Breeding Success of Red-billed Tropicbirds at Pilot Hill, St. Eustatius – Year 3 (2014-2015)

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Abstract

We assessed the breeding success of red-billed tropicbirds (*Phaethon aethereus*) at Pilot Hill on St. Eustatius, particularly in relation to predation at the nest. We conducted weekly surveys during 2014-2015 and measured chick and adult morphometrics. Apparent hatching success was 57% and apparent fledging success was 73.7%, with reproductive success 37.8%. Camera traps installed in nesting cavities documented rats opportunistically scavenging eggs left unattended for even short periods of time. In total we confirmed nine predation events by rats at eight individual nesting cavities. Given the importance of St. Eustatius as a nesting site for red-billed tropicbirds, the implementation of a rodent control program is urgently required for the coming season.

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1. Introduction

The red-billed tropicbird (*Phaethon aethereus*) is the largest of the three species of tropicbirds that occur in the tropical Atlantic, eastern Pacific and Indian Oceans. It is a long-lived, colonially-nesting, pelagic seabird with late sexual maturation (Nunes *et al.* 2013). Its diet comprises fish caught in the open ocean, and breeding takes place on remote oceanic islands, laying a single egg inside a naturally-occurring cavity between boulders or in cliffs. Tropicbirds are classified as a species of least concern by the IUCN at the global scale (Croxall *et al.*, 2012). Within the Caribbean, however, the species' status appears to vary among islands. The global population estimate for red-billed tropicbirds is between 5,000 and 20,000 individuals, with the current trend described as decreasing (Croxall *et al*. 2012). Following our initial study in 2012-2013 and follow-up study in 2013-2014, we continued monitoring during the 2014-2015 nesting season.

2. Study Area

The Pilot Hill study site is located on the north-western coast of St. Eustatius and covers an area of approximately 6.8 hectares (Figures 1 and 2). The terrain consists of steep slopes and sheer rocky cliffs, which are prone to erosion and can be unstable (Figure 3). Due to the topography of sites used for tropicbird nesting, it is only possible to monitor nests at lower elevations of between 10 and 40 meters. We located nests by traversing accessible areas of the slopes and marking active nests with a numbered tag, however many nests had already been marked from the previous two years' studies.

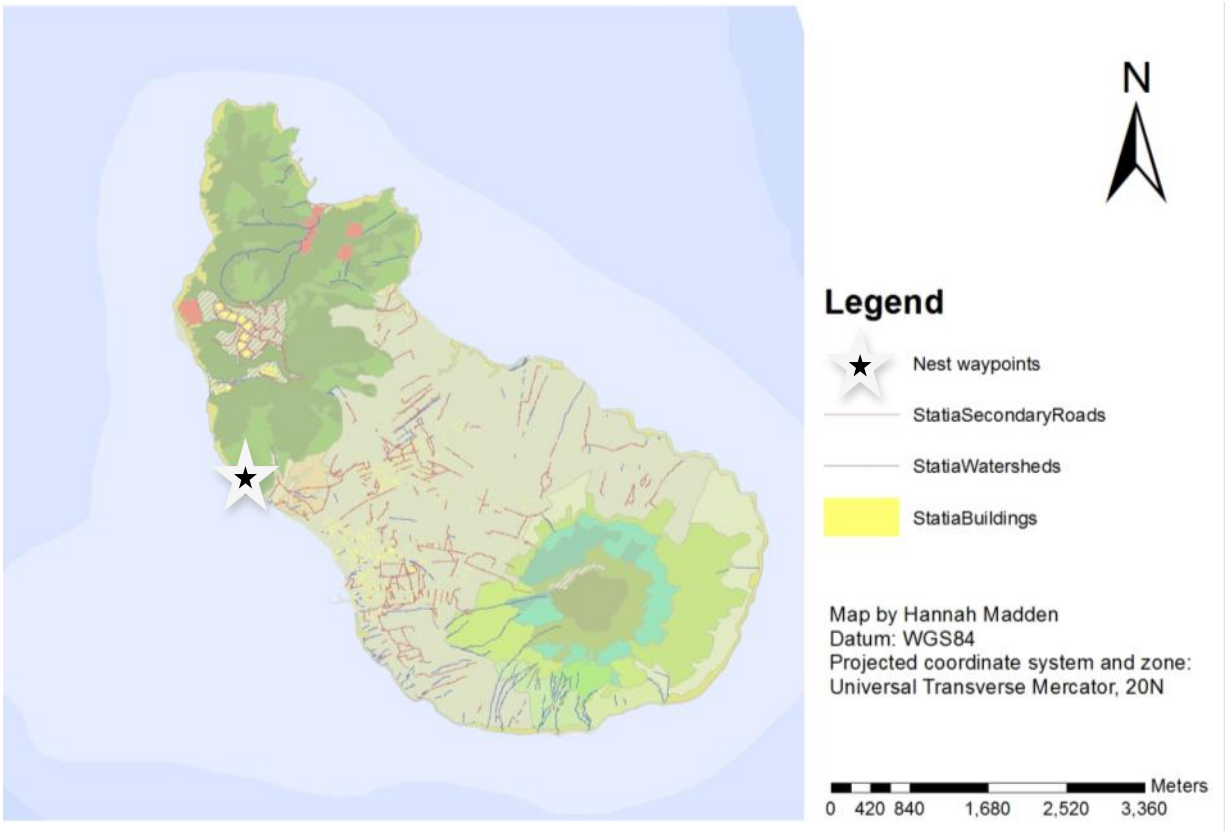

Figure 1: Map of St. Eustatius showing the Pilot Hill study site.

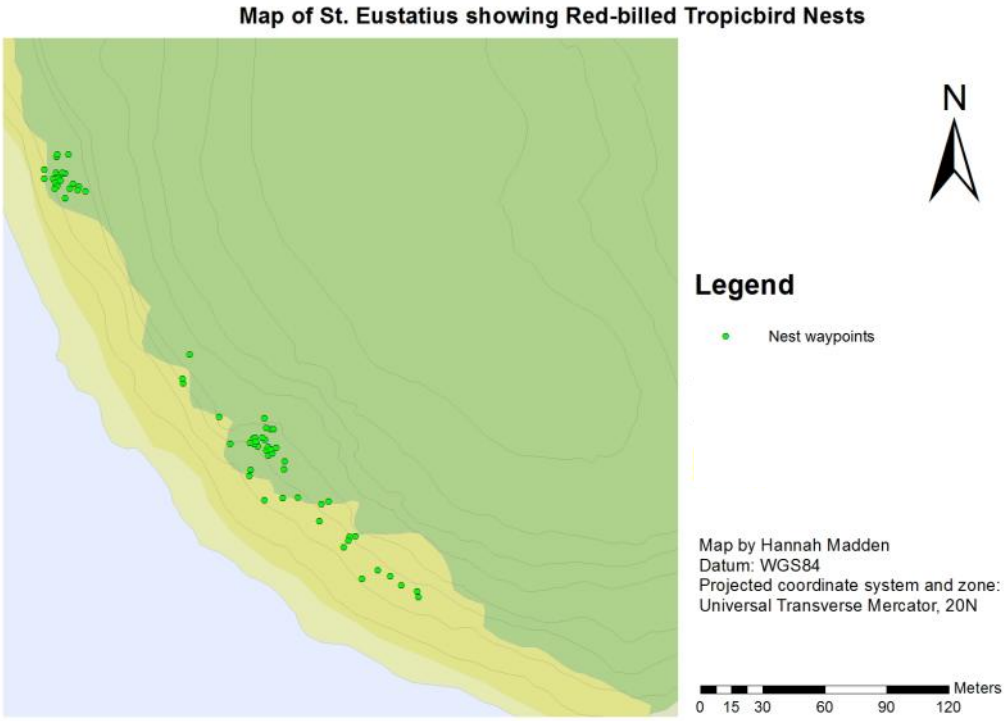

Figure 2: Locations of red-billed tropicbird nests at the Pilot Hill study site, St. Eustatius.

Figure 3: Field assistant Osbourne Johnson inspecting the damage caused by a landslide at Pilot Hill, St. Eustatius.

3. Methods

We visited each nest every 7.2 days ±0.13 days between 17 October 2014 and 28 May 2015. At each nest we noted the contents (empty/number of adults/egg or chick). We measured standard morphometrics for each bird (adult and chick). Culmen length (± 0.1 mm) was measured as the distance from the end of the upper mandible to the point where the feathering begins on the head. The length of the head plus bill (± 0.1 mm) was measured as the distance from the end of upper mandible to the back of the skull. Bill depth (± 0.1 mm) was measured at the gonydeal expansion. Each bird was also weighed using a spring scale and previously weighed bag (± 5 or ± 10 g depending upon its mass).

Birds were banded using numbered aluminium bands manufactured specifically for St. Eustatius, funded by the Dutch Caribbean Nature Alliance. These purple bands have the prefix EUX followed by four digits. Adults were only measured when first encountered to minimise disruption to their natural behaviour (Le Maho et al. 1992). Chicks were removed from the nest and measured on each visit, although occasionally the size or shape of the nest and the chick's location within it prohibited access. Measurements were taken using the smallest amount of handling and shortest possible time out of the nest to minimize stress. We estimated the age of chicks based on known or estimated hatch dates in order to monitor and compare growth.

We deployed ten Reconyx HC500 cameras to monitor activity within nests containing an egg. The cameras were set up to take one photo every five minutes 24 hours a day and also to take three photos, one second apart, every time a variance in temperature was detected. Where possible, cameras were installed inside cavities and pointed directly at the nest (Meek *et al.* 2014). Birds with cameras inside cavity did not abandon the nest. The main purpose of the camera traps was to document predators in nests, particularly cats (*Felis catus*) and black rats (*Rattus rattus*).

Given our prior knowledge of rat predation on eggs, cameras were installed inside suitable cavities whenever a new egg was discovered and remained until the egg had hatched and the chick was at least three weeks old. Where a nesting cavity was discovered empty, the camera was removed and placed inside another nest containing an adult incubating an egg. The photos from the failed nest were examined to determine the cause of failure.

We assigned nest failures to one of seven categories based on the following evidence:
1) egg cracked or damaged before 43 d but damage not indicative of predation (i.e., no signs of teeth marks);
2) egg predated - as evidenced from camera trap data;
3) egg failed to hatch – intact egg incubated longer than 43 d but did not hatch;
4) unknown – egg or chick disappeared – cause undetermined;
5) egg abandoned – cold egg discovered inside nesting cavity with no adult present;
6) dead chick found inside nest; and
7) nest destroyed (Table 1).

Based on methods by Schreiber & Schreiber (1993), we calculated apparent hatching success as the number of eggs laid that hatched, apparent fledging success as the number of hatched chicks that fledged, and apparent breeding success as the number of eggs laid that resulted in a fledged chick. Given that red-billed tropicbird clutches consist of just one egg, reproductive success is equivalent to the proportion of successful nests.

4. Results

Eggs were laid between October 2014 and May 2015, with peak activity between December and March. Chicks fledged between November 2014 and May 2015, with ten juveniles still in nests on our final visit. The mean incubation period was 43.4 d +/- 0.25 d (n = 88) and the mean fledging period was 85.9 d +/- 0.25 d (n = 38), resulting in a mean nesting cycle of 129.4 d +/- 0.25 d.

Apparent hatching success was 57%, apparent fledging success was 73.7%, and apparent breeding success was 37.8%. The known leading causes of failure were egg predation, cracked eggs, and the destruction of nests due to a landslide (Table 1).

Apparent hatching and fledging success, egg loss, chick loss, unknown chick fate, and breeding success at the study site are displayed in Figure 4.

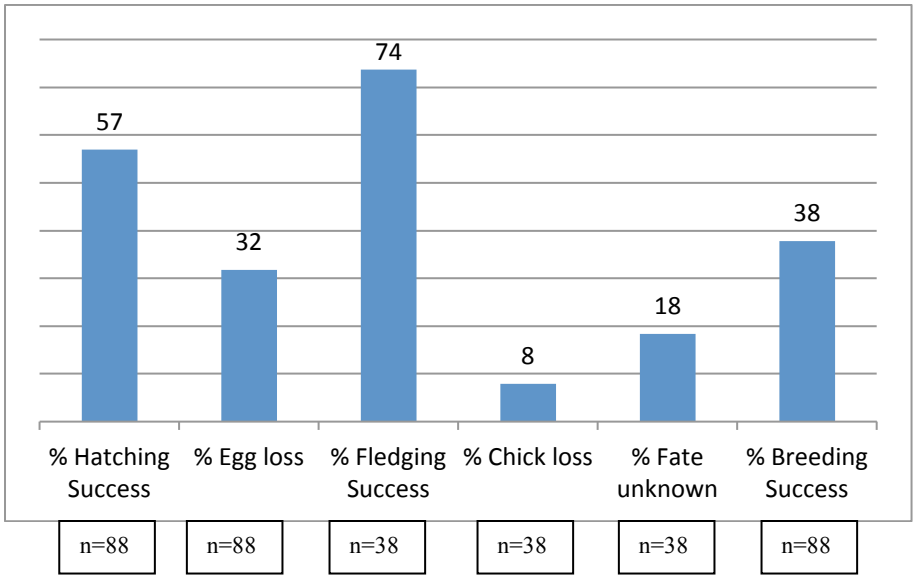

Figure 4: Reproductive success of red-billed tropicbirds at Pilot Hill on St. Eustatius, October 2014 – May 2015.

Data from 2013 to 2015, showing apparent hatching, fledging and breeding success, are displayed in Figure 5.

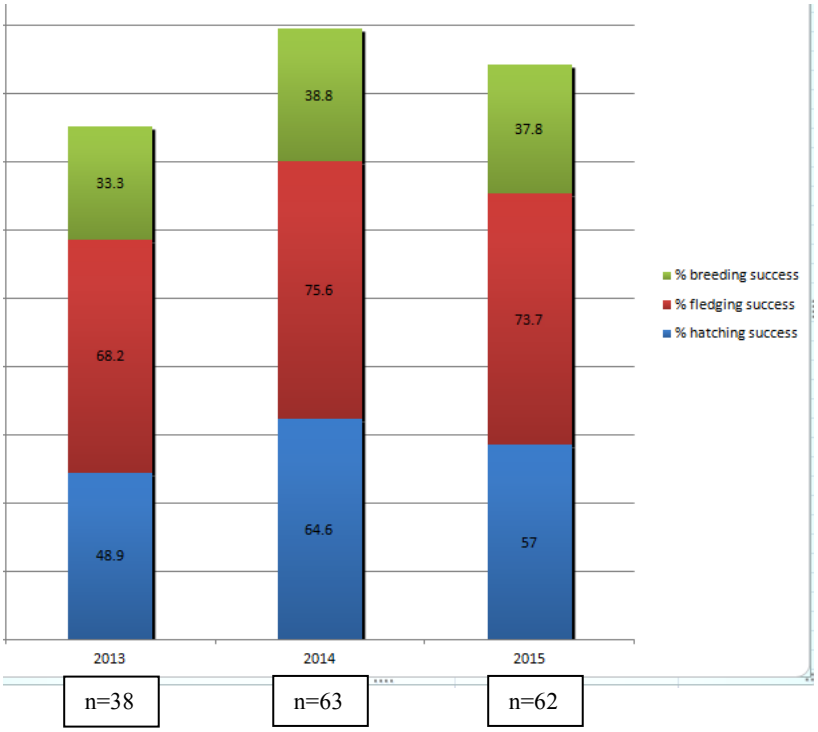

Figure 5: Apparent hatching, fledging and breeding success of red-billed tropicbirds at Pilot Hill on St. Eustatius between 2013 and 2015.

This season's results show that hatching success is 57% whereas of those eggs that hatch, fledging success is 73.7%. While it was not possible to accurately determine the cause of nest failure in the majority of cases, nine rat predation events were confirmed by camera trap data (Table 1; Figures 6, 7 and 8); three cracked eggs were discovered inside nesting cavities; and two nests were destroyed in a landslide following a lightning storm.

Cause	**Number**	**%**
Cracked egg	3	5.8
Abandoned egg	1	1.9
Predated egg	9	17.3
Egg failed to hatch	1	1.9
Dead chick	1	1.9
Nest destroyed	2	3.8
Unknown (egg/chick disappeared)	35	67.3
Total	**52**	**100**

Table 1: Causes of red-billed tropicbird nest failure at Pilot Hill on St. Eustatius between October 2014 and May 2015.

Figure 6: Camera trap placed inside nesting cavity showing rat activity in the presence of a juvenile and adult.

Figure 7: Camera trap image showing rat taking egg.

Figure 8: Image showing rat removing unhatched but almost fully developed chick from egg.

4.1 Chick growth

A total of 16 accessible chicks were monitored throughout the season to fledging. Ten juveniles were still in nests on our final visit. Two chicks were discovered dead inside their cavities; four disappeared, cause undetermined; and four were inaccessible. Figure 9 shows the average maximum culmen length (mm) of all juveniles measured one week prior to fledging between 2013 and 2015. As can be seen in the boxplots, culmen length ranged from 46 to 58 mm. The wider range in recorded culmen length from 2012-2013 could be attributed to measurements being taken by different persons during fieldwork. This was corrected in subsequent years by having the same person take measurements throughout the season.

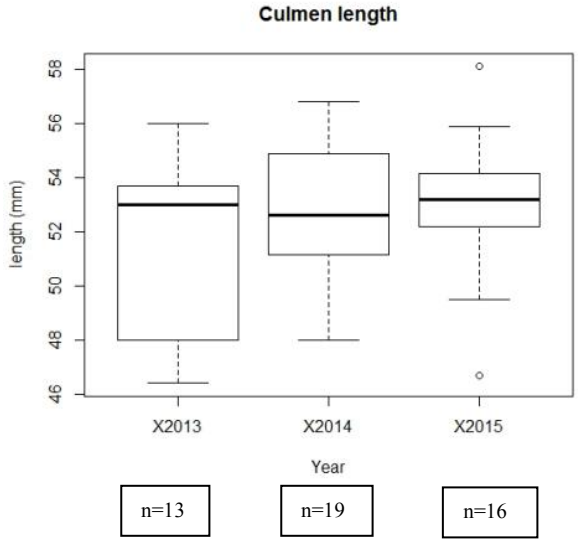

Figure 9: Average maximum culmen length (mm) of all monitored juveniles one week prior to fledging at Pilot Hill, St. Eustatius, between 2013 and 2015.

Figure 10 shows the maximum average weight of all measured juveniles within one week of fledging between 2013 and 2015. Weight ranged from 540 to 800 grams across all seasons.

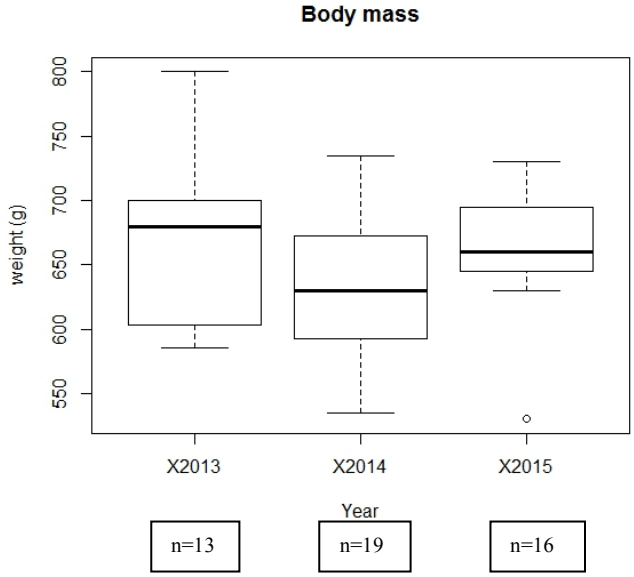

Figure 10: Average weight (g) of all juveniles weighed within one week of fledging at Pilot Hill on St. Eustatius between 2013 and 2015.

Figure 11 shows the growth curve of 11 juveniles measured from hatching to fledging. They all show a similar initial growth trend where the weight increases steadily to ca. 500 grams from 0-25 days, after which point there is some fluctuation. Around 50-65 days the chicks reach their maximum weight, at which point it begins to plateau, and as chicks near fledging by 75 days most have started to lose weight.

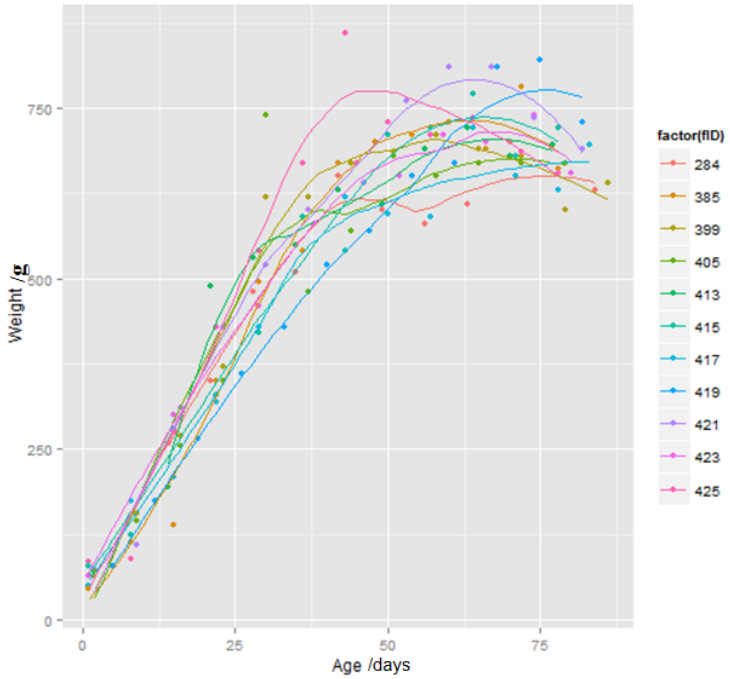

Figure 11: Graph showing the development (weight/age) of 11 juveniles from hatching to fledging during the 2014-2015 nesting season on Pilot Hill, St. Eustatius. Factor (ID) is the band number of each bird.

4.2 Leg bands

This season we banded 185 adults and juveniles. This brings the total number of birds banded to 443 since monitoring commenced in 2012. However, the quality of the aluminium bands is not sufficient for long-term use and we believe there could be some cases of birds losing bands and being double-banded. There were also two unfortunate incidents of tropicbirds becoming injured by the leg bands, where the band had opened up and slipped down the bird's leg and become embedded in its foot. Both bands were removed and not replaced. There is a need for good quality, durable bands that can be used for monitoring if we are to continue collecting reliable long-term data.

4.3 Nest fidelity and monogamy

Data from this season shows that seven incidents of nest fidelity were documented at Pilot Hill. Fidelity can be described as the same nesting cavity being used by one or more adult birds with the same band number in subsequent years. Long-term monitoring will enable us to better understand nest fidelity among red-billed tropicbirds on St. Eustatius in the future.

Band no.	Nest no.	No. of attempts	Attempt 1	Attempt 2
EUX0012	PH16	2	Fail	Success
EUX0387	PH20	2	Fail	Success
EUX0175	PH31	2	Fail	Fail
EUX0203	PH32	2	Fail	Fail
EUX0099	PH40	2	Fail	Success
EUX0278	PH74	2	Fail	Success
EUX0104	PH05	2	Fail	Unknown

Table 2: Overview of nest fidelity among red-billed tropicbirds at Pilot Hill on St. Eustatius, 2014-2015.

Red-billed tropicbirds are thought to pair for life (Winter 2014). Any alterations in breeding pairs are assumed to be due to the death of one of the partners. Of the data collected from 2012-2015, we have been able to determine monogamous behaviour among 25 of 90 pairs of adult nesting birds (Table 3). Fifteen pairs (46.9%) of birds that were banded in the 2012-2013 season were observed pairing again in the 2013-2014 season, incidentally also in the same cavities. Six pairs banded in 2013-2014 were observed in the same cavities in 2014-2015, and an additional four pairs nested in the same cavities for three consecutive years.

However, given the quality of the bands used, as mentioned earlier there may be cases of birds having lost a band and subsequently been re-banded with a different number. There is no way of knowing how many birds have lost their original bands or which birds have been double-banded, but we estimate this to be less than 50.

	2013	2014	2015
Successful nesting pairs	26	32	32
Monogamous pairs		15	10
% of total nesting pairs		**46.9**	**31.3**

Table 3: Overview of monogamous behaviour among red-billed tropicbirds at Pilot Hill, St. Eustatius, 2013-2015.

5. Discussion and Future Plans

The results of our analysis show that apparent hatching, fledging and breeding success from this season are slightly improved from 2013 (Madden and Ellis 2013) but show a slight decrease from 2014 (Madden 2014). The 2014-2015 season shows similar trends to previous years. Apparent hatching success is 57%, whereas apparent fledging success is much higher at 73.7%. Currently there is no evidence of cat predation on tropicbirds at Pilot Hill. However, given that some chicks disappeared from nests at various stages of development, the risk of cat predation cannot be ruled out. Nevertheless, birds of prey observed around the site during monitoring, such as the peregrine falcon (*Falco peregrinus*) and red-tailed hawk (*Buteo jamaicensis*), could also account for chick loss.

While we were unable to determine the cause of the majority of nest failures, data from camera traps documented regular black rat (*Rattus rattus*) activity within nesting cavities, even when adults were present, and documented nine cases of egg predation. Invasive rodents are a primary threat to seabird populations on oceanic islands (Sarmento *et al.* 2014). Tropicbirds are particularly vulnerable due to the fact that they have a long incubation period, their nest sites are easily accessible by rodents, and chicks are unable to escape from predators (Sarmento *et al.* 2014). For the 2015-2016 season there is an urgent need to implement a rodent monitoring and control pilot project. This will enable us to assess whether rodent reduction has a positive impact on hatching and reproductive success.

Estimates of extinction probability due to predation on red-billed tropicbirds in Brazil show that high levels of predation will give rise to the species' extinction unless preventive action is taken (Sarmento *et al.* 2014). Invasive rats are one of the largest contributors to seabird extinction and endangerment worldwide, and studies show that *Rattus rattus* has the largest mean impact on seabirds (Jones *et al.* 2008). Furthermore, the structure of communities and trophic interactions can also be negatively impacted by rats, for example through native plant consumption (Ringler, Russell, and Le Corre 2015). One case study of a successful rat eradication program is Anguilla's uninhabited Dog Island, which has resulted in a dramatic increase in nesting numbers of red-billed tropicbirds (Bright *et al.* 2014). While the total eradication of rats on inhabited islands is far more difficult to achieve, a reduction in the rodent population is certainly feasible (Sarmento *et al.* 2014).

6. Conclusion

Our results suggest that the future of the red-billed tropicbird population on St. Eustatius could be uncertain due to rat predation on eggs, and possibly young chicks. While rat eradication is the most preferred management option, it is difficult and costly, requiring stringent quarantine regulations to prevent future reinvasions (Sarmento *et al.* 2014). Therefore, rodent control is a more feasible short-term option for an inhabited island like St. Eustatius and should be implemented island-wide in collaboration with key local stakeholders such as the St. Eustatius Health Department and the Department of Agriculture and Fisheries.

7. Acknowledgements

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