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# EFFECTS OF SEVERE RAINS ON THE MORTALITY OF SOUTHERN ROCKHOPPER PENGUIN (*EUDYPTES CHRYSOCOME*) CHICKS AND ITS IMPACT ON BREEDING SUCCESS

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**Efectos de severas lluvias en la mortalidad de los pichones de Pingüino Penacho Amarillo (*Eudyptes chrysocome*) y su impacto en el éxito reproductivo.**

**Key words:** Southern Rockhopper Penguin, weather conditions, breeding success, Falkland Islands.

## INTRODUCTION

Breeding success of avian species can be affected by many factors, such as predation, food shortage, diseases, habitat destruction or weather conditions. Their impacts vary greatly among species (Newton 1998). Weather conditions may play a role in influencing food availability or affecting the cost of thermoregulation (Elkins 1983). In the case of penguins, considerable variations from year to year in mortality of both eggs and chicks are due to inclement weather (Warham 1975). Rain can be a real menace during reproduction (Williams 1995, Davis & Renner 2003). For example, the burrows of Jackass Penguins (*Spheniscus demersus*) may collapse or be flooded after heavy rain, causing the incubating adults to desert or the death of the chicks due to hypothermia (Randall *et al.* 1986, Seddon & van Heezik 1991).

The microhabitat within the colony may also influence the breeding success. It has been suggested that a lower nest density and a greater vegetal cover reduce the egg loss in Southern Rockhopper Penguin (*Eudyptes chrysocome*), a species breeding in open areas (St Clair & St Clair 1996). However, in the same colony, other studies found no relationship between habitat characteristics and breeding parameters (Matias 2005, Poisbleau *et al.* 2008). A reason for the breeding success variability between sub-colonies could be the direct predation of highly specialised predators, such as Brown Skuas (*Catharacta antarctica*) (Matias 2005) or Striated Caracaras

(*Phalcoboenus australis*) (Liljesthröm *et al.* 2008). On the other hand, the exposure of birds to different weather conditions according to the microhabitat in the colony could also greatly influence the breeding success. For example, Adélie Penguins (*Pygoscelis adeliae*) favoured ridges in the colony as they are more likely to remain free of snow and meltwater (Moczydlowski 1989). These results highlight that the egg and chick mortality of seabirds may vary between different parts of the colony.

The reproduction of the Southern Rockhopper Penguin is highly standardized. They lay two eggs; the larger second egg usually hatches first, and the chick from the first egg generally dies of starvation within days after hatching (Poisbleau *et al.* 2008). In the Falkland Islands, more than 80% of the pairs retained both eggs until at least one hatched successfully (Lamey 1993, Demongin *et al.* 2010). The male then guards the chick(s) for 20–28 days with the female returning with food almost every afternoon, after which the chick waits in a crèche to be provisioned by both adults (Williams 1995). The chicks start to moult at 35–40 days old and fledge at 10 weeks old (Strange 1982).

In the Falkland Islands, continuous heavy rainfall coupled with low temperatures was considered as the second largest factor (predation being the first) in chick loss during the crèche period for Southern Rockhopper Penguin (Strange 1982). However, Strange (1982) did not quantify the survival rate in his study. In the present paper, we describe the effects of severe rain on mortality of Southern Rockhopper Penguin chicks according to the habitat of the sub-colonies and discuss its impact on the estimation of the breeding success.

## METHODS

The study was carried out at the "Settlement Colony" on New Island (51°43'S, 61°17'W), Falkland Islands, between October 2007 and February 2008. The colony has approximately 5000 pairs of breeding Southern Rockhopper Penguins. Within the main part of the Settlement Colony we identified one sub-colony that was interspersed with and fringed by tussac grass (*Poa flabellata*), which provided a semi-open habitat (entitled the S-colony) and a second sub-colony in an open rocky area without vegetation (entitled the O-colony), both facing the south (Poisbleau *et al.* 2008). After the arrival of the first males back to the colony (early October), we visited the study sites daily to mark active nests and to record and follow breeding success, marking eggs and chicks with a unique code (for more details, see Poisbleau *et al.* 2008, in press). The laying period was highly synchronized, ranging from 27 October to 10 November (Poisbleau *et al.* 2009a, 2009b). The hatching period ranged from 2 to 15 December. The crèche period started at the end of December.

## RESULTS

On 2 and 10 January 2008, severe rainfall was recorded on the Falkland Islands (Fig. 1). On New Island, the local meteorological station recorded 120 mm of precipitation in 24 hours on 10 January, compared to 634 mm for the whole year in 2007. Moreover, this event was associated with low temperatures and high wind speeds (Fig. 1). On both occasions, the wind came from the south, hitting both of the sub-colonies with full force.

The chick survival rate was different according to dates and sub-colonies (Table 1). Among the chicks alive on first January, no chick died during the first rainfall in the O-colony, but 68.2% died during the second rainfall. In the S-colony, the survival rates were quite similar between the two events, respectively 8.4% and 10.2%. We then observed that the mortality rate was not significantly different between the sub-colonies during the first rainfall (Mann-Whitney test,

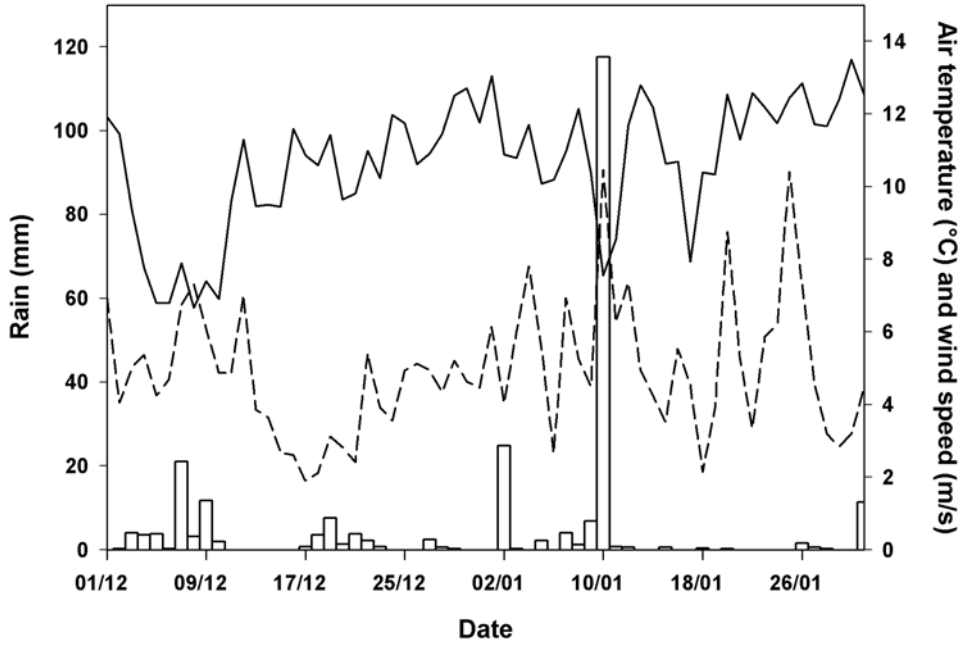


FIG. 1. Weather parameters at New Island from 1 December 2007 to 31 January 2008. Vertical bar: rain (sum per day, mm), Solid line: air temperature (mean per day, °C), Dash line: wind speed (mean per day, m/s).

$U$ = 1078, $P$ = 0.160) while there was a significantly higher mortality in the O-colony than in the S-colony during the second rainfall (Mann-Whitney test, $U$ = 453, $P$ < 0.001). Post-mortem examination of 20 dead chicks revealed that their stomachs were full of fresh food, indicating that neither starvation nor the absence of parents was the cause of death.

## DISCUSSION

*Chick mortality.* At the beginning of January, the chicks of Southern Rockhopper Penguins had just started to gather in crèche. Therefore, the adults no longer protected them during the majority of the day. Although penguin chicks had attained full thermoregulatory capacity at this stage (Seddon & van Heezik 1991), they were still covered with down, and not with waterproof adult-like feathers. In normal conditions, the mortality of chicks was very low once they reached eight days of age and was not related to the type of habitat of the sub-colonies (Poisbleau *et al.* 2008). Therefore, the breeding success should have been 0.66 chicks per nest this season instead of 0.49 without the observed harsh weather events (Table 1). The breeding success expected in 2008 before the heavy rainfall was very similar to the one recorded during the previous breeding season (0.69 chicks per nest, Poisbleau *et al.* 2008). These results suggest that both breeding seasons were not different in terms of breeding parameters but that rainfall was the factor responsible for the low success in 2008.

*Effects of habitat.* The impact of the rainfall on chick mortality differs significantly between

TABLE 1. Number of nests at laying and number of chicks according to dates in S- and O-colonies during the breeding season 2007–2008. The proportions are expressed as a percentage of the number of eggs at hatching.

| Sub-colony | S-colony | O-colony | Total |
|---|---|---|---|
| Nests at laying | 157 | 37 | 194 |
| Eggs at hatching | 137 (100%) | 32 (100%) | 169 (100%) |
| Chicks alive the 1 Jan | 107 (78.1%) | 22 (68.8%) | 129 (76.3%) |
| Chicks killed by rain the 2 Jan | 9 (6.6%) | 0 (0%) | 9 (5.3%) |
| Chicks killed by rain the 10 Jan | 10 (7.3%) | 15 (46.9%) | 25 (14.8%) |
| Chicks alive the 12 Jan | 88 (64.2%) | 7 (21.9%) | 95 (56.2%) |
| Breeding success (chick per nest) | 0.56 | 0.19 | 0.49 |

sub-colonies. There were three times more deaths in chicks from an open rocky habitat without vegetal cover than in the semi-open habitat fringed by tussac grass. Indeed, the day after the second rain event we found many dead chicks hidden under small rocks in the O-colony. Obviously, this protection was far from adequate, highlighting the importance of tussac grass, areas of which have largely declined in the Falkland Islands since the 19$^{th}$ century due to overgrazing and burning (Strange 2007). The contrasting results between different studies looking for a relationship between habitat characteristics and breeding parameters may also be explained by the possible effects of weather events.

*Estimation of breeding success.* In the Falkland Islands, the long-term monitoring of breeding success (chicks per nest) of rockhopper penguins is performed by double counting: one of the number of nests at incubation stage and one of the total number of chicks during crèche (Huin 2005). Small colonies or sections of large colonies are selected, and the overall breeding success is extrapolated. Such methods do not take into account the difference between sub-colonies, and especially of the differential impact of weather events on the breeding success. Our observations underline the necessity to count whole colonies or, when this is not possible, to sample sub-colonies representative of the whole colonies.

*Conclusion.* Black-browed Albatrosses (*Thalassarche melanophrys*) and Imperial Cormorants (*Phalacrocorax albiventer*) breed in the same rookery. Both of their chicks were covered with down at the beginning of January but were too big to be protected by their parents during the day (pers. observ.). Similar to the penguins, they suffered from high mortality during the events reported here. These three species are long-lived birds with a low annual productivity, and it is improbable that their population growth rate could really be impacted by this type of punctual events. However, the repetition of such events in case of climate change could have a significant impact on the growth rates of these three species' populations.

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