# Camera trapping reveals cooperative breeding in the Red-footed Booby Sula sula

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# CAMERA TRAPPING REVEALS COOPERATIVE BREEDING IN THE RED-FOOTED BOOBY *SULA SULA*

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**ABSTRACT**

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Cooperative breeding occurs in only 9% of bird species and is particularly rare among seabirds. We provide evidence that cooperative breeding occurs in a tropical seabird, the Red-footed Booby. Through camera monitoring of active nests, we found one nest in which a chick was raised by a trio of birds: its two parents and an immature bird. The immature bird fed the chick, guarded it, and preened it. The parents did not behave aggressively towards the immature bird when it approached the chick, suggesting that this trio was stable and composed of birds that knew each other. The growth of the chick cared for by the trio was not different from other chicks in the colony, suggesting that being fed by three birds did not result in more food provisioning. We hypothesize that the immature bird was the young of the pair that it was helping and had fledged the previous breeding season, and we discuss this in relation to the exceptionally long post-fledging parental care in this species. The prevalence of this behaviour is unknown and we recommend investigating parental care of boobies and gannets in greater detail to learn more about cooperative breeding among sulids.

**Key words:** camera trap, helping behaviour, parental care, seabird, Tromelin Island

## INTRODUCTION

Cooperative breeding is a reproductive strategy in which an individual that is not the parent of the young of a family shows parental behaviours oriented to these young (Cockburn 1998). This is particularly important and well-studied in birds; at least 9% of bird species show obligate or occasional cooperative breeding (Cockburn 2006). Several reviews have investigated the occurrence of this behaviour among birds and have demonstrated clear general patterns (Cockburn 1998, Hatchwell & Komdeur 2000, Cockburn 2006, Hatchwell 2009, Griesser & Suzuki 2016). In general, avian cooperative breeders are sedentary terrestrial species, often nesting in high densities, generally in the tropics or in temperate areas.

Cooperative breeding is extremely rare in seabird families, apart from the Family Stercorariidae (jaegers and skuas) in which it occurs frequently in the temperate population of Brown Skuas *Stercorarius antarcticus lonnbergi* of Chatham Island, New Zealand (Hemmings 1994), occasionally in Balearic Shearwaters *Puffinus mauretanicus* (Genovart *et al*. 2008), and very exceptionally in Herring Gulls *Larus argentatus* (Fitch & Shugart 1983). Among Sulidae, polyandry has been observed very occasionally in Brown Booby *Sula leucogaster*, Blue-footed Booby *S. nebouxii* (Castillo-Guerrero *et al*. 2005), and once in Red-footed Booby *S. sula* (Cao *et al*. 2010). In these studies, an adult female mated with two adult males, and the resulting trios were involved in parental care. Although these examples are intriguing and bare resemblance to cooperative breeding (i.e., when a chick is raised by a trio in which one of the males is not the true parent), this is not true cooperative breeding because when two males mate with a single female, they share a similar probability of paternity; it is this potential which drives their tendency to perform parental care. In true cooperative breeding, the helper does not mate with either of the parents (helpers are often immature individuals) and has no chance of being a parent of the chick it helps.

In this note, we report the first clear and unequivocal evidence of occasional cooperative breeding in a tropical seabird, the Red-footed Booby.

## METHODS

### Study area

This study was conducted at Tromelin Island (15°53′30″S, 054°31′26″E) as part of a long-term project on seabird population dynamics following rat eradication (Le Corre *et al*. 2015). Fieldwork was conducted from 25 July to 18 December 2017. Tromelin Island is a small (1 km$^2$) flat coralline island of the western Indian Ocean. The island holds a large colony of Red-footed Boobies (1200 pairs) together with Masked Boobies *S. dactylatra* (1300 pairs) and five other seabird species that recolonized the island after rat eradication in 2005 (Le Corre *et al*. 2015, unpublished data). The Red-footed Booby breeds all year round at Tromelin Island (Le Corre 1996, Le Corre *et al*. 2015). They breed on branches of the Tree Heliotrop *Heliotropium foertherianum* (formerly known as *Tournefortia argentea*).

### Sampling methods

We used camera traps to investigate parental care of boobies and other seabirds. We deployed camera traps (Bushnell Aggressor and StealthCam G42NG 24MP) at five nests of Red-footed Boobies (one at incubation and four during chick-rearing). All nests were

surveyed with the camera traps in photographic mode (three pictures per occasion, motion detection activated). Three nests were also surveyed with the camera trap in video mode (one video of 10 or 20 s per occasion, motion detection activated), after the photographic mode deployment. Camera traps were automatically activated from sunrise to sunset.

The Red-footed Booby population of Tromelin Island is polymorphic: 62% of the adults are of the white-tailed white morph, 26% are of the white-tailed brown morph, and 12% are mixed morphs (white-tailed white morph with brown scapulars and white-tailed brown morph with white scapulars, and various intermediate morphs; Le Corre 1999, Danckwerts 2017). In an effort to identify each parent of the five surveyed pairs on the photos or videos, we noted the plumage of each parent observed during camera trap surveys. We also noted if the observed parent was banded or not.

Twelve chicks in the colony were measured and weighed every five days from hatching until they fledged. Growth was studied from 04 August to 18 December 2017. During each visit to the nests, we also noted the colour morphs of all adults present at the nests, as well as the presence of any other attending bird. Two chicks selected for the growth study were also included in the camera trap protocol. It is in one of these nests surveyed by camera trap that we incidentally observed cooperative breeding. This provided an opportunity to compare the growth of a chick fed by three birds to the growth of other chicks fed by only two birds.

**Ethics statement**

This study has been approved by the Administration des Terres Australes et Antarctiques Françaises and by the Centre de Recherche sur la Biologie des Populations d'Oiseaux (permit PP616).

## RESULTS

Each nest was monitored with camera traps for 2–6 d (mean 3.8 ± 1.8 d, $n$ = 5 surveyed nests). Across all nests, we completed 19 days of observation. The camera monitoring produced 34 614 photos and 1634 videos. When all nests were combined, we detected eight feeding events and four incubation shifts. We were able to see both adults at the same time on images of the five surveyed pairs: three pairs consisted of two adults of the white-tailed white morph and two pairs consisted of one brown and one white morph. Two adults of the five surveyed pairs were banded, which increased our ability to individually identify the birds. In four of the five surveyed nests, we found no unusual parental behaviour: the chick or egg was attended or fed by two parents, with no evidence of any helping behaviour by a third individual.

In one nest, we observed a third bird—a two-year-old immature bird identified by its plumage and lack of facial colouring—which participated in parental care on 01 and 02 October. On 01 October, it first brought a twig to the nest and positioned it in the nest as one adult guarded the chick. It then flew away, returned, fed the chick once (Fig. 1), brooded the chick, and carried out some allopreening and guarding behaviour. On 02 October, the immature bird perched at the nest for 10 min, sometimes with one or both adults, and sometimes alone with the chick. During our six days of camera monitoring, this chick was fed twice, once by a parent and once by the immature bird (Fig. 1). Normally chicks are fed at least once a day, usually at sunset, so it is probable that the camera trap missed some feeding events; for example; the camera had been moved by a bird resulting in poor coverage of the nest during almost half the survey, and some feeding events may have occurred during the night.

On two occasions, we also observed the immature bird showing alarm behaviour and defending the chick while we were catching the chick for measurement. We obtained a few photos and video footage of the two adults with the immature bird and found no evidence of aggressive or territorial behaviour between them, suggesting that they knew each other. Notably, the immature bird guarded the chick for seven minutes alone on 02 October (i.e., without either adult nearby). Normally, chicks of this age are almost permanently guarded by one parent; if another bird perches next to the nest, the guarding adult would immediately chase it aggressively. The fact that the immature bird was not chased and was left alone with the chick suggests that it was familiar to both the parents and the chick. Collectively, our observations indicate that the behaviours that we captured during our short-term camera trap survey were not incidental. The immature bird and the two breeding adults formed a stable trio that cooperated to raise the


**Fig. 1**. Photos taken with a camera trap at a Red-footed Booby *Sula sula* nest, Tromelin Island. A) The two adults with the chick, with one adult feeding the chick. B, C) The immature bird feeding the chick. More photos and videos are available upon request from the first author.

chick. Unfortunately, our discovery that the immature bird also fed the chick came after our field work was complete, as we analyzed the SD cards at the end of the field season. Thus, we were not able to sample the blood of the immature bird to determine its sex or to investigate its genetic relationship with the two adults or the chick.

We visited each of the 12 nests used for chick growth 20 times on average (18–21 visits per nest) over the three-month study period, which allowed us to identify (with colour morphs or/and bands) each parent of 10 of the 12 chicks whose growth was studied (Fig. 2). For the remaining two chicks, we never saw more than one adult at the nest (white morph), so we assume that both adults were white morphs. None of the adult pairs were helped by a third bird, except for the pair for which we found cooperative breeding.

## DISCUSSION

To our knowledge, this is the first time that true helping behaviour—by an individual that has no chance of being the parent of the chick it helps—has been observed in this species and in the Family Sulidae.

Although our observation is unequivocal (the photos and videos clearly show that the immature bird was involved in parental care; e.g., nest consolidation, feeding the chick, and guarding the chick), it is not clear how prevalent this behaviour might be. We detected it "by accident" through camera trapping, and as far as we know, we are the first to use camera trapping to investigate parental behaviour in this species. It is possible that this behaviour is more common than previously thought. The fact that there was no aggressive behaviour between the adults and the immature bird suggests that they formed a stable trio in which all members were involved in parental care.

The "helper" in this study was an immature bird in its second year. We hypothesize that this bird may be the young of the pair that it was helping, probably from the previous breeding season, although we have no evidence to confirm this. Helping behaviour by kin is common in cooperative breeding and is explained by kin selection: helpers increase their inclusive fitness by providing parental care to the young to whom they are genetically related (see, for instance, Komdeur 1994). However, other direct benefits to the helper (e.g., learning parental behaviour, acquiring a territory) may be sufficient and even more important than the genetic benefits that may be accrued (Clutton-Brock 2002).

The Red-footed Booby and other tropical sulids have an extremely long period of post-fledging parental care (three to six months; Nelson 1978, Guo *et al*. 2010), a characteristic that, among seabirds, is shared only with frigatebirds (Diamond 1975). During this long period, young birds gradually improve their flight and fishing skills, but come back to the nest each evening to be fed by the parents (Guo *et al*. 2010, Mendez *et al*. 2017). This strategy provides fitness benefits for both parents (increased breeding success) and young (increased survival), particularly in the tropical marine environment where resources are more difficult to obtain than in more productive waters (Guo *et al*. 2010, Mendez *et al*. 2017). Parents gradually stop feeding the fledgling when the fitness gain from another nesting exceeds that from attending their current young (Guo *et al*. 2010).

Long post-fledging interactions between young and their parents may be favourable for the development of cooperative breeding because this increases the opportunity for young to live with their parents while the parents engage in a new nesting event. Indeed, it has been shown that post-fledging care is longer in cooperative breeders than in non-cooperative breeders (Langen 2000). We hypothesize that cooperative breeding occasionally occurs in the Red-footed Booby because of this very long post-fledging care. Although other studies suggest that once independent, fledged immature birds leave the colony for 1–2 y (Nelson 1978), this does not seem to be the case at Tromelin Island because the colony and nearby roosts are permanently occupied by hundreds of immature birds of various ages. The fact that immature birds stay at the colony after being independent may also increase the opportunity to engage in cooperative breeding behaviour.

The growth curve of the chick raised by three birds was not different from that of the other chicks that we measured (all of whom were raised by two parents). This suggests that having a helper did not significantly increase the amount of food brought to the chick. Having a helper may reduce the parental feeding rate, which is beneficial for the parents. However, our survey was too brief to know the relative amounts of food provided by the helper compared to the parents. Furthermore, we lack data to compare the feeding rate of this pair to that of pairs without helpers.

Camera traps are increasingly used in animal ecology studies (O'Brien & Kinnaird 2008, O'Connell *et al.* 2011). In seabird studies, camera traps are frequently used for investigating

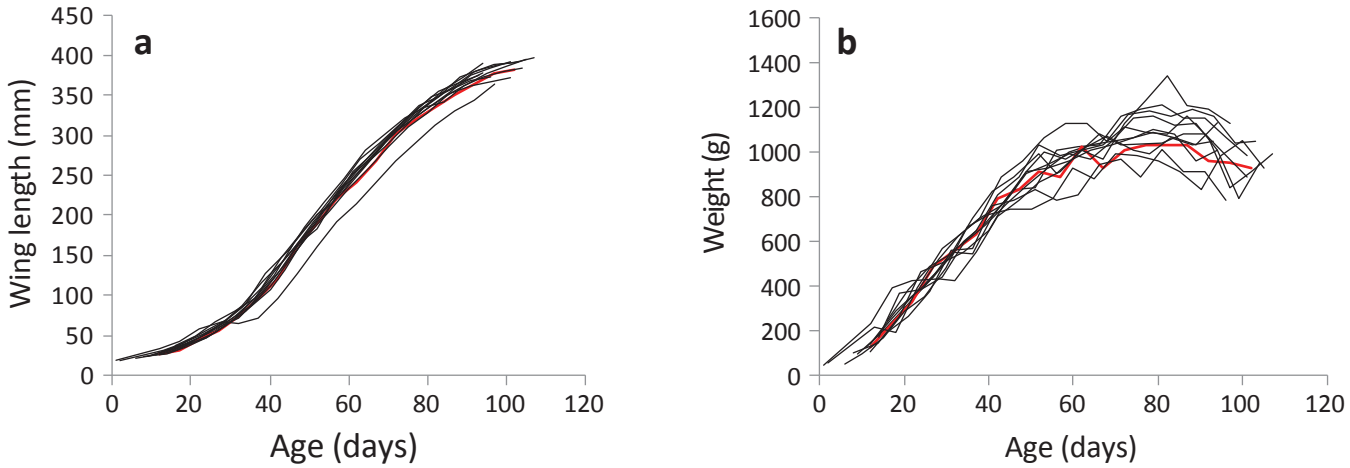


**Fig. 2.** Growth curves of chicks of Red-footed Boobies *Sula sula*, Tromelin Island, showing A) wing length. B) weight. The growth curves of the chick raised by a trio are in red.

interactions with invasive mammals (e.g., Stolpmann *et al*. 2019) or for behavioural studies (Hart *et al*. 2016, Fayet *et al.* 2020). In our context, we think that this cooperative breeding behaviour would have gone unnoticed without the use of camera traps. Thus, we suggest using systematic camera trapping to investigate parental behaviour in Red-footed Boobies in greater detail, and to examine the link between cooperative breeding and prolonged parental care. This approach could be employed not only in this population, but also in other populations and other tropical sulid species to determine whether helping behaviour is, in fact, common within this seabird family.

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