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TRENDS IN POPULATION SIZE AND BREEDING SUCCESS AT COLONIES OF MACARONI AND ROCKHOPPER PENGUINS, MARION ISLAND, 1979/80–1995/96

J. Cooper
Percy FitzPatrick Institute of African Ornithology
University of Cape Town, Rondebosch
7700, South Africa

A.C. Wolfaardt and R.J.M. Crawford
Sea Fisheries Research Institute
Private Bag X2, Rogge Bay
8012, South Africa

Abstract

At sub-Antarctic Marion Island, annual breeding success of macaroni (*Eudyptes chrysolophus*) between 1979/80 and 1995/96 and rockhopper penguins (*E. chrysocome*) between 1985/86 and 1995/96 was measured. For macaroni penguins, averages of 0.48 eggs and 0.35 chicks were hatched and fledged respectively for each clutch laid. Corresponding averages for rockhopper penguins were 0.68 eggs and 0.48 respectively. The largest of the three macaroni penguin colonies investigated decreased in size over the study period, while the other two remained stable. The only significant relationship between inter-season trends in the number of pairs breeding at the three colonies was a negative correlation between two adjacent colonies, which suggests inter-colony transfer. The larger two of the three rockhopper penguin colonies investigated decreased over the study period, while the other remained stable. Trends in the number of pairs breeding at the three rockhopper penguin colonies were all significantly correlated. The proportion of rockhopper penguins attempting to breed may have varied as a result of some environmental signal. Inter-season trends in breeding success of macaroni penguins were significantly correlated in all three inter-colony comparisons over the entire study period. Inter-season trends in breeding success and chick survival of rockhopper penguins were significantly correlated in only one of the three inter-colony comparisons. The greater coherence in the performance of macaroni penguin compared to rockhopper penguin colonies suggests that breeding success of macaroni penguins may be influenced by a wider-scale phenomenon than is applicable to rockhopper penguins. Trends in breeding success, hatching success and chick survival of macaroni penguins and rockhopper penguins were not significantly correlated to each other, even for nearby colonies. This suggests that factors influencing the reproductive performance of the two species are not the same.

Résumé

Mesure à l'île subantarctique Marion de la réussite annuelle de la reproduction des gorfous macaroni (*Eudyptes chrysolophus*) de 1979/80 à 1995/96 et des gorfous sauteurs (*E. chrysocome*) de 1985/86 à 1995/96. Chez les gorfous macaroni, pour chaque couvée, en moyenne 0,48 œufs ont éclos et 0,35 jeunes ont mué. Les moyennes correspondantes chez les gorfous sauteurs sont de 0,68 œufs éclos et de 0,48 jeunes ayant mué. Sur les trois colonies de gorfous macaroni étudiées, la plus grande a diminué de taille pendant la durée de la période d'étude alors que les deux autres sont restées stables. La seule relation importante entre les tendances inter-saisonnières du nombre de couples se reproduisant aux trois colonies est une corrélation négative entre deux colonies adjacentes, ce qui suggère un transfert d'une colonie à l'autre. Sur les trois colonies de gorfous sauteurs étudiées, les deux plus grandes ont diminué pendant la durée de la période d'étude, alors que la troisième est restée stable. Les tendances dans le nombre de couples se reproduisant aux trois colonies de gorfous sauteurs étaient toutes largement corrélées. Il est possible que la proportion de gorfous sauteurs ayant tenté de se reproduire ait varié en fonction de quelque facteur environnemental. Corrélation importante des tendances inter-saisonnières de la réussite de la reproduction des gorfous macaroni dans les comparaisons des trois colonies pendant toute la durée de la période d'étude. Corrélation importante dans une seule des trois comparaisons des

colonies des tendances inter-saisonnières de la réussite de la reproduction et de la survie des jeunes chez les gorfous sauteurs. La plus grande cohérence de la performance des colonies de gorfous macaroni par rapport à celle des colonies de gorfous sauteurs laisse entendre que la réussite de la reproduction des gorfous macaroni est susceptible d'être influencée par des phénomènes à plus grande échelle que ceux qui affectent les gorfous sauteurs. La corrélation des tendances de la réussite de la reproduction et de l'éclosion, et de la survie des jeunes chez les gorfous macaroni et les gorfous sauteurs était peu importante, même pour les colonies adjacentes. Ceci laisse entendre que les facteurs influençant la performance liée à la reproduction chez les deux espèces ne sont pas les mêmes.

Резюме

Была проведена оценка ежегодного репродуктивного успеха золотоволосых пингвинов (*Eudyptes chrysolophus*) за период с 1979/80 по 1995/96 г. и хохлатых пингвинов (*E. chrysocome*) за период с 1985/86 по 1995/96 г. на острове Марион. У золотоволосых пингвинов на каждое гнездо с яйцами в среднем вылупилось и оперилось соответственно 0,48 и 0,35 птенца. Соответствующие средние величины у хохлатых пингвинов - 0,68 и 0,48 птенца. На протяжении всего периода исследования численность самой крупной из трех изучавшихся колоний золотоволосых пингвинов уменьшилась, в то время как численность остальных колоний не изменилась. Единственная существенная закономерность в межсезонных тенденциях изменения количества размножающихся пар во всех колониях - это отрицательная корреляция между двумя соседними колониями, что говорит о возможных миграциях между колониями. За весь период исследования численность двух самых крупных из трех изучавшихся колоний хохлатых пингвинов уменьшилась, а численность третей колонии не изменилась. Тенденции изменения количества пар хохлатых пингвинов, размножающихся в трех колониях, характеризовались существенной степенью корреляции. Изменения количества хохлатых пингвинов, попытавшихся принять участие в размножении, могут быть связаны с изменениями в условиях окружающей среды. Была найдена существенная корреляция между межсезонными тенденциями изменения репродуктивного успеха золотоволосых пингвинов во всех трех колониях на протяжении всего периода исследования. Существенная корреляция была найдена между межсезонными закономерностями репродуктивного успеха и выживания хохлатых пингвинов только в одном из трех проведенных сравнений между колониями. Бóльшая степень когерентности у золотоволосых пингвинов по сравнению с хохлатыми пингвинами наводит на мысль о том, что на репродуктивный успех золотоволосых пингвинов влияет какое-нибудь более широкомасштабное явление, чем в случае хохлатых пингвинов. Не было обнаружено существенной корреляции между закономерностями репродуктивного успеха, успеха вылупления и выживания птенцов у золотоволосых и хохлатых пингвинов, даже в случае сравнения между соседними колониями. Это говорит о том, что на репродуктивный успех обоих видов влияют различные факторы.

Resumen

Se efectuaron estimaciones del éxito de reproducción anual de los pingüinos macaroni (*Eudyptes chrysolophus*) entre 1979/80 y 1995/96, y de los pingüinos de penacho amarillo (*E. chrysocome*) entre 1985/86 y 1995/96 en la estación subantártica de la isla Marion. Los pingüinos macaroni incubaron con éxito un promedio de 0.48 huevos por nidada y de éstas alcanzaron la etapa de emplumaje un promedio de 0.35 polluelos. Los promedios correspondientes al pingüino de penacho amarillo fueron 0.68 huevos y 0.48 polluelos respectivamente. De tres colonias de pingüinos macaroni estudiadas, la mayor disminuyó su tamaño durante el período de la prospección, en tanto que el tamaño de las otras dos permaneció estable. La única correlación significativa en las tendencias estacionales del número de parejas reproductoras en las tres colonias fue una correlación negativa entre dos colonias adyacentes, lo que indica una transferencia entre colonias. El tamaño de las dos colonias mayores de pingüinos de penacho amarillo estudiadas disminuyó durante el período de la prospección, mientras que el tamaño de la tercera colonia permaneció estable. Las correlaciones de las tendencias del número de parejas reproductoras en las tres colonias de pingüinos de penacho amarillo fueron

todas significativas. La proporción de pingüinos de penacho amarillo que intentaron reproducirse puede haber variado como consecuencia de un estímulo medioambiental. Las tendencias estacionales del éxito reproductor y supervivencia de polluelos del pingüino macaroni se correlacionaron significativamente en las comparaciones entre las tres colonias durante el período total de la prospección. Las tendencias estacionales del éxito reproductor y supervivencia de polluelos del pingüino de penacho amarillo se correlacionaron significativamente en sólo una de las comparaciones entre las tres colonias. La mayor coherencia en el comportamiento de las colonias de pingüino macaroni comparado con el de las colonias de pingüino de penacho amarillo indica que el éxito reproductor del pingüino macaroni puede ser afectado por fenómenos de mayor escala que los que afectan al pingüino de penacho amarillo. Las tendencias en el éxito reproductor, éxito de la incubación y supervivencia de los polluelos de los pingüinos macaroni y de penacho amarillo no se correlacionaron significativamente entre ellas, aún para colonias cercanas. Esto sugiere que los factores que afectan el éxito de la reproducción de las dos especies no son los mismos.

Keywords: breeding success, macaroni penguin, Marion Island, rockhopper penguin, CCAMLR

INTRODUCTION

The sub-Antarctic Prince Edward Islands, including Marion Island, support four species of penguin, including two *Eudyptes* species – the macaroni penguin (*E. chrysolophus*) and the rockhopper penguin (*E. chrysocome*). There are some 400 000 pairs of macaroni penguins and about 140 000 pairs of rockhopper penguins at Marion Island (Cooper and Brown, 1990). Trends in the size of the breeding population and the breeding success of these two species have been monitored at selected colonies at Marion Island, commencing in the 1979/80 summer season for macaroni penguins and the 1983/84 season for rockhopper penguins. Monitoring is continuing on an annual basis as a contribution to the CCAMLR Ecosystem Monitoring Program (CEMP). Macaroni penguins have been chosen as a key predator within CEMP (SC-CAMLR, 1995).

This paper summarises results to the end of the 1995/96 summer season and compares trends in breeding parameters at colonies, both within and between species. Based on the degree of coherence between colonies, we comment on the likely extent to which environmental factors influence the proportion of adults attempting to breed and breeding success. This information is relevant to the use of parameters for monitoring marine ecosystems using seabird populations, and may add to the design and assessment of appropriate protocols within CEMP (Croxall et al., 1988; SC-CAMLR, 1995).

METHODS

Three colonies were selected at Marion Island to study macaroni and rockhopper penguins. They were chosen for their ease of access, discreteness and relatively small size, which enabled accurate counts to be undertaken from their boundaries without causing excessive disturbance.

The colonies selected for macaroni penguins were at Van den Boogaard River, to the north of Macaroni Bay and at Archway Bay (Figure 1). From 1979/80 to 1982/83, each colony was visited twice, towards the start of the breeding season when parents were incubating, or towards the end when chicks were in creches. On the first visit the number of incubating adults was counted, on the second the number of chicks. From 1983/84 to 1995/96, each colony was visited three times, as before towards the start and end of breeding, but also soon after hatching, when the number of hatchlings was counted. The colonies selected for rockhopper penguins were at Van den Boogaard River, at Trypot Fault and at Trypot Hole (Figure 1). In 1983/84 and 1984/85, only the number of incubating adults at the start of the breeding season was recorded. From 1985/86 to 1995/96, numbers of incubating adults, hatchlings and chicks in creches were counted.

Based on information on breeding schedules summarised in Cooper and Brown (1990), the count of incubating macaroni penguins was conducted between 20 and 24 November, and of incubating rockhopper penguins as close as possible to 4 December. The count of chicks of both species soon after hatching was undertaken as close as possible to 4 January. Macaroni penguin chicks in creches were counted as close to 10 February as possible and rockhopper penguin chicks as close to 28 February as possible. There is as yet no precise information on interannual variation in the timing of the breeding schedules of these two species at Marion Island,

so the dates of counts were standardised. Elsewhere, their breeding schedule varies only slightly from year to year (Marchant and Higgins, 1990).

The number of incubating adults present on the first visit was assumed to represent the number of breeding pairs and hence the number of clutches laid. The number of chicks present at the second visit was taken to represent the number of eggs that hatched, and the number of chicks in creches on the third visit to represent the number of chicks that fledged.

In addition to the number of chicks fledged as a proportion of those eggs that hatched (chick survival) the mean numbers of eggs hatched and chicks fledged per clutch were calculated for each colony in each season. These three parameters were also calculated for each species for the three colonies combined. The three parameters, and the number of clutches laid, were used as indices of the reproductive performance at various stages of the breeding cycle. The relationship between breeding patterns at the various colonies was investigated using correlation analysis. Comparisons (between both species of penguin) were made for each of the four parameters listed above for all three possible inter-colony comparisons. Inter-species comparisons were made for all four parameters, using information derived from the combination of colonies, as well as for just the colonies at Van den Boogaard River, where both species bred.

RESULTS

Macaroni Penguins

There was no obvious long-term trend over the study period in the number of clutches laid at Archway Bay and Van den Boogaard River (Figure 2). However, the number of clutches laid decreased at Macaroni Bay, especially between 1982/83 and 1992/93, when 961 and 243 incubating adults respectively were counted. In 1995/96 the number of breeding pairs at this colony had increased to 476. The sizes of the breeding colonies at Macaroni Bay and Archway Bay were negatively correlated, but numbers of breeders at Van den Boogaard River were not significantly correlated to those at the other colonies (Table 1).

The mean number of eggs hatched per clutch varied between nil (in the case of complete failure of clutches at Van den Boogaard River in 1989/90) and 0.83 at Archway Bay in 1985/86 (Figure 3). The overall mean number of eggs hatched per clutch was 0.48 (n = 8 894). There was a strong correlation between hatching success at Macaroni Bay and Archway Bay (Figure 4), but there was no significant relationship between either of these localities and Van den Boogaard River (Table 1). Trends at Van den Boogaard River and the other colonies were similar after 1989/90 (Figure 3).

At Van den Boogaard River, chick survival to the date at which chicks in creches were counted was 100% in three seasons: 1988/89, 1993/94 and 1994/95. The same level of success was also attained at Archway Bay in 1994/95 (Figure 5). No eggs were hatched, and hence no chicks fledged, at Van den Boogaard River in 1989/90. The lowest survival of chicks was 29% at Macaroni Bay in 1989/90. The overall mean value for chick survival was 72% (n = 4 312). Trends in chick survival at the three colonies were significantly correlated, except between Van den Boogaard River and Archway Bay (Table 1).

The average number of chicks fledged per clutch varied between nil at Van den Boogaard River in 1989/90 and 0.79 at the same locality in 1981/82 (Figure 6). The overall mean value was 0.35 (n = 8 894). Trends in breeding success were significantly correlated in all three inter-colony comparisons (Table 1).

Rockhopper Penguins

There were overall decreases in the number of clutches laid at all three colonies monitored, with considerable fluctuations (Figure 7). In all three inter-colony comparisons, numbers of breeders were significantly correlated (Table 2).

The mean number of eggs hatched per clutch varied between 0.41 at Trypot Fault in 1985/86 and 0.96 at Van den Boogaard River in 1990/91 (Figure 8). The overall mean number of eggs hatched per clutch was 0.68 (n = 3 369). None of the inter-colony comparisons of hatching success were significant (Table 2).

Chick survival ranged between 36% at Trypot Fault in 1994/95 and 93% at Van den Boogaard River in 1988/89 (Figure 9). The overall mean value for chick survival was 71% (n = 2 306). Trends in chick survival at Van den Boogaard River and Trypot Hole were significantly correlated, but there was no significant relationship between these two colonies and Trypot Fault (Table 2). At Van den Boogaard

River and Trypot Hole, trends in chick survival were closely matched up until 1994/95, with major divergence observed only in 1995/96 (Figure 9).

The average number of chicks fledged per clutch varied between 0.17 at Trypot Fault in 1994/95 and 0.72 at Trypot Hole in 1986/87 (Figure 10). The overall mean value was 0.48 (n = 3 369). Trends in breeding success were significantly correlated only in the comparison between Van den Boogaard River and Trypot Hole (Table 2).

Interspecies Comparisons

No 'correlation' was significant at the 10-per-cent level or lower in comparisons between macaroni penguins and rockhopper penguins for all four parameters considered. This was the case both for overall trends for the two species, and for the colonies at Van den Boogaard River (Table 3).

On average, macaroni penguins hatched a lower number of eggs per clutch (0.48) than did rockhopper penguins (0.68). As a consequence, macaroni penguins fledged fewer chicks per clutch (0.35) than did rockhopper penguins (0.48). Mean chick survival for both species was similar (71–72%).

DISCUSSION

Breeding Population

The numbers of rockhopper penguins breeding were significantly correlated in all three inter-colony comparisons (Table 2). The only significant relationship in numbers of macaroni penguins breeding was a negative correlation between the colonies at Macaroni Bay and Archway Bay (Table 1). These colonies are close to each other, and there may have been movement of breeders between them. The colonies at Archway Bay and Van den Boogaard River remained stable throughout the study period, but there was a decrease in the larger colony at Macaroni Bay (Figure 2).

The proportion of adult rockhopper penguins breeding varied between seasons. The correlations between the numbers of pairs producing clutches at the various colonies suggest that this proportion may be influenced by environmental conditions before, or at the onset of, breeding. The same does not appear to be the case for macaroni penguins. With the exception of long-term trends and possible movement between colonies, numbers of breeding macaroni penguins remained relatively stable (Figure 2).

Estimating trends in the adult population of rockhopper penguins from counts of breeders may be complicated by a variable annual proportion of breeders. For this reason, it may be necessary to undertake repeat counts at each colony and take the maximum count in any given period as representing the population at that colony, as has been done for African penguins *Spheniscus demersus* (Crawford et al., 1995). This method assumes minimal interchange of breeders between colonies. The degree of interchange between colonies will need to be quantified before such a method is used for rockhopper penguins. The lack of substantial interannual variation in the breeding proportion of macaroni penguins inferred from the stable numbers breeding at Archway Bay and Van den Boogaard will facilitate monitoring trends in the breeding population through counts of birds initiating breeding.

Breeding Success

Trends in breeding success of colonies of macaroni penguins were better correlated than those of rockhopper penguins. This was primarily the result of similar trends in the survival of chicks at all three macaroni penguin colonies, although there was also a highly significant correlation between hatching success at the Macaroni Bay and Archway Bay colonies. The poor correlation of hatching success of macaroni penguins at Van den Boogaard River with the other two colonies is largely attributable to complete failure of the colony at Van den Boogaard River in 1989/90. Excluding that season, breeding success at both the incubation and brooding stages was well correlated for all three colonies of macaroni penguins.

There was little relationship in hatching success of rockhopper penguins at the three colonies. Chick survival at Van den Boogaard River and Trypot Hole followed similar trends, resulting in a significant correlation in overall breeding success at these two localities.

Implications for Monitoring

The lower inter-colony variability (higher correlation) in breeding success of macaroni penguins compared with rockhopper penguins suggests that once laying is completed, breeding

success of macaroni penguins may be influenced by a wider-scale phenomenon than is the case for rockhopper penguins. For rockhopper penguins, the greatest coherence is in numbers of birds laying, i.e. the breeding proportion. Thus meso- or macroscale phenomena appear to exert their greatest influence on these two penguins at different stages of the reproductive cycle – before or at laying for rockhopper penguins, and during incubation and brooding for macaroni penguins. As a consequence, there is little relationship between the performance of the two species at the various stages of breeding.

Cooper and Lutjeharms (1992) found that breeding success of macaroni penguins (but not of rockhopper penguins) in the same study colonies at Marion Island over a shorter time period was significantly negatively correlated with summer rainfall. The more open breeding sites of macaroni penguins at Marion Island may increase their exposure to high rainfall.

Croxall et al. (1988) noted major fluctuations in breeding population size and breeding success of several seabirds, including macaroni and other penguins, at South Georgia and Signy Islands in a study that evaluated the utility of measuring these parameters for monitoring purposes, such as for CEMP. Fluctuations in reproductive success of different species of summer-breeding penguins at Signy Island were not synchronised with those at South Georgia, but correlated best with the date of the ice break-out in late spring. Differences in trends of breeding parameters for two closely related species of penguin at Marion Island shown in this paper also have implications for use of seabirds in monitoring marine ecosystems. If the aim is to detect the influence of factors operating at a meso- or macroscale, the best parameters to monitor will depend on the species under study.

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REFERENCES

Cooper, J. and C.R. Brown. 1990. Ornithological research at the sub-Antarctic Prince Edward Islands: a review of achievements. *South African Journal of Antarctic Research*, 20: 40–57.

Cooper, J. and J.R.E. Lutjeharms. 1992. Correlations between seabird success and meteorological conditions on Marion and Gough Islands. *South African Journal of Science*, 88: 173–175.

Crawford, R.J.M., A.J. Williams, J.H. Hofmeyr, N.T.W. Klages, R.M. Randall, J. Cooper, B.M. Dyer and Y. Chesselet. 1995. Trends of African penguin *Spheniscus demersus* populations in the 20th Century. *South African Journal of Marine Science*, 16: 101–118.

Croxall, J.P., T.S. McCann, P.A. Prince and P. Rothery. 1988. Reproductive performance of seabirds and seals at South Georgia and Signy Island, South Orkney Islands, 1976–1987: implications for Southern Ocean monitoring studies. In: Sahrhage, D. (Ed.). *Antarctic Ocean and Resources Variability*. Springer-Verlag, Berlin Heidelberg: 261–285.

Marchant, S. and P.J. Higgins (Eds). 1990. *Handbook of Australian, New Zealand and Antarctic Birds*. Vol. 1 Ratites and Ducks. Oxford University Press, Melbourne: 735 pp.

SC-CAMLR. 1995. *CCAMLR Ecosystem Monitoring Program: Standard Methods for Monitoring Studies*. CCAMLR, Hobart, Australia.

Table 1: Results of correlation analysis between three colonies of macaroni penguin for: the number of pairs that bred, hatching success, chick survival and breeding success, 1979/80 to 1995/96. The value of the correlation coefficient (r), the time period of the comparison and the probability of the observed correlation being due to chance (P) are indicated in each instance.

	Macaroni Bay	Archway Bay
Number of breeding pairs:		
Van den Boogaard River	$r = 0.153$ 1979/80–1995/96 $P > 0.5$	$r = 0.409$ 1979/80–1995/96 $P < 0.2$
Macaroni Bay		$r = -0.538$ 1979/80–1995/96 $P < 0.05$
Hatching success:		
Van den Boogaard River	$r = 0.430$ 1983/84–1995/96 $P < 0.2$	$r = 0.486$ 1983/84–1995/96 $P < 0.1$
Macaroni Bay		$r = 0.899$ 1983/84–1995/96 $P < 0.001$
Chick survival:		
Van den Boogaard River	$r = 0.612$ 1983/84–1995/96 $P < 0.05$	$r = 0.480$ 1983/84–1995/96 $P < 0.1$
Macaroni Bay		$r = 0.680$ 1983/84–1995/96 $P < 0.02$
Breeding success:		
Van den Boogaard River	$r = 0.516$ 1979/80–1995/96 $P < 0.05$	$r = 0.655$ 1979/80–1995/96 $P < 0.005$
Macaroni Bay		$r = 0.623$ 1979/80–1995/96 $P < 0.01$

Table 2: Results of correlation analysis between three colonies of rockhopper penguin for: the number of pairs that bred, hatching success, chick survival and breeding success, 1983/84 to 1995/96. The value of the correlation coefficient (r), the time period of the comparison and the probability of the observed correlation being due to chance (P) are indicated in each instance.

	Trypot Hole	Trypot Fault
Number of breeding pairs:		
Van den Boogaard River	$r = 0.734$ 1983/84–1995/96 $P < 0.005$	$r = 0.686$ 1983/84–1995/96 $P < 0.01$
Trypot Hole		$r = 0.627$ 1983/84–1995/96 $P < 0.05$
Hatching success:		
Van den Boogaard River	$r = 0.430$ 1985/86–1995/96 $P < 0.2$	$r = 0.194$ 1985/86–1995/96 $P > 0.5$
Trypot Hole		$r = 0.162$ 1985/86–1995/96 $P > 0.5$
Chick survival:		
Van den Boogaard River	$r = 0.757$ 1985/86–1995/96 $P < 0.01$	$r = 0.376$ 1985/86–1995/96 $P < 0.5$
Trypot Hole		$r = 0.051$ 1985/86–1995/96 $P > 0.5$
Breeding success:		
Van den Boogaard River	$r = 0.644$ 1985/86–1995/96 $P < 0.05$	$r = 0.269$ 1985/86–1995/96 $P < 0.2$
Trypot Hole		$r = 0.187$ 1985/86–1995/96 $P > 0.5$

Table 3: Results of correlation analysis between macaroni penguins and rockhopper penguins for: the number of pairs that bred, hatching success, chick survival and breeding success, 1983/84 to 1995/96. The value of the correlation coefficient (r), the time period of the comparison and the probability of the observed correlation being due to chance (P) are indicated in each instance.

	All Colonies Combined	Van den Boogaard River
Number of breeding pairs	$r = 0.443$ 1983/84–1995/96 $P < 0.2$	$r = 0.217$ 1983/84–1995/96 $P < 0.5$
Hatching success	$r = -0.188$ 1985/86–1995/96 $P > 0.5$	$r = -0.145$ 1985/86–1995/96 $P > 0.5$
Chick survival	$r = -0.122$ 1985/86–1995/96 $P > 0.5$	$r = -0.116$ 1985/86–1995/96 $P > 0.5$
Breeding success	$r = -0.008$ 1985/86–1995/96 $P > 0.5$	$r = 0.069$ 1985/86–1995/96 $P > 0.5$

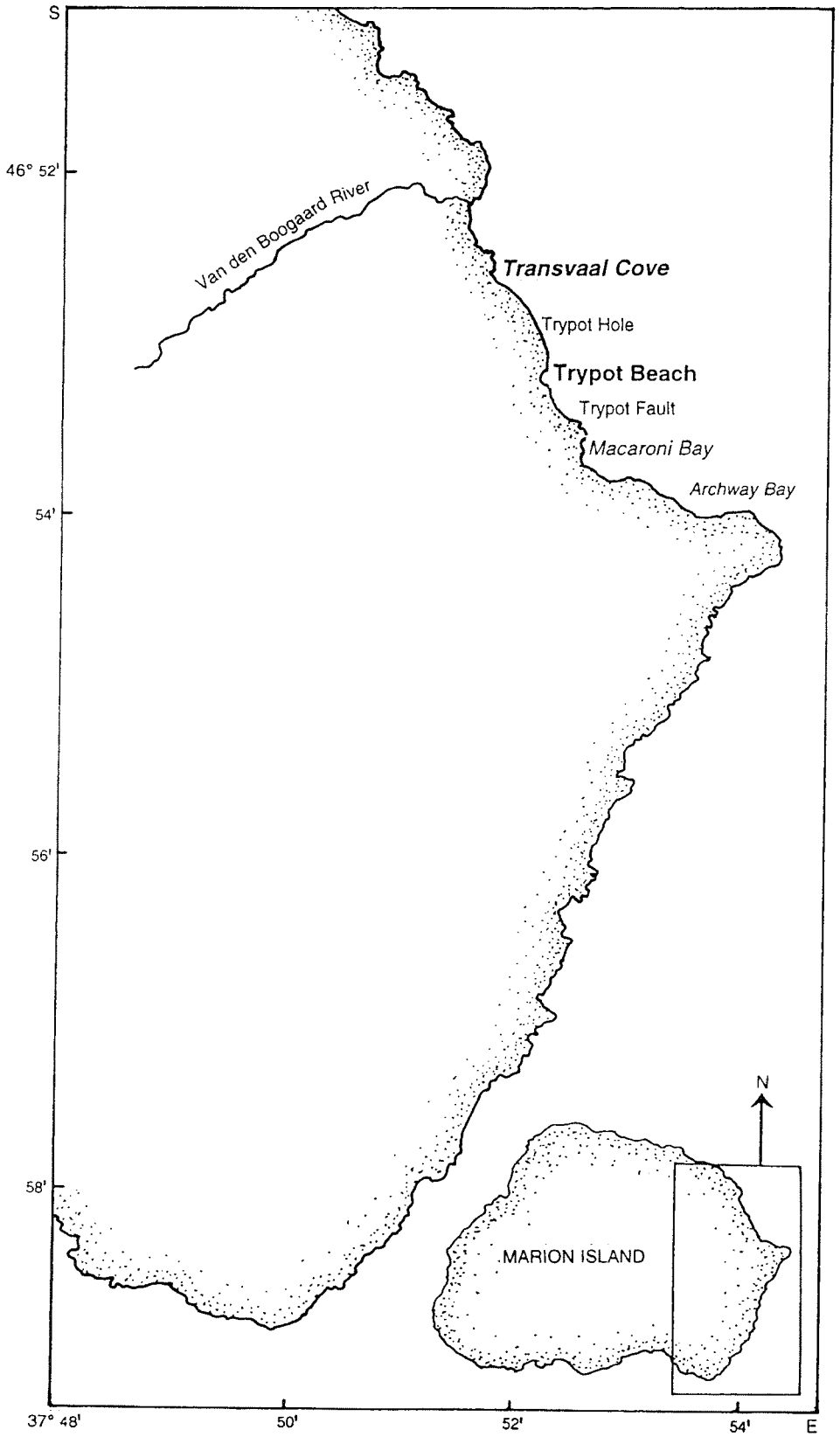


Figure 1: Locations of colonies of macaroni and rockhopper penguins monitored at Marion Island.

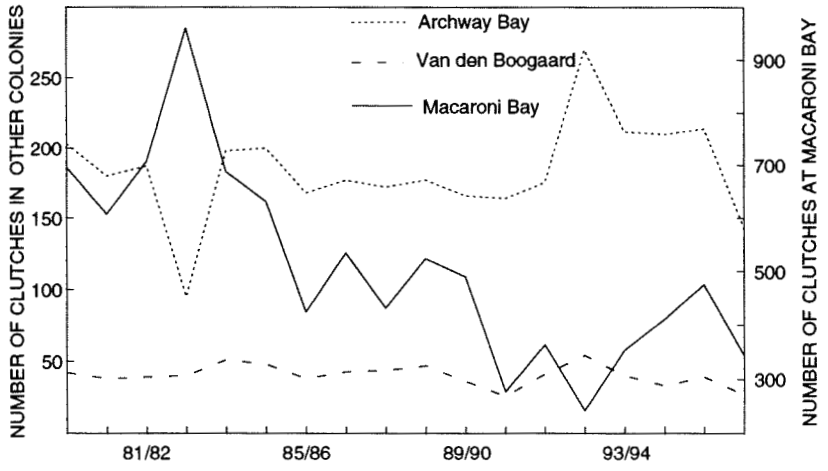
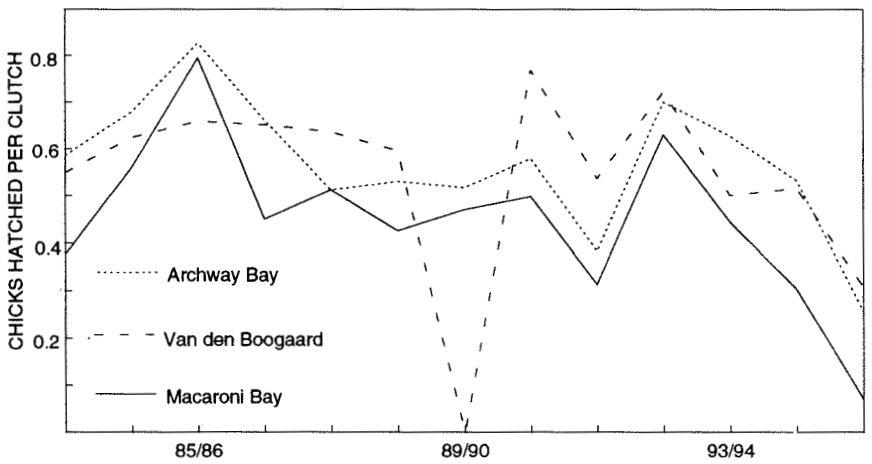


Figure 2: Trends in the numbers of clutches laid by macaroni penguins at the three colonies monitored from 1979/80 to 1995/96.



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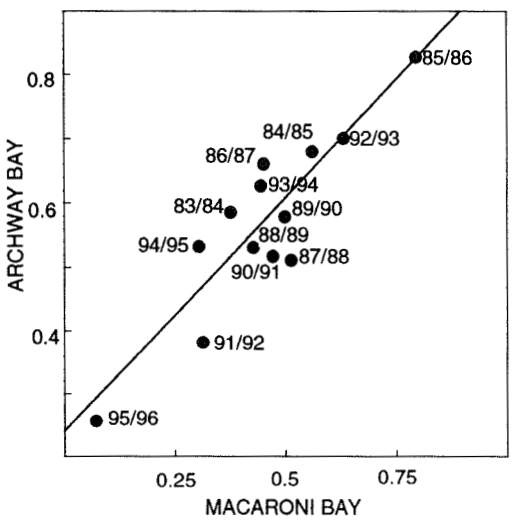

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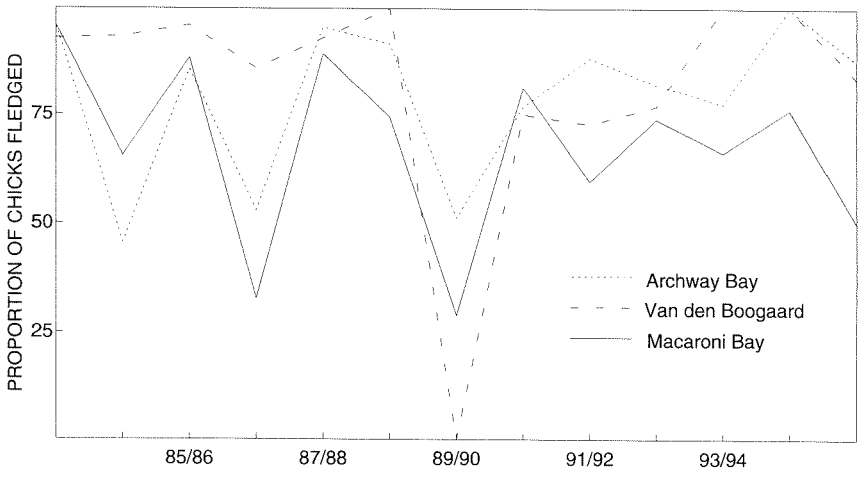


Figure 5: Trends in the proportional survival of macaroni penguin chicks at the three colonies monitored from 1983/84 to 1995/96.

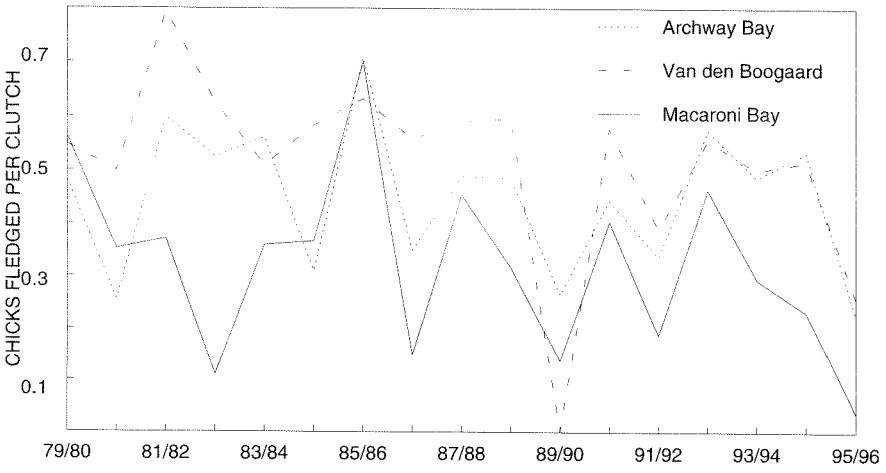
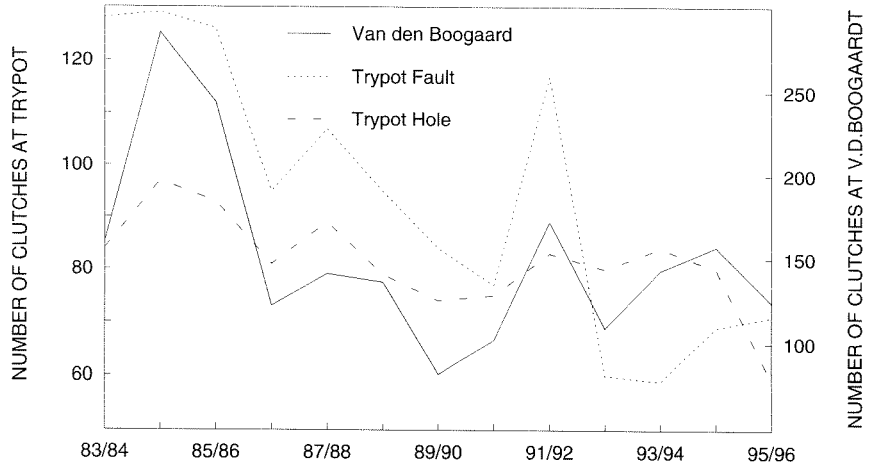


Figure 6: Trends in the numbers of macaroni penguin chicks fledged per clutch at the three colonies monitored from 1979/80 to 1995/96.



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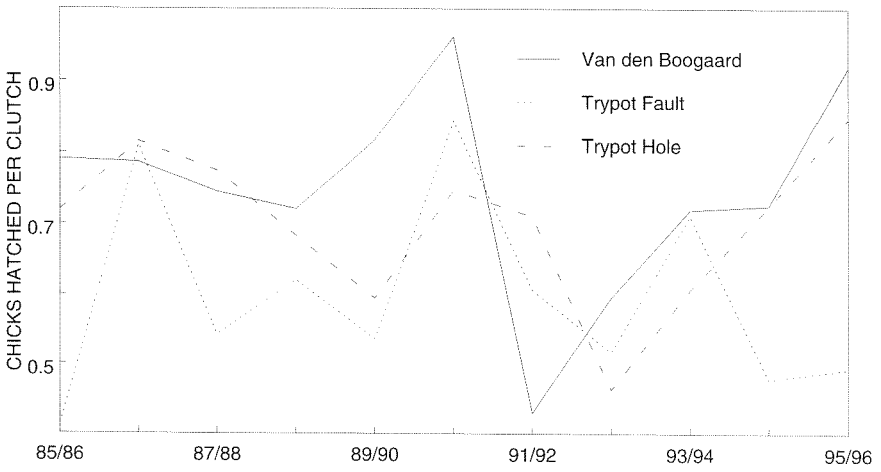

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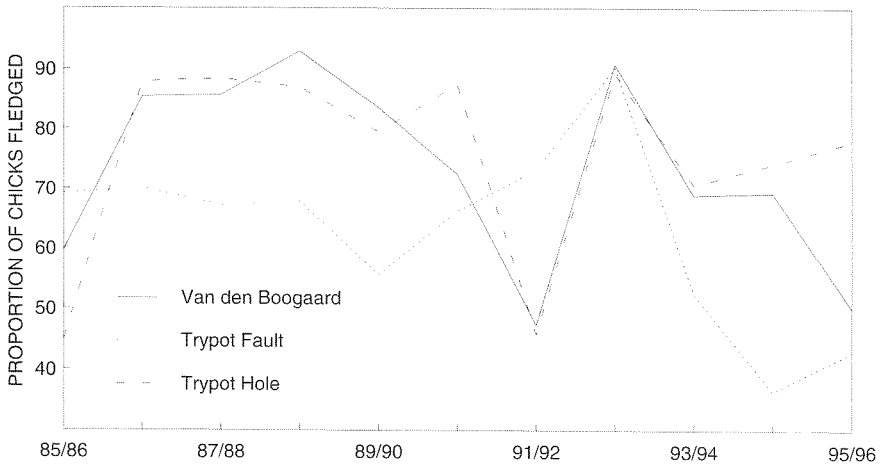

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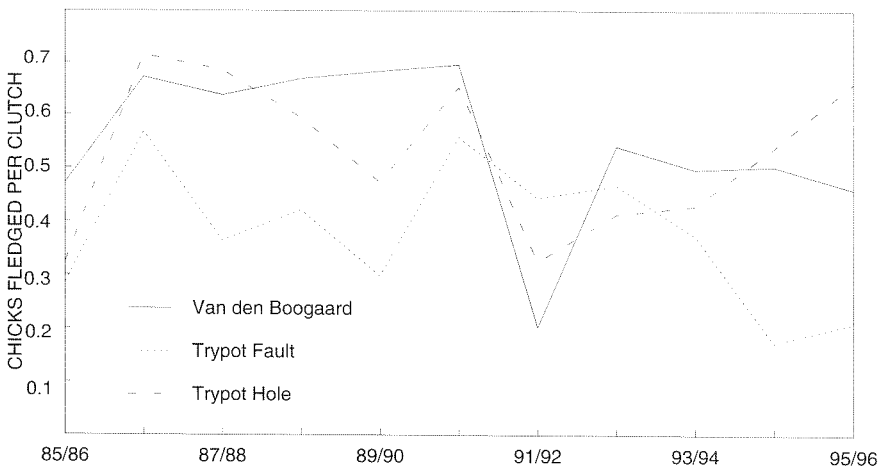

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