2021. The last hatched chicks were estimated flown around 4 or 5 September 2021, and the population probably finished its breeding and quitted the islet just a few days before our visit, because no signs of massive death has been observed on the islet.

The settling of Roseate Tern on Nosy Bataiza revealed the success of inclusion of islet within conservation system of Ambodivahibe MPA. The poaching (of Great crested tern) has been stopped since around 2016 (local villagers). The trend of seabird populations in Nosy Bataiza is currently therefore positive, although of existing of rat on the islet.

Table 4. Counts of Roseate terns in Madagascar

Island/Islet	Number (pairs)	Year of census	Sources	Current situation
Nosy manampaho	300	2022	[12, 14], and This study	
Nosy Bataiza (MPA of Ambodivahibe)	1174	2021	This study	
Nosy Barren	1750	2007	[3, 5, 7, 8, 10, 16, 35]	unknown
Nosimborona/Nosy Manitsa	250	2006	[3, 5, 7, 8, 16, 35]	unknown
Hara Archipelago	500	2001	[3, 5, 10, 16]	unknown
Nosy Dombala	50	1971	[5, 7, 16, 35]	Unknown, probably extinct
<b>Total</b>	<b>4024</b>			

#### Local extinction of two seabirds colonies on Nosy Tsara : Great crested terns and Caspian terns

In March-April 1947, Nosy Tsara in Bay of Sakalava was reported to hold the colonies of 65 pairs of Caspian Terns and 160 pairs of Great Crested Terns [18]. We visited Nosy Tsara on 22 July 2020, but we did not observe these two colonies. These two colonies currently appear to be disappeared. Human pressures (egg harvest and hunting) and existence of rats were reported by local guides, leaded probably the causes of this extinction. The islet is too close to the coast and easily accessible on foot at low tide. During the interview with local guides, they told that they don't observe these 2 colonies of seabirds in 2020 on Nosy Tsara. However, they suggested us that Nosimbato (a small islet in north of Nosy Tsara) holds probably seabirds, but they refused to go with us to get the islet because of bad weather

and of difficult access (surrounded by high waves). So, we could not visit Nosimbato. [19] have reported 32 individuals of white-tailed tropicbird from the reef islet close to Orinjia PA but they did not mention the islet, which is probably Nosimbato. This small reef islet is the most protected than others in the area. Thus, an investigation of Nosimbato is necessary in the future.

The non-existence of conservation from local structures and organizations working in conservation could be the origin of decline or extinction of seabird populations on this area. The extension of the Orinjia Protected Area in the marine part of the “bays of Sakalava”, “bay of Dunes” and “bay of Pigeon”, to include the islets and its biodiversity is needed. The recolonization of seabird species could be possible in the future, thanks to the potential habitats of the islets.

**Brown Booby *Sula leucogaster* of Nosy Ankivonjy/Kasinjy**

The brown booby is relatively rare in the western Indian Ocean [2]. In Madagascar, two sites are known to hold this species, the “Quatre frères” islets of the Mitsio archipelago and Nosy Ankivonjy (Nosy Kasinjy) [2, 3, 16, 20]. The last information of the population of brown booby at Nosy Ankivonjy was reported by [3] with tens pairs. So, the presence of sixteen pairs of this species recorded on the islet after 20 years, obtained from this study, indicated that the islet is potential of breeding of this species. However, no chicks have been found suggests that the breeding appears to not have started. On the other hand, although the existence of Brown booby reported at Nosy Ankivonjy for long time, the discussion of evidence of Brown booby breeding on the islet could be advanced. There was lack of report to reveal the breeding phenology of this species on the islet (observation of laying and chicks,...). The survey of breeding phenology of this species is essential in the future, by using materials and new technologies such as drones to explore inaccessible upper parts of the island.

The existence of brown booby reported for long time until now could be due to the success of natural protection on the cliffs, within MPA, and the existence of “Fady” on the islet. Nosy Ankivonjy is “Fady” and the place of traditional ritual. No one can access the islet without authorization from “Mpitanjiny=Mpijoro” (traditional priest or ancestral priest).

**New colony of Bridled Terns *Onychoprion anaethetus* of Nosy Manjaboaka**

Based on available information of the population of bridled terns in Madagascar, the population 4,330 pairs recorded at Nosy Manjaboaka is the largest colony of this species in the country. Because, four known colonies count approximately 1,630 pairs in total (Nosimborona Sud, Nosy Manitra, Barren Islands, Nosy Hara) [2] (Table 5).

In the Western Indian Ocean, the colony of Sooty Terns of Nosy Manjaboaka could be the most important, compared to the regional database on breeding seabird species in the Western Indian Ocean (3300 pairs at Recif Seychelles as the largest) [2].

This colony of Nosy Manjaboaka could also be the one of the most important in Indian Ocean in general. Gurna (Eritrean island in the Red Sea) holds the largest colony with 5,000 pairs [21]. In the eastern Indian Ocean, the largest colony is on Penguin Island, Australian western coast (3000 to 4000 pairs in 2007 [22]). This comparative analysis shows that the colony of Bridled Terns of Nosy Manjaboaka is the one of the most important in the Indian Ocean.

About breeding phenology, the fact no chicks found in the colony suggests that the breeding was starting or eggs are systematically harvested before hatching because a lot of rest of broken egg shells have been noted on the islet. The fact that the colony already contained incubating adults during the discovery by Dominique Ponton in December 2021 [23], with knowing 30 days incubating period, inter-annual variation of breeding could be possible for this population. Which suggests that the breeding season of this species at Nosy Manjaboaka probably extends from December to April. In other sites in Madagascar, Bridled terns breed from June to September at Nosimborona-Sud/Nosy Manitra [5, 24], at Nosimborona Barren Islands in July [25] and in December [5].

In addition, Nosy Manjaboaka could be the second site to hold Wedge-tailed Shearwater in Madagascar, after the islets of Morombe and Andavadoake Nosy Anjamanjiky Bé, Nosy Anjamanjiky Anivo, and Nosy Anjamanjiky Antimo (43 pairs) [2, 5, 26]. Although we have not recorded it alive, existence of clipped wings found suggests that this species nests probably on the islet, but may be highly hunted.

As Nosy Manjaboaka is not legally protected, the colony of Bridled Terns is heavily threatened by egg harvest and also probably by hunting. The local community association “Mandrevorevo” (local manager of fishery resources) has an



initiative to protect the population of bridled terns including Nosy Manjaboaka in its management system. Thus, the formal conservation of the colony with settling a Marine Protected Area, islet included, is needed in order to stop the egg harvest.

Table 5. Counts of bridled terns in Madagascar

Island/Islet	Number (pairs)	Year of census	Sources	Current situation
Nosimborona Sud	1000	2006	5 ; 2	Unknown
Nosy Manitra	100	1948	24 ; 5 ; 2	Unknown
Barren Islands	500	2007	5 ; 2	Unknown
Nosy Hara	30	2013	12 ; 2	Unknown
Nosy Manjaboaka	4330	2023	This study	
<b>Total</b>	<b>5960</b>			

## V. CONCLUSION

### Importance of conservation and seabirds

The findings of the present study clearly reveal the importance of conservation and the beneficial effects of inclusion of islands and islets within the management system of the protected area, despite of the existence of natural threats. Islets included in protected sectors host a new breeding species and seabird populations are dynamic and present a positive trend (Nosy Manampaho and Nosy Bataiza). Whereas, in unprotected sites, seabirds either breed in few numbers, or has declined, or has been extinct (seabirds breeding of Nosy Tsara, of Mer d'Emeraude islets and of Cap Miné).

Seabirds have an important ecological role in the marine and coastal ecosystems, provide valuable information on the structure of the landscape, are excellent bioindicators of the health and productivity of the marine environment [4, 27]. Then, the conservation of seabird populations could be also beneficial for the local economy through the development of ecotourism related to seabirds. Ecotourism can generate the incomes of local communities, because seabird colonies are often spectacular, attractive and highly appreciated by ecotourists [2, 28, 29]. Although, the observations and visits must be conducted responsibly, avoiding the animal disturbances and respecting the local traditional cultures and regulations.

### Perspectives

Considering of importance of seabird populations, some actions are suggested in the future in Madagascar :

1. Raising awareness of the importance of seabirds to the local community and settling conservation measures for unprotected sites to stop the poaching and egg harvest, especially during the period of seabird (Case of the population of Bridled Terns at Nosy Manjaboaka) ;
2. Strengthening of the conservation for sites already protected, particularly during the season breeding seabirds ;
3. Eradication of rats for small and middle islands. Eradication is very positive for the population dynamics of seabirds, case observed in Nosy Ve Toliara and Tromelin Island [30, 31, 32, 33] ;
4. Update on information and improvement of knowledge level on seabird populations (trend, breeding penology, threats, uses, demography, diets, migration and movement at sea, genetics etc.), needed for the conservation strategy and management (on poorly known and on new potential islands) ;
5. Development of ecotourism responsible related to seabirds, for alternative of poaching and egg harvest.

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#### REFERENCES

- [1] Paulian, R., « Zoogéographie de Madagascar et des îles voisines », Faune de Madagascar, 1961, 13, p. 1-483.
- [2] Le Corre, M., E. Bemanaja, A. Mbelomanana, A. Jaeger, R. Rabarisoa, L. Andriatahina, and D. Tammy 2022. The seabirds of Madagascar: population status, threats, and conservation. Pages 1637-1650 in S. M. Goodman, editor. The new natural history of Madagascar. Princeton University Press, Princeton, New Jersey, USA.
- [3] ZICOMA, 2001. Madagascar. In Fishpool, L. D.C. and Evans, M. I. (eds) Important Bird Areas in Africa and associated islands : priority sites for conservation. Newbury and Cambridge, UK : Pisces Publications and BirdLife International : 489-537
- [4] Le Corre, M. and Jaquemet, S., 2005. "Assessment of the seabird community of the Mozambique Channel and its potential use as an indicator of tuna abundance". Estuarine, Coastal and Shelf Science 63: 421-428.
- [5] Bemanaja, E. 2009. Les colonies d'oiseaux marins des futures aires protégées marines et côtières du sud-ouest, de l'ouest et du nord de Madagascar : diagnostic écologique et socio-économique pour une exploitation durable de la ressource. Ph.D. thesis, Institut Halieutique et des Sciences Marines, Université de Toliara.
- [6] Dias, M. P., Martin, R., Pearmain, E. J., Burfield, I. J., Small, C., Phillips, R. A., Yates, O., Lascelle, B., Borboroglu, P. G., and Croxall, J. P. 2019. Threats to seabirds: A global assessment. Biological Conservation 237: 525-537.
- [7] Milon, P. 1950. Quelques observations sur la nidification des sternes dans les eaux de Madagascar. Ibis 92: 545-553.
- [8] Langrand, O. 1990. Guide to the birds of Madagascar. New Haven, USA and London, UK : Yale University Press.
- [9] Ranaivomanana, L.N.J. (2006). Identification des conditions d'appropriation de la gestion durable des ressources naturelles et des écosystèmes : cas du Grand Récif de Toliara., Université de Rennes, Université de Toliara (IH. SM).
- [10] Le Corre, M., and Bemanaja, E. 2009. Discovery of two major seabird colonies in Madagascar. Marine Ornithology 37: 153-158.
- [11] Bemanaja, E. 2012. Aspect socio-économique, bioécologique et conservation des oiseaux marins dans la région Nord de Madagascar. Centre National de Recherches Oceanographiques (CNRO) (Internal report).
- [12] Bemanaja, E. 2013. Suivi écologique et conservation de la population d'oiseaux marins dans la région Nord de Madagascar. Centre National de Recherches Oceanographiques (CNRO) (Internal report).
- [13] Fanamby 2014. Nouvelle Aire Protégée (NAP) de la Loky Manambato – Plan d'Aménagement et de Gestion 2014 – 2018.
- [14] Le Corre, M., Caumes, C., and Randriamoria, T.M. 2018. Seabird monitoring in Nosy Manampaho, Madagascar, rapport interne Island Conservation - Vahatra - UMR ENTROPIE - Madascarenes - Time and Tide Foundation – Fanamby (Internal report).
- [15] Feare, C. J., Jaquemet, S. and Le Corre M. 2007. An inventory of Sooty Terns in Western Indian Ocean with special reference to trends and threats. Ostrich 78 : 423-434.
- [16] Safford, R.J. and Hawkins, A.F.A. (eds) 2013. The birds of Africa. Volume VIII : The Malagasy region. Christopher Helm, London : 462.
- [17] Goodman, S. M., Anbdou, Y., Andriamiantsoa, Y., Fisher, B. L., Griffiths, O., et al. 2017. Résultats d'un inventaire biologique du groupe d'îles de Nosy Ankao, Parc National de Loky-Manambato, nord-est de Madagascar. Malagasy Nature 11: 1-59.
- [18] Rabarisoa, R. 2018. New observation on the breeding of the crested tern (*Thalasseus bergii*) in Madagascar. Indian Ocean Seabird Group Newsletter 4: 10.
- [19] Raheirilalao, M. J., et Razakolona J., 2015. Les oiseaux de la Nouvelle Aire Protégée d'Oronjia, Antsiranana : 15p.
- [20] Polunin N.V.C. 1979: Sula leucogaster and other species in the Ile Mitsio, Madagascar. Bull. B.O.C. 1979 : 99(3)
- [21] Semere Dawit, Tewolde Hagosa, Ghebregzghi Selebaa, Yossief Gebrezgabghiera, Zeweldi Hailea, Giorgio Chiozzib and Giuseppe De Marchib 2008. The status of breeding seabirds and waterbirds on the Eritrean Red Sea island. Bull ABC Vol 15 No 2 : 228- 237.
- [22] Labbé, A. M. T. 2017. Effects of age on reproduction and chick rearing in bridled Terns (*Onychoprion anaethetus*) at Penguin Island, Western Australia. BSc (Hons.) (Murdoch University, Western Australia).

- [23] Le Corre, M. and Dominique P. 2022. Discovery of a very large bridled tern colony at Nosy Manjaboaka, Madagascar, and first evidence of the possible breeding of wedge-tailed shearwaters on this island. in Mathieu Le Corre & Sabine Orłowski (Coordinators / Editors), Indian Ocean Seabird Group (IOSG) Newsletter n°11 : 4.
- [24] Milon, P. 1948. Visites à Nosy Mborono et à Nosy Manitra dans le Sud-Ouest de Madagascar. *Alauda* 16 : 55-72.
- [25]. ZICOMA, 1998. Visite ornithologique des îles barren et les zones côtières aux environs de Maintirano : 1-7 (Internal report).
- [26] Appert, O. (1965). Découverte de la nidification de *Puffinus pacificus* (Gmelin) près de la côte ouest de Madagascar. *L'Oiseau et la Revue Française d'Ornithologie* 35(2): 135-139.
- [27] Blondel, J. 1975. L'analyse des peuplements d'oiseaux, élément d'un diagnostic écologique. 1. La méthode des échantillonnages fréquents progressifs (E.F.P). *Terre et Vie*, 29: 533-589.
- [28] Higham, JES. 1998. Tourists and albatross : the dynamics of tourism at the Northern Royal Albatross Colony of Taiaroa Head, New Zealand. *Tourism Management* 19(6) :521-531.
- [29] Yorio, P., Frere, E., Gandini, P., Schiavini, A. 2001. Tourism and recreation at seabird breeding sites in Patagonia, Argentina: current concerns and future prospects. *Bird Conservation International* 11 : 231-245.
- [30] Towns, D.R., Broome, K.G., 2003. From small Maria to massive Campbell, forty years of rat eradications from New Zealand islands. *New Zeal. J. Zool.* 30, 377-398.
- [31] Lilette, V. 2006. Mixed results: conservation of the marine turtle and the red-tailed tropicbird by Vezo semi-nomadic fishers. *Conservation and Society* 4(2): 262-286.
- [32] Jones, H., 2010a. Seabird islands take mere decades to recover following rat eradication. *Ecol. Appl.* 20, 2075-2080.
- [33] Le Corre, M., D. K. Danckwerts, D. Ringler, M. Bastien, S. Orłowski, C. Morey Rubio, D. Pinaud, and T. Micol. 2015. Seabird recovery and vegetation dynamics after Norway rat eradication at Tromelin Island, western Indian Ocean. *Biological Conservation* 185:85-94. <https://doi.org/10.1016/j.biocon.2014.12.015>.
- [34] Milon, P. 1946. Nidification dans le nord de Madagascar de l'oiseau du tropique ou paille-en-queue à bec jaune. *Alauda* 14: 3-43.
- [35] Salvan, J. 1971. Une visite sur les îlots au sud de Tamatave (Madagascar). *Alauda* 34(3): 213- 222





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