EFFECTS OF CYCLONE ROSIE ON BREEDING RED-TAILED TROPICBIRDS *PHAETHON RUBRICAUDA* ON CHRISTMAS ISLAND, INDIAN OCEAN

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SUMMARY

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Extreme weather events, such as storms or flooding, can have a strong impact on the reproductive success of seabirds. Because an increase in frequency and intensity of such catastrophic events attributable to global climate change is predicted, quantitative data on the impacts of these events are important to help to evaluate potential long-term effects on seabird populations. In the present study, the impact of a cyclone on Red-tailed Tropicbirds *Phaethon rubricauda* breeding on Christmas Island, Indian Ocean, is examined. In April 2008, Cyclone Rosie hit the island and caused a loss of 34.3% of nest sites, 41.3% of active nests and 61.3% of eggs. Despite this substantial impact, long-term consequences might not be problematic with respect to population size because no adult birds were found dead. Given the predicted increase of strong storms because of climate change, cumulative effects of frequent breeding failures caused by extreme weather conditions have to be monitored and taken into account for future management strategies.

Key words: Cyclone, reproduction, Red-tailed Tropicbird, *Phaethon rubricauda,* climate change

INTRODUCTION

Extreme weather events can have severe negative effects on animal populations. Events such as storms, fires or floods can substantially reduce current reproductive success or even population size. Especially if the numbers and spatial extension of a population are small, and if exposure to such events is direct and frequent, the impact can be detrimental and even lead to extinction (e.g. Parmesan *et al.* 2000, Scheffer *et al.* 2001).

Marine birds have adapted well to bad weather conditions at sea. They are able to out manoeuvre even severe weather or climate events, such as storms or El Niño; they can even "use" them for travelling efficiently (e.g. Blomquist & Peterz 1984, Culik *et al.* 2000, Catry *et al.* 2004). However, seabirds must breed on land, and there, extreme weather conditions can have strong negative effects. Specifically, reproductive success can be substantially reduced by unfavourable weather events (e.g. Gochfield & Ford 1974, White *et al.* 1976, King *at al.* 1992). Yet quantitative data on the impacts of catastrophic weather events on seabirds are scarce. This data will become important, because the frequency and intensity of catastrophic weather events in marine ecosystems are predicted to increase as result of the ongoing climate change (IPCC 2007). Consequently, the impacts of these events on seabirds will also increase, and understanding how seabirds are affected will help to evaluate potential long-term effects on these animals and their populations.

The Red-tailed Tropicbird *Phaethon rubricauda* is a tropical seabird with a wide distribution ranging from the Western Indian Ocean to the eastern Pacific (Harrison 1985, Del Hoyo *et al.* 1992). The bird breeds on the ground, often in nests close to shore or on sites not highly elevated above sea level. As a result, the species is prone to be affected by tropical cyclones hitting the coasts at breeding locations.

Christmas Island, Indian Ocean, harbours the largest breeding colony of Red-tailed Tropicbird in Australia, with approximately 1400 breeding pairs (Stokes 1988). This colony is also the main breeding location of this seabird in the tropical Eastern Indian Ocean (Harrison 1985, Marchant & Higgins 1990). This colony therefore represents an important breeding site for this species and its reproductive success and perseverance is of relevance to the total population of Red-tailed Tropicbird.

During the morning of 22 April 2008, tropical cyclone Rosie passed Christmas Island at a short distance. It caused strong winds and heavy rains, and a large swell hit the island's north and northwestern shores where the major breeding sites of Red-tailed Tropicbirds are located. In the present study, we examine the effects of Cyclone Rosie on the reproduction of Red-tailed Tropicbirds at one of the main breeding sites of this species on Christmas Island.

STUDY AREA AND METHODS

Surveys were conducted on Christmas Island, Indian Ocean (10°25′S 105°40′E), on 20 and 21 April 2008 in the afternoons before the cyclone and on 23 April 2008 in the morning after the cyclone. The surveys were conducted at Sitting Room, one of the two main breeding sites of Red-tailed Tropicbirds on Christmas Island, at the northeast tip of the island. The site extends about 300 m along the coastline, facing north, and is exposed only to salt spray under normal conditions. The breeding habitat is characterized by sharp, water-eroded limestone rock, forming terraces that vary from one metre to 12 m in width. The vegetation consists mostly of Pandanus *Pandanus christmatensis,* Salt Bush *Pemphis acidula,* Octopus Bush *Argusia argentea* and Beach Naupaka *Scaevola sericea.* Tropicbird nests are located on the ground beneath this vegetation and within the small caves and crevices in the limestone all along the extension of the site.

Since July 2006, systematic and regular surveys of the colony have been taking place. Searches for nest sites are made under vegetation and in rock crevices, and nest content is recorded. A nest site is defined as a scrape on the ground with at least one adult in attendance (occasionally both adults can be present) independent of whether the nest contains an egg, a chick or is empty. Each nest site is marked with a numbered plastic tag attached to rocks or vegetation close to the nest without disturbing the birds, making it possible to unequivocally identify every nest site even if the site is not active at the time.

Cyclone Rosie

Cyclone Rosie formed as a low to the southwest of Sumatra on 18 April 2008. It moved in an east-southeast direction, gained strength and reached tropical cyclone intensity (TC 28S, Category 2) early on 22 April (Commonwealth of Australia 2008a). During the morning of 22 April, Rosie had reached its greatest proximity to Christmas Island, with the centre located approximately 100 km west of the island. The centre moved southwards with a speed of approximately 24 km h^{-1} and an air pressure of 988 hPa. Maximum wind speeds were about 83 km h^{-1} with gusts of up to 100 km h^{-1} (Commonwealth of Australia 2008b). The heavy swell caused by Rosie coincided with the high tide at Christmas Island during the morning of 22 April (08h30), resulting in waves of five to seven metres that hit the island at its west and northwest coast (Commonwealth of Australia 2008a).

RESULTS

In the survey during the two days before the cyclone, 108 nest sites in total were found and checked for contents. In 37 nest sites (34.3%), an adult bird was present, and of those birds, 31 (83.8%) were incubating an egg. Two birds (5.4%) were brooding a small chick (Table 1). These observations account for 28.7% and 1.9% respectively of the 108 nest sites found. Six birds observed on empty nests were considered to be prospecting a nest site or about to lay an egg.

After the cyclone, 71 (65.7%) of the 108 nest sites found before the cyclone were still present. The other 37 sites had been destroyed, mainly because the vegetation above or the ground where the nest had been located, or both, was gone. Of the 71 nest sites still present, 21 (29.6%) were occupied by adults, 17 of which had incubated an egg before the cyclone. After the storm, 12 (57.1%) of the 17 were still incubating an egg, and one was brooding a chick (4.1%). These observations account for 16.9% and 1.4% respectively of all 71 nest sites found. These numbers equal a decrease of 34.3–61.3 % in the respective nest categories (Table 1). No dead adults were found, and one egg with a cracked shell was found between several nest sites.

Table 1
Number of nests before and after Cyclone Rosie and relative change

	Before Rosie (n)	After Rosie (n)	Relative decrease (%)
Total nest sites	108	71	34.3
Active nests	37	21	43.2
Nests with eggs	31	12	61.3
Nests with chicks	2	1	50.0

DISCUSSION

Cyclone Rosie had a strong impact on the breeding Red-tailed Tropicbirds: about one third of all nest sites were destroyed and almost 40% of all eggs were lost. The egg loss might have been even higher, because some of the eggs may have been abandoned by the adults during the cyclone and have cooled too much. Because the number of chicks before the cyclone was low, no sound conclusion can be drawn with respect to chick mortality. However, it is likely that at least small chicks would have been lost at the same rate as the eggs were, because they can easily die of hypothermia or from the destruction of the nest site. In addition, Cyclone Rosie destroyed large parts of the Pandanus and Beach Naupaka vegetation that Red-tailed Tropicbirds frequently use to nest beneath. At some areas of Sitting Room, the line of vegetation was shifted by up to two to three metres landwards as waves washed away the Pandanus and Beach Naupaka bushes. Thus, not only reproduction, but also nesting habitat was considerably affected by the cyclone.

Severe effects of storms and cyclones on breeding seabirds are common. Small chicks often die from exposure to inclement weather (e.g. Gochfield & Ford 1974, White *et al.* 1976), and after a cyclone, Langham (1986) reported on adult Bridled Terns *Sterna anaethetus* that were injured by fallen trees. Secondary effects are also possible: chicks may die of starvation after the actual cyclone, because the parents are not able to forage and provision sufficiently, and because chicks need more energy for thermoregulation (e.g. Feare 1976, Langham 1986). Also, detrimental effects of cyclones have been recorded previously for Christmas Island. In March 1988, Abbott's Boobies *Papasula abbotti,* canopy-nesting birds endemic to the island, were severely affected when exceptionally strong winds destroyed one third of nesting sites and killed one third of chicks (Reville *et al.* 1990). The number of nesting adults in the 1988 breeding season after the cyclone was 30% lower than in previous years, and it was hypothesised that these birds may have been killed in the storm (Reville *et al.* 1990).

Although loss of eggs and nest sites was substantial and considerable destruction of nesting habitat occurred, the effects of Cyclone Rosie on the reproduction of Red-tailed Tropicbirds may not be severe from a long-term perspective. Firstly, no adult mortality was observed. It is certainly possible that adults were injured or killed (e.g. by waves or broken vegetation) and that their corpses were washed into the sea, but most likely, the adults abandoned nests and flew away so as not to risk their own survival, a behaviour to be expected by these long-lived animals (e.g. Furness & Monaghan 1987, Ricklefs 1990, Stearns 1992, Daan & Tinbergen 1997). In the case of egg or chick loss, Red-tailed Tropicbirds are able to lay a replacement egg within a short period of time (Fleet 1972, 1974, Del Hoyo *et al.* 1992). Furthermore, in contrast with other populations having pronounced breeding peaks (Fleet 1974, Marchant & Higgins 1990, Le Corre 2001), the birds on Christmas Island breed year round (Parks Australia North unpubl. data, Hennicke unpubl. data). Although the underlying reasons for this breeding regime are still unclear, obviously Christmas Island birds are able to reproduce under the conditions prevailing over the year. Consequently, the adults affected by Cyclone Rosie can be assumed to resume reproduction relatively quickly. Secondly, although a substantial part of the nesting habitat was destroyed by Rosie, a high number of unoccupied nest sites were still available, and vegetation is likely to grow back relatively quickly given the tropical conditions, allowing the birds to resettle the affected areas. Thus, a shortage of breeding sites affecting the future reproductive performance seems unlikely. For these reasons, it is likely that events such as Cyclone Rosie will have only a limited impact on the reproductive population and population dynamics of Red-tailed Tropicbirds on Christmas Island as long as high mortality among adults does not occur.

However, even if the effects of Rosie do not appear to be severe from a long-term perspective, cumulative effects have to be taken into account. Rosie was the third strong storm passing Christmas Island during the rainy season 2007/08 (Christmas Island Tourist Association pers. comm.). Before Rosie, Cyclone Pancho developed west-southwest of Christmas Island at the end of March 2008 and affected the island with strong winds, heavy rain and large swell (Commonwealth of Australia 2008c). Nothing is known about the effects of Pancho on the Red-tailed Tropicbirds, but that storm may also have caused high egg loss and chick mortality. As mentioned earlier, Red-tailed Tropicbirds breed on Christmas Island year round, but in the present study, mainly incubating birds and only two small chicks were recorded. No older chicks were found. Red-tailed Tropicbirds incubate their single egg for about 42–46 days and re-lay in the event of breeding failure (Fleet 1972, 1974; Del Hoyo *et al.* 1992). Thus, Cyclone Pancho may have caused high loss of eggs and chicks, which resulted in the breeding phenology observed in the present study.

Global climate is expected to lead to the frequency and intensity of storms increasing worldwide (IPCC 2007). As a result, the impacts on Red-tailed Tropicbirds on Christmas Island may also increase. Although Red-tailed Tropicbirds, like seabirds in general, have evolved to cope with environmental variability potentially causing repeated breeding failure (e.g. Furness & Monaghan 1987, Ricklefs 1990, Schreiber & Burger 2001), on a long-term perspective, their population dynamics will be negatively affected if natural events such as cyclones happen frequently. Therefore, the effects of these natural, but anthropogenically enhanced catastrophic events on Red-tailed Tropicbirds on Christmas Island, and on other seabird colonies and populations in general, should be carefully monitored. Future management strategies such as installation of artificial nest sites, rehabilitation of coastal vegetation and creation of protected areas should take this threat into consideration.

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