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Reproductive success of Falkland skua at Sea Lion Island, Falkland Islands

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Summary

The Falkland skua is an important, but understudied, component of the Falkland Islands marine megafauna and biodiversity. We carried out field work on skuas at Sea Lion Island during six breeding seasons, 2014-2015 to 2019-2020. We collected data on nest location and spatial distribution, nesting habitat, and reproductive success. In this report, we analyze the variation of skua reproductive parameters, showing that the population experienced a dramatic decline in reproductive success. Current fledglings production is about 6.4% of the maximum production observed (10 fledglings in 2019-2020 *vs* 157 in 2015-2016). At Sea Lion Island, skuas breed in clusters that are aggregated in two main zones, one close to the Sea Lion Lodge (Lodge) and one at the west end of the island (West). We show that, although both zones were affected, the decrease in reproductive success was stronger in the West. We discuss the possible causes of the decline, and of the difference between the two breeding zones, we summarize the information available for other breeding sites in the Falklands, and we suggest some lines of investigation for the future that may help understanding the causes of the skua poor reproductive performance. The low breeding success is probably related to the interaction between prey abundance and the number of the only potential skua predator, the striated caracara. When food resources are scarce, due to low breeding success of marine birds, skuas can reduce nest attendance, and be less effective at protecting eggs and chicks and, therefore, the caracara predation rate may be higher. Due to the important role of the Falklands skua in the food chain of the South Atlantic ocean, both on land and at sea, the drivers of its demography and population dynamics at Sea Lion Island and in the Falkland Islands at large deserve further investigation.

Introduction

The Falkland skua (*Catharacta antarctica antarctica*) is a taxon nearly endemic to the Falkland Islands, is an important component of the South Atlantic biodiversity (Phillips *et al.* 2007), and has been rarely studied. For example, a review of southern hemisphere skua breeding success listed only one study (i.e., Lamey 1995) about the Falkland skua, while other species and subspecies had multiple studies carried out in a number of locations (Reinhardt 1997). A review of southern hemisphere skua diet stated that "The literature research revealed a surprisingly poor knowledge of the food of the Falkland Skua" (Reinhardt *et al.* 2000). The situation was improved by the publication of a study on movement at sea and diet (Phillips *et al.* 2007), and of a study on breeding success (Catry *et al.* 2011), both carried out at New Island, but information about skuas in the rest of the Falkland Islands remained almost nonexistent.

Sea Lion Island, the southernmost inhabited island of the Falkland Islands, shelters a breeding population of Falkland skua that comprises up to about 150 nesting pairs. At Sea Lion Island, skuas are an important regulator of various marine bird species, because they prey on eggs and chicks of gentoo (*Pygoscelis papua*), rockhopper (*Eudyptes chrysocome chrysocome*) and Magellanic (*Spheniscus magellanicus*) penguins, king cormorants (*Phalacrocorax atriceps albiventer*), and dolphin (*Larus scoresbii*) and kelp (*Larus dominicanus*) gulls, and can have a notable effect on the breeding success of those species. From 2014 to 2020 we carried out regular censuses of the skua nesting areas, locating nests, and counting eggs, hatchlings and fledglings. In this report, we analyze the seasonal variation of various measures of nesting and breeding success, we compare the two main breeding zones of the island, we summarize the information available for other places of the Falklands, we discuss the possible reasons of the poor skua reproductive success, and we suggest that, due to its role in marine birds regulation, the demography and population dynamics of the Falkland skua deserve further investigation.

Methods

We carried out field work at Sea Lion Island during six skua breeding seasons (November 2014 - March 2020). Skuas breed in clusters that are aggregated in two main zones, one close to the Sea Lion Lodge (Lodge hereafter) and one at the west end of the island (West hereafter; Figure 1). In 2014-2015 we regularly collected data only for the Lodge zone, while data collection for the West zone was irregular. Therefore, the 2014-2015 data was analyzed only for the Lodge zone.

We searched the whole island to locate skua nests. Skuas are territorial and, therefore, it is usually easy to identify nests by observing the behavioural reaction of the adults when approached by an operator (Catry *et al.* 2011). After locating a nest, we took its position using GPS receivers (GPSMap 60, Garmin) and we used the GPS position to identify the nest in following surveys. We considered as nesting pairs only the pairs that showed territorial behaviour around a clearly visible hollow (i.e., pairs that had begun at least the building

phase of the nesting). Pairs that showed territorial behaviour but never started building a nest were excluded from the study.

We gave to each nest a serial number, and we collected data about the aspect of the nest, the nearby substrate and vegetation (circle of 5 m radius centred on the nest), the size and colour of the adults, and the remains of prey and food leftovers in proximity to the nest. We checked each nest once per week, and we recorded the number of adults, eggs and chicks, and the size and moult level of the chicks.

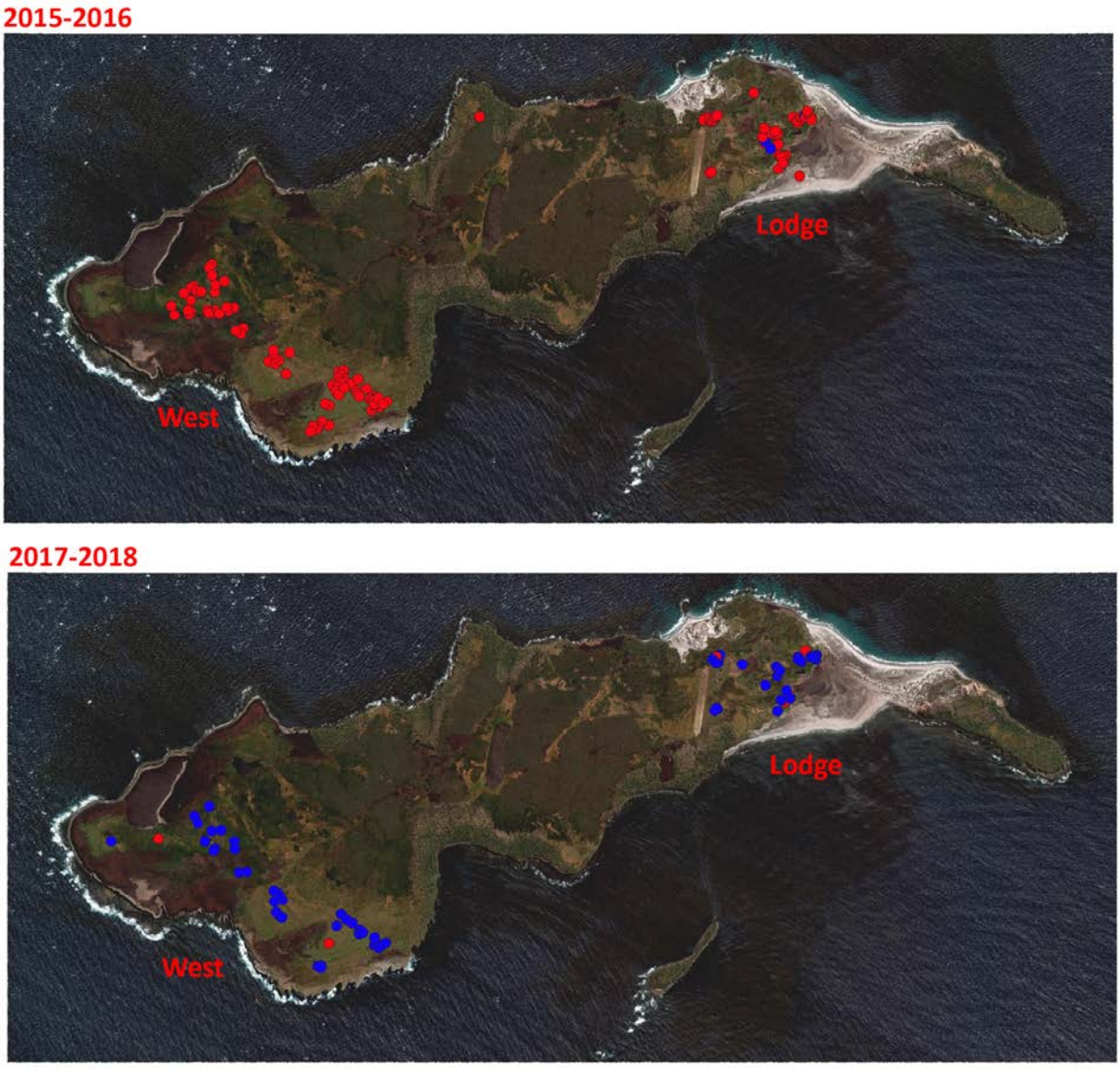

Figure 1 - Map of the successful and unsuccessful nests of the best (2015-2016) and worst (2017-2018) season. Red dots: successful nests (i.e., nests that produced one or more fledglings). Blue dots: unsuccessful nests.

We avoided excessive disturbance of nesting pairs by checking nests once per week. Although a more frequent checking of the nests would have provided more accurate information about the duration of the nesting stages and the fate of the nesting attempts, it

would have also increased the risk of nest abandonment (Reinhardt 1997), something that we absolutely wanted to avoid, both on ethical ground, and to not introduce biases in the measures of breeding performance. The study required no handling or marking of adults or chicks, and was fully non invasive. Although in the first two seasons we used numbered flags to help locating nests, in following seasons we did not use flags anymore, because GPS positions were accurate enough to permit nest identification even without flags, which may attract predators. During each visit at the nest, we recorded the behavioural reaction of adults and chicks to the operator approach, and we took detailed notes on the vocal and visual displays, to monitor the impact of our visits on the skuas. We strictly followed professional guidelines for the study of wild birds (Fair et al. 2010).

From the census data, we calculated: number of nesting pairs; laying success (= percentage of pairs that laid one or more eggs); hatching success (= percentage of pairs that had one or more hatched chicks); fledging success (= percentage of pairs that had one or more fledged chicks); mean number of eggs, hatchlings, and fledglings per nesting pair.

We fit a convex hull to all GPS locations of all nests of each nest cluster (minimum bounding geometry algorithm, convex hull option, QGIS software, www.qgis.org), and we calculated the area of the convex hull (hectares). We summed the areas of all convex hulls to calculate the total nesting area and the nest density (number of nests/total area). We calculated a matrix of nest distances in QGIS, we extracted a sub-matrix for each nest cluster, and calculated nest distance statistics for each cluster using a custom script. Confidence intervals of percentages were calculated using the Wilson score method. To assess the strength of the relationship between the measures of success, we calculated the coefficient of determination (R^2) of the linear regression of fledging success *vs* laying success and hatching success, and its standard error and confidence interval (bootstrap, bias-corrected accelerated, 1000 replicates). R^2 is the proportion of the variance of the dependent variable explained by the linear relationship with the independent. All calculations were carried out in Stata (version 15, www.stata.com).

Results

Summary statistics of the skua breeding performance are presented in Table 1. Detailed tables of breeding measures are presented in Appendix I. There was a notable variation in the number of nesting pairs, from 75 pairs in 2017-2018 to 151 in 2018-2019 (Figure 2, a; Mean = 109.4, SD = 31.0, CV = 0.28). The most successful season was not the one with the maximum number of nesting pairs (2015-2016: 126 pairs), and the season with most pairs showed a very low fledging success (2018-2019: 17.9). Laying success was less variable than other reproductive parameters, ranging from 87.4% in 2016-2017 to 100% in the most successful season (Figure 2, b; Mean = 92.6, SD = 6.7, CV = 0.07). Hatching success ranged from a maximum of 100% in the most successful season to a minimum of 34.7% in the worst one (2017-2018; Figure 2, c; Mean = 65.4, SD = 24.4, CV = 0.37). Hatching success was five times more variable than laying success, and was equal or below 75% in all seasons except the most successful one. Fledging success ranged from 92.9% in the most successful season

to 9.3% in the worst one (Figure2, d; Mean = 33.4, SD = 34.7, CV = 1.04). Fledging success was three times more variable than hatching success, and was equal or below 35% in all seasons except the most successful one. All measures of success were greater in 2015-2016 *vs* the pooled success of the four following seasons, and 95% confidence intervals were never overlapped (Table 2).

Breeding season	Nesting pairs	Laying success	Hatching success	Fledging success	Total fledglings	Mean fledglings	Nest density
2015-2016	126	100.00	100.00	92.86	157	1.25	3.80
2016-2017	111	87.39	66.67	35.14	44	0.40	3.62
2017-2018	75	90.67	34.67	9.33	7	0.09	3.10
2018-2019	151	99.34	73.51	17.88	30	0.20	4.68
2019-2020	84	85.71	52.38	11.90	10	0.12	5.63

Table 1 - Summary statistics of Sea Lion Island skua breeding performance. Nesting pairs: total number of pairs that attempted nesting. Laying success: percentage of nesting pairs that laid one or more eggs. Hatching success: percentage of nesting pairs that had one or more hatched chicks. Fledging success: percentage of nesting pairs that had one or more fledged chicks. Total fledglings: total number of fledged chicks at the end of the season. Mean fledglings: mean number of fledged chicks per nesting pair. Nest density: number of nests per hectare (see Methods for area calculation).

Laying success				
Season	**Pairs**	**With eggs**	**Success**	**95% CI**
2015-2016	126	126	100.00	97.04-100.00
Other seasons	421	387	91.92	88.93-94.16

Hatching success				
Season	**Pairs**	**With hatchlings**	**Success**	**95% CI**
2015-2016	126	126	100.00	97.04-100.00
Other seasons	421	255	60.57	55.83-65.12

Fledging success				
Season	**Pairs**	**With fledglings**	**Success**	**95% CI**
2015-2016	126	117	92.86	86.98-96.20
Other seasons	421	83	19.71	16.20-23.78

Table 2 - Comparison of success measures of 2015-2016 *vs* the pooled following seasons. Pairs: total number of pairs; With eggs: pairs with one or more eggs; With hatchlings: pairs with hatched chicks; With fledglings: pairs with fledged chicks; measures of success as in Table 1; 95% CI: 95 % confidence interval (Wilson score).

The number of fledged chicks dropped from 157 in 2015-2016 to 7 in 2017-2018 (a 95.5% reduction), and remained equal or below 30 chicks in the two following seasons. The mean number of fledglings per nesting pair dropped from 1.25 in 2015-2016 to 0.09 in 2017-2018 (Mean = 0.41, SD = 0.48, CV = 1.17). The average number of fledglings per nesting pair of the last four breeding seasons was 0.20.

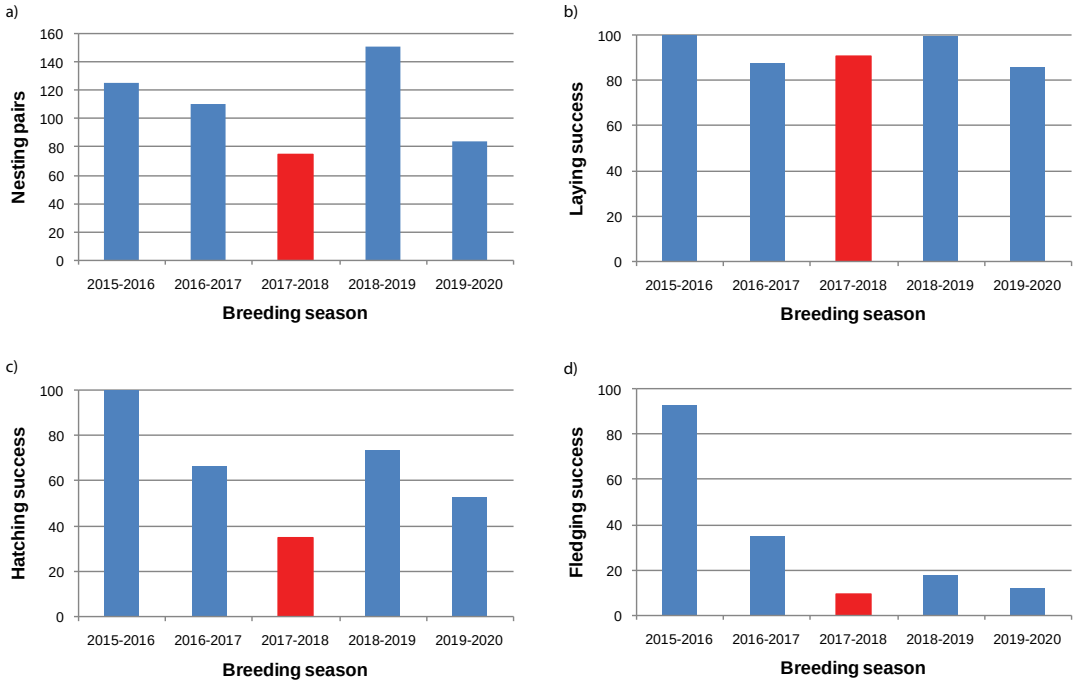

Figure 2 - Variation in measures of skua breeding performance. a) Number of pairs attempting to nest. b) Laying success (= percentage of pairs that laid one or more eggs). c) Hatching success (= percentage of pairs that had one or more hatched chicks). d) Fledging success (= percentage of pairs that had or more fledged chicks). Red: the worst breeding season, 2017-2018.

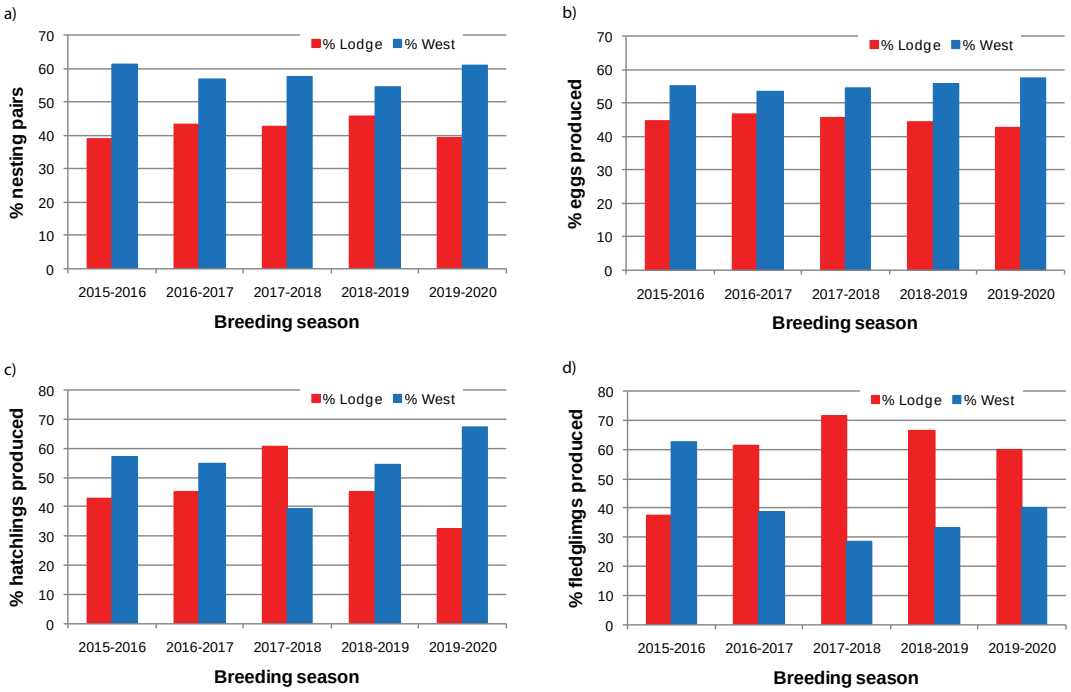

Figure 3 - Breeding performance of the Lodge and West zones. a) Percentage of pairs attempting to nest. b) Percentage of eggs produced. c) Percentage of hatchlings produced. d) Percentage of fledglings produced. Red bars: Lodge, blue bars: West.

Laying success was a poor predictor of fledging success both for the five seasons pooled (R^2 = 0.0877, SE = 0.0200, 95% CI = 0.0464-0.1290) and for each season (Table 3). Hatching success was a better predictor of fledging success than laying success, but the proportion of variance explained was anyway very low (R^2 = 0.3840, SE = 0.0365, 95% CI = 0.3198-0.4567; Table 3). Considering each season, hatching success was a decent predictor of fledging success in the best season, 2015-2016 (R^2 = 0.7152), but was a poor predictor of it in the other four (R^2 < 0.25 in all cases; Table 3).

Season	Success	R^2	SE	95%CI
2015-2016	Laying	0.4498	0.0744	0.3113-0.5830
	Hatching	0.7152	0.0552	0.6035-0.8001
2016-2017	Laying	0.1110	0.0427	0.0258-0.1866
	Hatching	0.2452	0.0748	0.1423-0.4059
2017-2018	Laying	0.1131	0.0644	0.0214-0.2475
	Hatching	0.2323	0.1070	0.0877-0.4787
2018-2019	Laying	0.0281	0.0196	0.0004-0.0657
	Hatching	0.1668	0.0534	0.0738-0.2813
2019-2020	Laying	0.0001	0.0046	0.0000-0.0004
	Hatching	0.0737	0.0372	0.0348-0.1680

Table 3 - Relationships of fledging success *vs* laying and hatching success. R^2: coefficient of determination; SE: standard error of R^2; 95% CI: 95% confidence interval of R^2. See Methods for calculation details.

Although the decrease in breeding success affected both the Lodge and the West zone, it was greater in the West. The West always had more than 50% of the nesting pairs (Figure 3, a), produced always more than 50% of the eggs (Figure 3, b), and almost always more than 50% of the hatchlings (except in the worst season, 2017-2018; Figure 3, c), but fledglings production showed a notable variation (Figure 3, d). In 2015-2016 the West contributed the most of the fledged chicks (62.4%), while in the four last seasons the majority of fledglings was produced in the Lodge zone (mean = 64.9%), and in the worst season the West contributed only 28.6% of the fledglings. Therefore, the difference in the two zones was mostly due to a greater increase in the post-hatching mortality in the West. In 2018-2019 the West produced 54.7% of the hatchlings, but only 33.3% of the fledglings. Maps of the nest of the West are presented in Figure 4, and of the nests of the Lodge zone in Figure 5.

The mean distance between nests within each nest cluster was lower in the Lodge zone (44.4 m to 79.2 m, mean = 59.4 m), than in the West zone (124.8 m to 208.0 m, mean = 166.6 m) during all seasons. The ratio of mean nest distance between the two zones ranged from 0.26 to 0.41 (Mean = 0.36). While the nest distance of the Lodge zone remained quite similar in consecutive seasons, the West distance showed a decrease (Figure 6). We present statistics of nest distance in Appendix II.

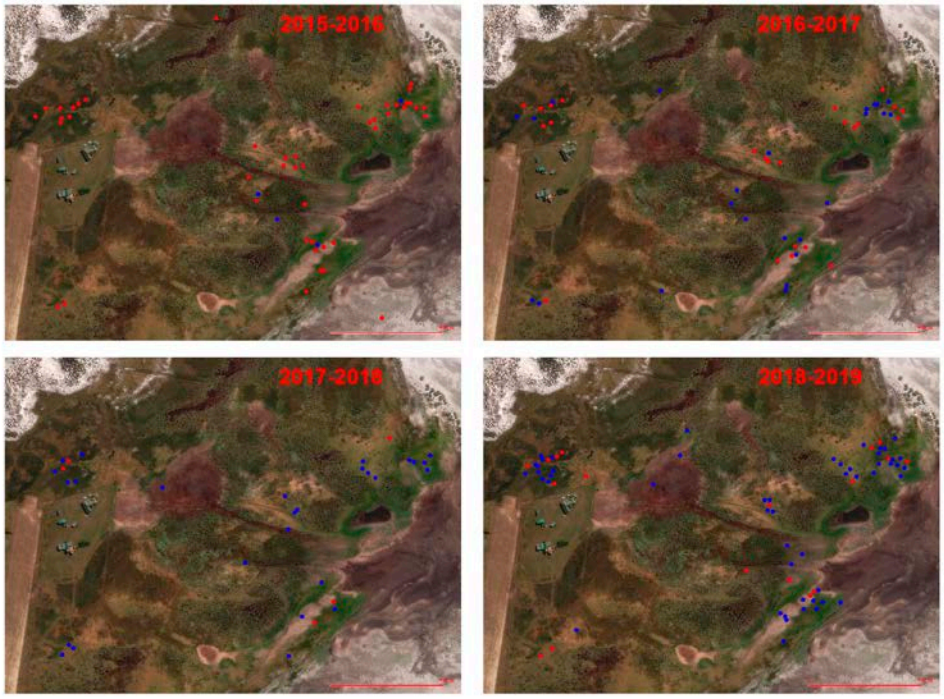

Figure 4 - Map of the nests of the Lodge zone, 2015 to 2019. Red dots: successful nests (i.e., nests that produced one or more fledglings). Blue dots: unsuccessful nests.

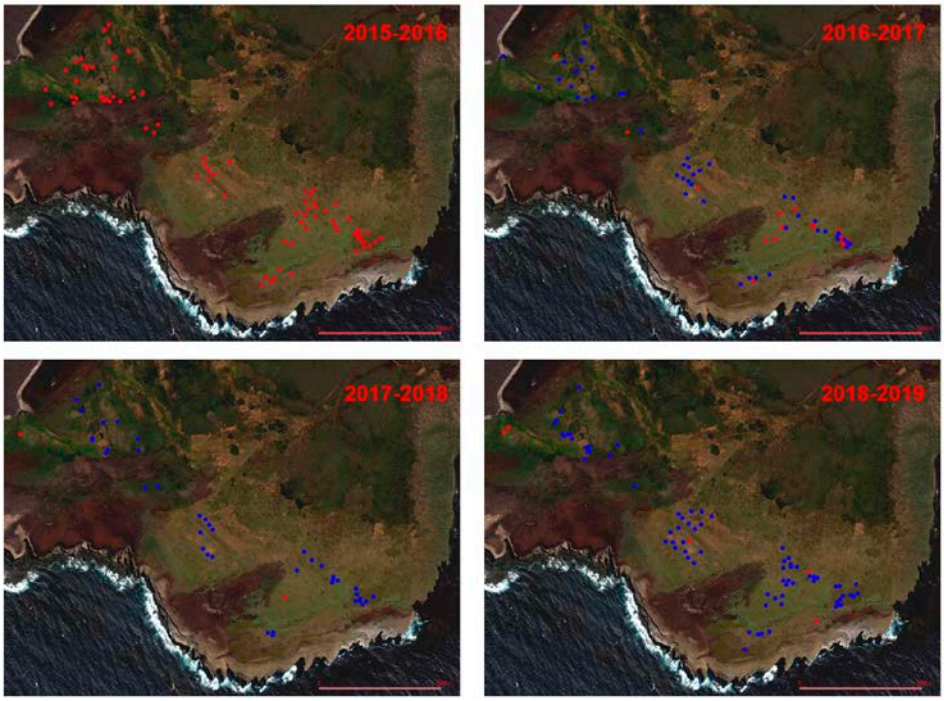

Figure 5 - Map of the nests of the West zone, 2015 to 2019. Red dots: successful nests (i.e., nests that produced one or more fledglings). Blue dots: unsuccessful nests.

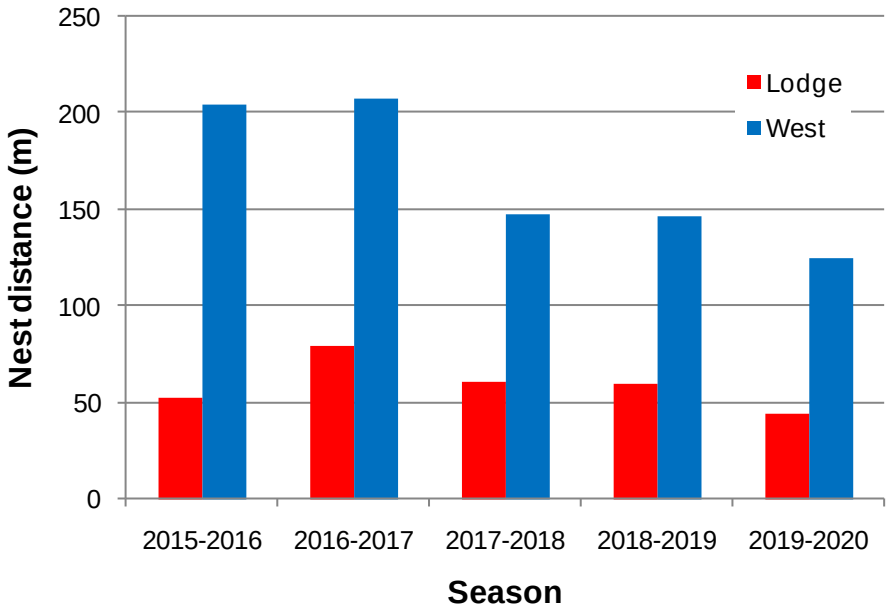

Figure 6 - Nest distances of the Lodge and West zones. See Methods for distance calculation procedure. Red bars: Lodge, blue bars: West.

The most successful season of the five for which we have full data (Lodge and West) was the first one of the series. To check if it was an exceptional season, we compared the Lodge data of the 2015-2016 season with the previous season. In the Lodge zone in 2014-2015 we had 41 nesting pairs (16.33% less than the following season). Laying success was 100%, hatching success 90.24%, and fledging success 85.37%. Total number of fledglings produced was 41, 30.51% less than the following season, and mean number of fledglings per nesting pair was 1. All together, although the reproductive success in 2014-2015 was lower than during the most successful season, the difference was much smaller than the reduction observed during the last four seasons.

Discussion

Our results clearly show that after a very good breeding season (2015-2016) the Sea Lion Island skua had a string of four seasons with poor or very poor breeding performance. The comparison of the Lodge data between the 2014-2015 season and the 2015-2016 season showed that the latter was in fact a very successful season, but was not exceptional. Although the end result of the four poor seasons was the same, i.e., a small or very small number of chicks that survived to fledging, the reduction in breeding performance acted at different stages of the nesting process during the different seasons. Fledging success was more variable between seasons than hatching success, which was in turn much more variable than laying success, which showed a low variability. In 2017-2018, the worst breeding season, there was a smaller number of pairs attempting nesting. Although in that season the laying success was normal, the hatching success was very low, almost one third of the most successful season, showing that main reason of the failure was egg loss and nest abandonment before hatching

of chicks. On the contrary, in 2018-2019 season the number of pairs attempting nesting was the maximum observed in the five seasons, the laying success was almost 100%, the hatching success was the highest of the last four seasons, but the fledging success was anyway low, showing that the main reason of the failure was post-hatching mortality of chicks (mean number of hatched chicks per pair = 0.92, mean number of fledged chicks per pair = 0.20).

Laying success was a poor predictor of fledging success, both overall and for each season. Hatching success was a better predictor of fledging success than laying success, but was a decent predictor of it only during the most successful season. During the last four seasons, variance in hatching success explained a small or very small proportion of variance in fledging success. Therefore, at least at Sea Lion Island, measures of success obtained before fledging are poor proxies of reproductive success. From a practical point of view, it is of paramount importance to get better estimates of true reproductive success by carrying out counts of chicks near to fledging.

The reduction in the breeding success affected both the Lodge and the West, but the decrease was stronger in the latter. The West, which at the beginning of our study was contributing to the population the majority of fledglings, is now producing fewer fledglings than the Lodge. Therefore, the drivers of the reduction in breeding success have acted differently in the two zones. It is interesting to note that after the dramatic failure of the 2017-2018 season, the West showed some slight signs of recovery, with an increase in the percentage of fledglings produced compared to the Lodge, although this conclusion is obviously tentative, due the very small total number of chicks.

On a practical ground, one of the most interesting results of our study is the great variation of success during the different stages of the nesting and the different seasons. Short term studies, based on one or two seasons (i.e., Lamey 1995) can produce strongly biased estimates of breeding success. Moreover, if just one or a few censuses are carried out, there is a big risk to overestimate success by missing mortality at later stages of nesting. We suggest that at least three censuses should be carried out, one around mid December to estimate nesting pairs, one around mid January to estimate hatching success, and one toward the end of the breeding season (end of February) to get a good estimate of fledging success, which is the measure of greatest interest from a demographic point of view.

The breeding success of skuas of the Southern Hemisphere was reviewed by Reinhardt (1977). The seasonal variability of breeding success was a common aspect of all species, and was in part related to a latitude gradient, but the different species and subspecies showed a different pattern. The South Polar skua (*Catharacta maccormicki*) showed a notable variation of fledging success between seasons, but the overall success was rather low, and during some seasons the breeding performance was as poor as the one observed at Sea Lion Island in bad seasons. On the contrary, the Brown skua (*Catharacta skua lonnbergi*) showed a smaller variation of success, and a greater overall success, similar to best performance observed at Sea Lion Island. Mixed pairs of South Polar and Brown skua showed an intermediate pattern, although in this case samples were very small. The comparison with the Brown skua is probably the most relevant, because of the close relationship and similarity of breeding biology with the Falklands skua.

Skua reproductive success can be affected by many different factors, one of which is human disturbance (Reinhardt 1997). This can be ruled out for Sea Lion Island skuas,

because there was no increase of human presence on the island during the years of the study, the frequency of nest monitoring was low, and the West, that is the least disturbed of the two breeding zones, showed the greatest reduction in reproductive success. Skua breeding performance is obviously related to changes in availability of food resources (Reinhardt et al. 2000). The skuas of the Lodge zone depend mostly on gentoo penguin eggs and chicks, and their nesting areas are located on vantage points around the gentoos nesting colonies. The skuas in the West zone have a more variable diet. Pairs nesting close to the Sheffield Memorial should prey mostly on rockhopper penguins, while observation of food remains around nests of the Beaver Pond area shows that those pairs feed mostly on Magellanic penguins. Food remains show that pairs that nest close to the main king cormorant colony prey on that species eggs and chicks. These pairs showed a total failure in recent years (8 fledglings produced in 2015-2016, 0 in the last three seasons) that is probably related to the complete failure of breeding of king cormorants, which is currently lacking an explanation by itself.

It has been suggested that striated caracara (*Phalcoboenus australis*) can regulate Falkland skua populations by predation on chicks, and that an increase in caracara number and density was the main determinant of the skua decrease in the biggest skua colony in the Falkland Islands, New Island (Catry *et al.* 2011). Contrary to what happened at New Island, the reduction in skua reproductive success observed at Sea Lion Island was not simply related to a change in the size of the caracara population, because the number of resident caracaras (nesting pairs/trios and non nesting territorial adults) has been almost steady in recent years (ESRG unpublished data). Moreover, the density of resident caracaras at New Island is apparently much higher than the Sea Lion Island density (Catry *et al.* 2008; Giselle Hazell pers. comm.). The reduction of skua success observed at Sea Lion Island is more likely related to the joint variation of food availability and predation pressure. When food resources are scarce, nesting skuas may leave eggs or chicks unprotected and, therefore, it can be easier for caracaras to predate on them, although we never directly observed any event of caracara predation of skua nests, notwithstanding the large field work effort. Predation rates can be affected by the nest spacing, because adults of clustered nests can be able to better defend the area by mobbing predators. The West, i.e. the area that suffered the greatest reduction in reproductive success, always had more spaced nests than the Lodge, while showing a gradual reduction of the nest distances along the seasons.

A specific situation may have happened in the skua nesting cluster of the grass plains at the west end of the island. In 2015-2016 this cluster had 20 skua pairs that produced 27 fledglings (mean = 1.35 fledglings per pair), while during the last season the 13 pairs that bred there failed to produce any fledgling. This total failure can be related to the establishment in the area of a caracara trio that showed a persistent presence around skua nests. Caracara trios may be more effective in predating on skua nests because two of the caracaras can attack the same nest and dislodge the attending skua.

The breeding success of skua in the Falkland Islands at large is mostly unknown. An intensive two year study carried out at New Island (Lamey 1995) reported an average number of fledged chicks per pair of 0.84, higher than Sea Lion Island average of the last four breeding seasons, but lower than Sea Lion Island maximum. The Lamey (1995) estimates of fledging success were based on survival of chicks to 16 days of age, which is definitely not

the time to fledging and, therefore, was a relaxed measure of fledging success. The more recent study by Catry *et al.* (2011) reported for New Island an average of chicks fledged per pair ranging from 0 to 0.80, but these estimates were based on a rather small number of nests per season (10 to 43). During a recent visit to New Island we observed a great number of adult pairs showing territorial behaviour but a very small number of active nests with either eggs or chicks (Appendix III). The poor breeding performance of Falkland skua at New Island was confirmed by Paulo Catry (pers. comm.).

The only other place of the Falklands where regular skua counts were carried out is Steeple Jason Island (data and information provided by Sarah Crofts, Conservation Officer of Falklands Conservation). At Steeple, a single annual count was carried out around mid January during the last four breeding seasons (2016-2017 to 2019-2020), and productivity was estimated as the average content of the nests (eggs + chicks). To obtain comparable estimates for Sea Lion Island, we calculated productivity for the last four breeding seasons using the weekly census closer to mid January. Productivity was higher at Steeple than at Sea Lion during all breeding seasons (Steeple: 1.31 to 1.46, Sea Lion: 0.51 to 1.23), although the difference was not big during the last two seasons (2018-2019: 1.31 *vs* 1.23, 2019-2020: 1.39 *vs* 1.13). All together, Steeple skuas showed a better breeding performance than Sea Lion skuas, although at least at Sea Lion productivity calculated around mid January is not representative of true reproductive success.

The information about skuas in other places of the Falkland Islands is scarce. Anecdotal information suggests that the decrease in skua breeding performance may have happened also in other places (Carcass Island, Robert McGill, pers. comm.; Saunders Island, David Poole-Evans, pers. comm.). In January 2016 we carried out brief skua surveys in four islands: Bleaker, Carcass, Pebble (including Pebble Islet), and Saunders. Although the surveys were partial (i.e., not the whole extension of the islands was searched), we visited the places that were locally known to be skua breeding ground. The goal of our surveys was to record skua vocalization for a communication study, so our data is definitely biased. On the other end, we found in all four islands more breeding skuas than we expected, and most territorial pairs observed actually had an active nest with eggs and/or chicks (Appendix IV). At Bleaker Island, in the last two breeding seasons the skuas nesting around the settlement and the main king cormorant colony showed a reduced reproductive success compared to three or four years ago, with most pairs raising zero or one chick to fledging, while pairs with two fledglings were previously common (Nick Rendell, pers. comm.). All together, the current status of Falkland skua is highly uncertain. The low reproductive success observed at New Island and Sea Lion Island is in contrast with the apparently high success of Steeple Jason Island. Which of the two situations is prevalent in the Falklands is currently unknown, and the matter deserves further investigation.

Conclusion and perspectives

The Falklands skua is a very important component of the biodiversity of the islands, but has been rarely studied. The species is an important component of the food chain of the South

Atlantic ocean, and may play an important role in regulation of the demography of penguins, and seabirds at large. The low reproductive success observed in recent seasons at Sea Lion Island deserves further investigation. In particular, we would like to study the joint variation of skuas, their potential preys (penguins and cormorants) and their potential predator, the striated caracara, to test the hypothesis of an increased caracara predation rate when food resources are scarce, and adult skuas may be less able to defend nests, eggs and chicks. The first step toward this goal would be to monitor nest attendance using either direct observation, video cameras, or temperature loggers. Moreover, we are currently looking for funding to carry out surveys of breeding skuas in other places of the Falklands. Based on our Sea Lion Island experience, in each place at least three full censuses should be carried out, one in early December to estimate number of nesting pairs, one around mid January to estimate hatching success, and one in late February to obtain a good estimate of fledging success. Ideally, a whole island census should be carried out to assess the status of the species, which has such an important role in the food chain of the South Atlantic ocean.

Acknowledgments

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Appendix I - Breeding performance of Sea Lion Island skua

In each table we present the numbers for the Lodge area, the West area and the whole island (Total), and the percentages for the Lodge area and the West area, for each breeding season, and for all the five breeding seasons together. SD = standard deviation, CV = coefficient of variation (= SD/Mean).

Number of nesting pairs

Year	Lodge	West	Total	% Lodge	% West
2015-2016	49	77	126	38.89	61.11
2016-2017	48	63	111	43.24	56.76
2017-2018	32	43	75	42.67	57.33
2018-2019	69	82	151	45.70	54.30
2019-2020	33	51	84	39.29	60.71
Total	231	316	547	42.23	57.77
Mean	46.20	63.20	109.40		
SD	15.06	16.59	30.97		
CV	0.33	0.26	0.28		

Number of pairs with eggs

Year	Lodge	West	Total	% Lodge	% West
2015-2016	49	77	126	38.89	61.11
2016-2017	43	54	97	44.33	55.67
2017-2018	29	39	68	42.65	57.35
2018-2019	68	82	150	45.33	54.67
2019-2020	28	44	72	38.89	61.11
Total	217	296	513	42.30	57.70
Mean	43.40	59.20	102.60		
SD	16.44	19.38	35.21		
CV	0.38	0.33	0.34		

Number of eggs produced

Year	Lodge	West	Total	% Lodge	% West
2015-2016	85	105	190	44.74	55.26
2016-2017	74	85	159	46.54	53.46
2017-2018	42	50	92	45.65	54.35
2018-2019	110	139	249	44.18	55.82
2019-2020	40	54	94	42.55	57.45
Total	351	433	784	44.77	55.23
Mean	70.20	86.60	156.80		
SD	29.69	37.04	66.62		
CV	0.42	0.43	0.42		

Number of pairs with hatched chicks

Year	Lodge	West	Total	% Lodge	% West
2015-2016	49	77	126	38.89	61.11
2016-2017	33	41	74	44.59	55.41
2017-2018	15	11	26	57.69	42.31
2018-2019	46	65	111	41.44	58.56
2019-2020	15	29	44	34.09	65.91
Total	158	223	381	41.47	58.53
Mean	31.60	44.60	76.20		
SD	16.30	26.70	42.58		
CV	0.52	0.60	0.56		

Number of hatched chicks

Year	Lodge	West	Total	% Lodge	% West
2015-2016	75	100	175	42.86	57.14
2016-2017	43	52	95	45.26	54.74
2017-2018	20	13	33	60.61	39.39
2018-2019	63	76	139	45.32	54.68
2019-2020	16	33	49	32.65	67.35
Total	217	274	491	44.20	55.80
Mean	43.40	54.80	98.20		
SD	25.89	34.36	59.68		
CV	0.60	0.63	0.61		

Number of pairs with fledged chicks

Year	Lodge	West	Total	% Lodge	% West
2015-2016	45	72	117	38.46	61.54
2016-2017	24	15	39	61.54	38.46
2017-2018	5	2	7	71.43	28.57
2018-2019	19	8	27	70.37	29.63
2019-2020	6	4	10	60.00	40.00
Total	99	101	200	49.50	50.50
Mean	19.80	20.20	40.00		
SD	16.30	29.38	44.97		
CV	0.82	1.45	1.12		

Number of fledged chicks

Year	Lodge	West	Total	% Lodge	% West
2015-2016	59	98	157	37.58	62.42
2016-2017	27	17	44	61.36	38.64
2017-2018	5	2	7	71.43	28.57
2018-2019	20	10	30	66.67	33.33
2019-2020	6	4	10	60.00	40.00
Total	117	131	248	47.18	52.82
Mean	23.40	26.20	49.60		
SD	21.98	40.56	61.91		
CV	0.94	1.55	1.25		

Appendix II - Nest distance statistic

All distances are in meters. West-Lodge: difference of distance; Lodge/West: ratio of distance; Nests = number of nests; Distances = number of distances between nest pairs; SD = standard deviation; CV = coefficient of variation (SD/Mean).

Summary of nest distance statistic of Lodge and West area

Season	Lodge	West	West-Lodge	Lodge/West
2015-2016	52.79	205.02	152.22	0.26
2016-2017	79.19	207.95	128.76	0.38
2017-2018	61.33	148.10	86.77	0.41
2018-2019	59.45	147.00	87.55	0.40
2019-2020	44.37	124.78	80.41	0.36
Mean	59.43	166.57	107.14	0.36

Distance statistics of the 2015-2016 breeding season

Zone	Area	Nests	Distances	Mean	SD	CV	Min	Max
LODGE	CAMOMILLA	9	36	52.40	30.79	0.59	7.06	119.99
LODGE	LODGE	9	36	47.19	24.65	0.52	10.44	113.60
LODGE	METEO	2	1	15.91	0.00	0.00	15.91	15.91
LODGE	PRATI_POZZA	16	120	61.37	33.95	0.55	7.54	146.12
LODGE	STRADA_LODGE	11	55	87.10	38.88	0.45	14.58	164.87
WEST	PISTA_VECCHIA	18	153	334.89	219.88	0.66	13.79	755.81
WEST	PRATI_CORMO	6	15	76.24	37.20	0.49	24.67	155.55
WEST	PRATI_OVEST	20	190	205.81	104.46	0.51	15.39	490.01
WEST	PRATI_SHEFFIELD	33	528	203.13	116.77	0.57	16.07	482.85

Distance statistics of the 2016-2017 breeding season

Zone	Area	Nests	Distances	Mean	SD	CV	Min	Max
LODGE	CAMOMILLA	11	55	77.11	45.21	0.59	9.64	208.10
LODGE	LODGE	10	45	90.66	88.11	0.97	7.99	312.42
LODGE	METEO	3	3	20.55	7.67	0.37	15.92	29.40
LODGE	PRATI_POZZA	15	105	59.87	32.55	0.54	6.87	147.05
LODGE	STRADA_LODGE	6	15	52.02	36.42	0.70	8.40	111.05
LODGE	VADO	3	3	174.92	111.90	0.64	45.71	240.28
WEST	PISTA_VECCHIA	13	78	98.31	46.40	0.47	23.18	227.89
WEST	POZZA_BEAVER	2	1	446.09	0.00	0.00	446.09	446.09
WEST	PRATI_CORMO	5	10	68.19	40.17	0.59	20.76	150.84
WEST	PRATI_OVEST	17	136	244.15	131.86	0.54	17.53	587.99
WEST	PRATI_SHEFFIELD	26	325	183.00	116.88	0.64	9.63	419.81

Distance statistics of the 2017-2018 breeding season

Zone	Area	Nests	Distances	Mean	SD	CV	Min	Max
LODGE	CAMOMILLA	6	15	82.47	43.74	0.53	16.54	173.19
LODGE	LODGE	8	28	81.81	77.12	0.94	11.12	235.07
LODGE	METEO	3	3	21.66	8.57	0.40	11.87	27.81
LODGE	PRATI_POZZA	10	45	79.96	43.74	0.55	10.71	149.14
LODGE	STRADA_LODGE	4	6	40.74	20.09	0.49	8.32	71.23
WEST	PISTA_VECCHIA	8	28	104.74	55.55	0.53	25.87	213.83
WEST	PRATI_CORMO	3	3	22.57	7.65	0.34	13.75	27.33
WEST	PRATI_OVEST	14	91	279.32	157.63	0.56	9.70	736.79
WEST	PRATI_SHEFFIELD	17	136	185.79	117.79	0.63	9.51	442.33

Distance statistics of the 2018-2019 breeding season

Zone	Area	Nests	Distances	Mean	SD	CV	Min	Max
EXTRA	5S_6S	2	1	28.01	0.00	0.00	28.01	28.01
LODGE	CAMOMILLA	13	78	59.63	34.68	0.58	7.76	148.50
LODGE	GENTOOS_LODGE	3	3	92.85	41.24	0.44	56.03	137.42
LODGE	LODGE	17	136	46.09	25.07	0.54	5.72	130.51
LODGE	METEO	3	3	63.39	33.16	0.52	28.91	95.04
LODGE	PRATI_POZZA	23	253	66.28	35.37	0.53	9.81	158.66
LODGE	STRADA_LODGE	5	10	17.90	7.11	0.40	11.02	30.63
LODGE	VADO	5	10	70.00	34.18	0.49	31.44	125.92
WEST	PISTA_VECCHIA	19	171	129.66	59.32	0.46	26.70	262.85
WEST	POZZA_BEAVER	4	6	100.67	36.85	0.37	42.74	145.53
WEST	PRATI_CORMO	5	10	77.92	40.58	0.52	17.18	151.83
WEST	PRATI_OVEST	19	171	224.64	146.91	0.65	9.69	707.21
WEST	PRATI_SHEFFIELD	35	595	202.09	110.30	0.55	7.45	464.51

Distance statistics of the 2019-2020 breeding season

Zone	Area	Nests	Distances	Mean	SD	CV	Min	Max
LODGE	CAMOMILLA	6	15	30.29	15.54	0.51	7.46	55.54
LODGE	LODGE	9	36	54.85	28.63	0.52	10.06	134.93
LODGE	METEO	7	21	34.47	13.44	0.39	13.25	56.88
LODGE	PRATI_POZZA	7	21	65.09	34.66	0.53	14.26	112.12
LODGE	STRADA_LODGE	3	3	37.15	14.28	0.38	26.25	53.32
WEST	PISTA_VECCHIA	10	45	127.25	58.09	0.46	12.58	236.89
WEST	POZZA_BEAVER	4	6	69.85	32.66	0.47	31.77	111.91
WEST	PRATI_CORMO	3	3	50.77	20.68	0.41	37.95	74.62
WEST	PRATI_OVEST	13	78	188.08	100.91	0.54	14.69	375.11
WEST	PRATI_SHEFFIELD	21	210	187.94	114.77	0.61	22.04	382.73

Appendix III - Summary table of the ESRG 2020 survey of New Island skua

Total pairs: pairs showing territorial behaviour; % pairs with nest: percentage of pairs having a nest; % successful pairs: percentage of pairs having eggs or chicks; % pairs with chicks: percentage of pairs having chicks; Total nests: total number of nests, abandoned or not; % active nests: percentage of nests having eggs of chicks; % nests with eggs: percentage of nests having eggs; % nests with chicks: percentage of nests having chicks; % with two chicks: percentage of nests having two chicks on number of nests having chicks. We excluded from the table the following areas that were searched: North Hut, where we found only non-territorial skuas; Sabina Point, which was only partially checked and where we found just one territorial pair with no nest; South Pond, that was intensively checked but where we found just one territorial pair with no nest.

Area	Total pairs	% pairs with nest	% successful pairs	% pairs with chicks	Total nests	% active nests	% nests with eggs	% nests with chicks	% with two chicks
Bold Point	2	100.00	100.00	100.00	2	100.00	0.00	100.00	50.00
Bull Point	20	45.00	15.00	5.00	9	33.33	22.22	11.11	0.00
Eddy Point	14	42.86	0.00	0.00	6	0.00	0.00	0.00	0.00
Fur seal col.	1	100.00	100.00	100.00	1	100.00	0.00	100.00	0.00
North Bluff	3	66.67	66.67	66.67	2	100.00	0.00	100.00	100.00
North Harbour	23	47.83	34.78	26.09	11	72.73	18.18	54.55	0.00
Rookery Hill	8	87.50	75.00	62.50	7	85.71	14.29	71.43	0.00
Settl. Rookery	4	25.00	25.00	25.00	1	100.00	0.00	100.00	100.00
Ship Harbour	6	33.33	33.33	16.67	2	100.00	50.00	50.00	0.00
Skua Valley	17	23.53	5.88	0.00	4	25.00	25.00	0.00	0.00
Airstrip	16	37.50	18.75	18.75	6	50.00	0.00	50.00	0.00
Whaling station	20	70.00	60.00	45.00	14	85.71	21.43	64.29	33.33
Total	136	47.79	30.15	22.79	65	63.08	15.38	47.69	22.58

Appendix IV - Summary table and maps of the ESRG 2016-2017 survey of Bleaker, Carcass, Pebble and Saunders islands

For each island we present: the number of nests; the percentage of nests with one or more eggs; the percentage of nests with one or more chicks; the percentage of nests with eggs, chicks or both; the percentage of failed nests (no eggs or chicks, but territorial adult(s) in attendance); the percentage of nests with two chicks on the number of nests with chicks; the total number of chicks; the mean number of chicks per nest. On Bleaker Island we searched only the part of the island from the Settlement to the North Point; on Carcass we did not search the north east coast; on Pebble Island we moved by car along tracks, and we searched by foot only the areas where we saw skuas; on Saunders Island we searched only the area from the Neck to Elephant Point.

Island	Nests	With eggs	With chicks	With eggs or chicks	Failed nests	Two chicks	Total chicks	Mean chicks
Bleaker	56	1.79	96.43	98.21	1.79	16.67	63	1.13
Carcass	29	10.34	82.76	93.10	6.90	50.00	36	1.24
Pebble	23	8.70	86.96	95.65	4.35	10.00	22	0.96
Saunders	17	0.00	94.12	94.12	5.88	25.00	20	1.18
Total	125	4.80	91.20	96.00	4.00	23.68	141	1.13

Maps of the nests found in the different islands


Carcass Is.


Carcass Is. - North-west point


Saunders Is.


Saunders Is. - Elephant point


Pebble Island