

Skua (*Catharacta* sp.) foraging behaviour at the Cape Crozier Adélie Penguin (*Pygoscelis adeliae*) colony, Ross Island, Antarctica, and implications for breeding

E. C. YOUNG AND C. D. MILLAR

School of Biological Sciences, The University of Auckland, Auckland, New Zealand

ABSTRACT

We observed that South Polar Skuas (*Catharacta maccormicki*) breeding near the Adélie Penguin (*Pygoscelis adeliae*) western colony at Cape Crozier, Ross Island, Antarctica were able to forage throughout the colony, the majority of which was not defended by territorial skuas as in other Ross Island colonies. All local skuas were able to find enough food on the colony throughout January to support breeding and none were seen to forage at sea. Skuas foraged as individuals to obtain penguin eggs and chicks but kleptoparasitism usually occurred so that several skuas fed in turn on a single carcass. At the end of each feeding event a general melee occurred in which up to 30 skuas fought over the chick remains. The implications for skua breeding of this foraging regime, in which any skuas in the local area can obtain penguin food, are considered. We suggest that the high levels of food availability contributed to the unusually high success for this region of these skuas in raising both chicks. Desertion of chicks while foraging, however, leads to some mortality among older chicks later in the season through predation. It is recommended that further research on skuas at super-large penguin colonies be undertaken.

KEY WORDS: South Polar Skua, foraging, Adélie Penguin, prey-predator relations, Cape Crozier.

INTRODUCTION

Throughout Antarctica South Polar Skuas (*Catharacta maccormicki*) and Adélie Penguins (*Pygoscelis adeliae*) commonly nest together in snow- and ice-free areas. In the past it was generally assumed that penguins provided all the food needed by skuas over the breeding season, but it has become clear from more recent work that although skuas at penguin colonies may forage there, others feed almost exclusively at sea (Young 1963, 1994; Pietz 1986). At the Cape Royds and Cape Bird penguin colonies on Ross Island Young (1963, 1994) found that skuas could not be entirely supported by the penguins and except for a short period in mid summer they also fed at sea. Furthermore, only those skuas which had territories among the penguins could forage off penguins. All other skuas were excluded by these territorial pairs.

Despite these general findings there are, however, three possible ways that skuas breeding away from a penguin colony might be able to forage there. First, through the establishment of feeding-only territories, as described at Cape Hallett

by Trillmich (1978); second, where the nonbreeding 'club' lies within the penguin colony allowing young skuas and visiting breeders access to the margins of penguin breeding groups, as described at Cape Bird (Young 1994); third, if the penguin colony was not defended by resident territorial skuas. This last possibility has been reported for the Cape Crozier colony (Müller-Schwarze & Müller-Schwarze 1977) and may also occur at Point Thomas, King George Island (Trivelpiece & Volkman 1982).

In this paper the foraging behaviour of the skuas at Cape Crozier is described and the implications for skua breeding success at this particularly large colony assessed. Although there has been extensive research on both skuas and penguins at this colony (Wood 1971; Schlatter 1972; Oelke 1975; Müller-Schwarze & Müller-Schwarze 1977; Ainley *et al.* 1983; Ainley *et al.* 1990) skua feeding ecology in this area has not been described in detail. Early in the study it became obvious that the breeding skuas on the study area were feeding at the penguin colony (from penguin remains at the nests and the evidence of blood on the face and chest). What needed to be determined was whether all skuas fed there, whether this food was supplemented by foraging at sea, and whether the penguin colony could provide all the food needed by the skuas later in the season.

STUDY AREA AND METHODS

The research was carried out from 23 December 1993 to 26 January 1994 at the western Adélie Penguin colony at Cape Crozier (77°27'S, 169°11'E) on Ross Island, Antarctica. This colony, the largest on Ross Island, contains c. 150 000 pairs (Taylor *et al.* 1990). The immediate Cape Crozier area contains c. 1000 skua pairs (Wood 1971; Ainley *et al.* 1990). Most research on skua breeding for the current paper occurred in the wide valley immediately to the west of the penguins (areas A - E, Fig. 1).

Foraging by skuas on the penguin colony

Most observations on foraging skuas were made in the western half where steep slopes high above the colony basin allowed excellent viewing. It was easy to observe how the skuas fed from penguin chicks. Attacks on chicks could be monitored from the slopes above the colony, and once chicks had been taken the whole feeding sequence could then be watched from the same place, or seen more closely by walking down to where the birds were feeding.

Skuas at sea

Scanning for skuas at sea was done from a high coastal headland at the end of E ridge, (Fig. 1, 'lookout'). This lookout gave exceptional viewing over an enormous area of ocean, including the entire coast fronting the penguin and skua breeding areas. Scanning was done using X8 field glasses for at least 10 minutes at a time generally twice a day throughout January. At this time of the year there is 24 hour daylight.

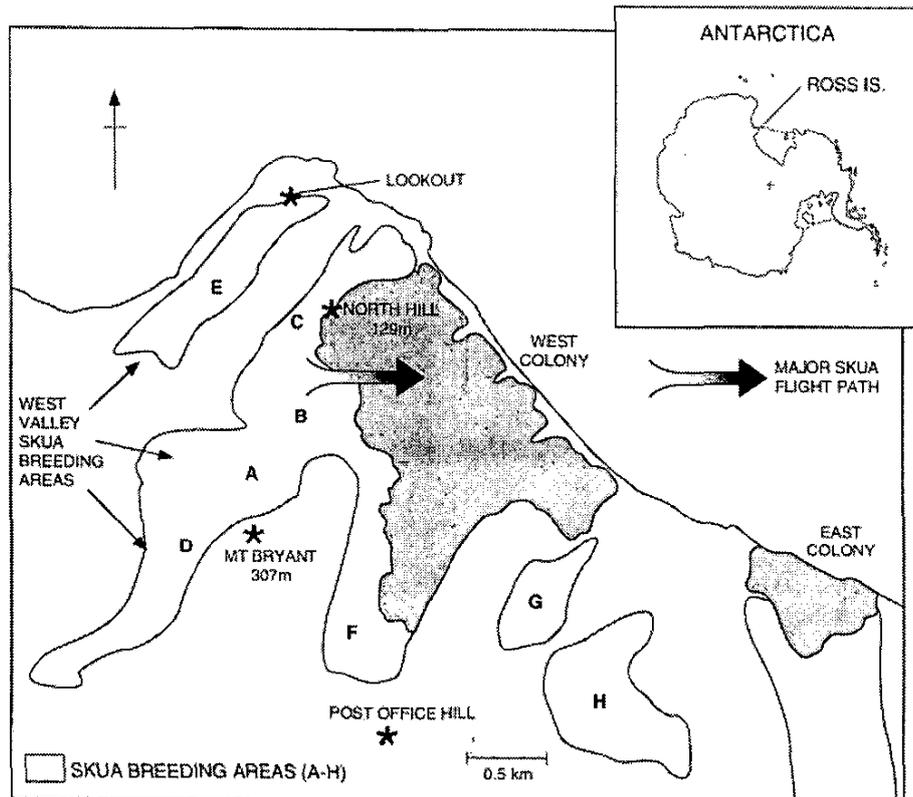


FIGURE 1 – The Adélie penguin and skua colonies at Cape Crozier, Ross Island. Skua breeding areas are identified A - H. (following Ainley *et al.* 1990). The research on skua breeding took place in the valley to the west of the western penguin colony (areas A - E).

Observations on breeding skuas

Nests with eggs were mapped and chick hatch, survival and growth were recorded daily. During these visits the parents were checked for blood stains (as evidence of feeding on penguins), their occupancy recorded, and any flights monitored as a pointer to foraging area. If the parents were absent when the territory was visited a watch was kept from a distance to record the time they were away, whether other skuas took advantage of their absence to enter the territory, and to monitor the behaviour of chicks while the parents were absent.

RESULTS

Skuas on the penguin colony

The very first observations on 28 December, 1993 showed that the central area of this penguin colony was not effectively defended by breeding skuas. This was established by the following observations. First, from the high number of skuas in seemingly continuous flight without challenge over the colony. Individual skuas could be followed as they flew to and fro along the length of the colony, banking and twisting in flight to follow the geography of the linked breeding groups. They could be followed for several hundred metres, much greater distances than would be accommodated within a single skua territory. Second, from the presence

of large numbers of skuas on the ground among the penguin breeding groups. None of these were actively defending areas by chasing off others or engaging in any of the usual territorial displays (Spellerberg 1971) to birds flying overhead. Moreover, at any place where a skua was feeding from a penguin chick carcass, up to 30 others might be present on the ground in the immediate area.

A search was made in late December for skua pairs with eggs or chicks within the boundary of the penguin colony. None occurred anywhere in the centre or seaward margin of the colony and only one nest was found along the high landward margin within a line linking the outer penguin breeding groups. Other pairs with eggs or chicks found near the colony along this margin nested away from the penguins.

Foraging behaviour

Twenty-five hours observation of foraging birds was carried out, in which 42 attacks on penguin chicks were recorded, and over 40 feedings observed. All attacks observed on penguin nests with eggs or chicks or on post-guard chicks were by single birds, rarely by two birds. More significantly, no attacks were seen by groups of skuas in concert. Scavenged eggs and small chicks were eaten by the skua that gained them. Large chicks were fed on by single birds in turn. While one skua fed on the carcass 10 - 30 others gathered in the vicinity, with the nearest birds 2 - 6 m away. Five to seven different skuas fed in turn on a single carcass. Supplanting at the carcass was mostly from flight, with birds landing near or on top of the feeding skua. Supplanting occurred also through skuas approaching in 'aggressive upright' (Spellerberg 1971) followed by direct attack. Feeding birds usually had a hard time retaining the carcass and feeding was often interrupted while fighting off would-be usurpers. For this reason feeding was a desperately frantic business with the head and neck buried within the carcass to gobble up the soft internal flesh.

Consistently at the end of feeding, when the carcass had been reduced to little more than skin and skeleton, a general melee occurred - a vulture-like flocking - in which up to 30 skuas fought over the remains (Fig. 2).

Observations on skua behaviour at nests away from the penguin colony

None of the numerous skua territories on the slopes and basins away from the penguin colony contained any food. However, in spite of the absence of penguins in these nesting areas many of the skuas there were seen to be flecked with blood, in some cases, drenched with blood over the forehead, neck and breast, providing graphic evidence of penguin feeding.

These skuas could gain food very quickly at the penguin colony. The shortest record was of a parent away for only nine minutes before returning to feed its chicks. This was an exceptional record, but there were others within 15 minutes and few exceeded 30 minutes. Penguin flesh was brought back to these territories after ingestion, not carried in the bill. Except in territories which overlapped



FIGURE 2 – Skuas fighting for bits of penguin carcass at the end of a feeding sequence. The 'vulture-like' melee.

penguin breeding groups no penguin remains, except indigestible skeletal parts regurgitated by parents or chicks, were found around the nest areas. Nests of territories containing penguins were, however, liberally scattered with penguin remains.

All skuas watched leaving territories in the study area headed across the valley towards the penguin colony to the east. Most flew through the low pass between the skua valley and the penguin colony on the inland side of the steep coastal hill near C block. Those farthest away overflowed some 20 skua territories on this passage. The birds on lower C and on E blocks flew along the coast directly to the penguins.

Nil evidence of foraging at sea

Visibility through January was usually good and sea ice invested the coast for only a few days. On other days clear water extended to the horizon to the north, from the Ross Sea Barrier cliffs east of the colony along the northern coast of Ross Island to as far as Beaufort Island in the west. Because of these excellent viewing conditions it would have been impossible to miss any birds flying to and from the sea or foraging at sea during the scans made from this coast yet not a single bird (of the 1000 or so pairs in this area and 300 - 400 nonbreeders) was observed to do so, except for those flying no further than the nearest ice flow to inspect penguins resting there or to bathe and preen.

Skua breeding success: the number of pairs of chicks raised from 2-egg nests

In a cohort of 47 nests hatching both chicks 19 (40.4 %) retained both chicks and 23 (48.9%) one chick to 20 days of age when the study finished in late January. That is, 61 chicks of 94 hatching (64.9%) survived to this age, including 38 (62.3 % of chicks surviving) in pairs.

Predation on skua chicks

Killed and wounded skua chicks were found on the breeding areas in late January. At this date skua chicks are too big to be eaten whole or carried by flight back to the home territory so that the extent of skua predation on chicks becomes manifest. Earlier in summer chicks simply disappear and there is usually no indication of the cause of loss. The most striking record of predation at this time was made on 23 January when four chicks, representing 9 % of the group being monitored, were found to have been killed or severely wounded by predatory skuas immediately before the daily survey. These chicks weighed between 470 g and 640 g, and were between 18 and 25 days old. This predation occurred towards the end of two days of fine, calm weather, and was recorded less than two hours before a sudden switch to severe storm conditions. Monitoring later in the day might well have attributed these deaths to wind and cold, with subsequent scavenging, rather than to predation. Two days earlier another of the study chicks weighing 700 g (at 20

days), and again considered beyond the normal vulnerable size range for predation, was seen being killed while the parents were absent.

DISCUSSION

Foraging behaviour and impact on breeding penguins

This study has demonstrated a very different relationship between skuas and penguins at Cape Crozier to that described previously at Capes Royds and Bird (Young 1963, 1994). At the Cape Crozier penguin colony most skuas nested well away from the penguins yet were able to forage throughout the greater part of the colony. At the other Ross Island colonies only those skuas whose territories incorporated breeding groups of penguins had access to penguin food.

No skuas in the central area of the Cape Crozier colony appeared to be defending territories, had nests or were protecting chicks or fledglings when surveys were made of the area in late December. It was not possible, however, at this stage of the season, to find out whether the central colony area had ever been occupied. Nor was it possible to establish whether any of the local skuas had foraging-only territories on the penguin colony at this time, although from watching the way the skua flocks moved freely throughout the area this seemed unlikely. Such territories were described by Trillmich (1978) at Cape Hallet, but these may have occurred at this colony because of the exceptionally high level of human disturbance from the scientific base and it is not certain how commonly these territories occur in natural situations. Only one was known at the Cape Bird colonies (Young 1994).

Earlier studies (Müller-Schwarze & Müller-Schwarze 1973; Müller-Schwarze & Müller-Schwarze 1977; Oelke 1975; Schlatter 1972) indicate conclusively that at least since research began at the Western Colony in the 1960s there has been little if any breeding in the colony centre, allowing unusually wide access to the penguins there by local skuas. In many areas the penguin groups are so closely packed that breeding would be precluded, while in the more open areas the high number of penguins moving through the colony would deter nesting skuas.

Using the Müller-Schwarze & Müller-Schwarze (1973) mean figure for the distance peripheral territories reach into the colony (65 m) it is calculated that approximately 18.5% of the colony fell within the peripheral territories. On this basis, assuming equal breeding densities for the penguins throughout the colony, 27 750 pairs of penguins were contained within skua territories and 122 250 were in the central area accessible by any skuas.

Local skuas preying and scavenging on penguin chicks at this colony late in the season when large penguin chicks occur had three feeding options: scavenging and preying on penguin chicks directly; supplanting skuas already feeding on a carcass (kleptoparasitism); and joining the general melee that occurs at the end of a feeding sequence to gain some of the skin and skeleton. The 'vulture-like' behaviour of these skuas at the end of a feeding sequence had not been seen previously at Cape Royds and Cape Bird (Young 1963, 1994) where chicks were retained exclusively by the pair, or stolen by neighbours when abandoned. Nor has it been described

for other penguin colonies, but it is commonplace where skuas scavenge on kitchen waste, dead seals or other large prey.

There are large amounts of penguin food available to skuas on penguin colonies during the late guard and early post-guard breeding stages (Young 1994). This amount (as maturing chicks) peaks about mid January and thereafter the amount that the skuas can exploit declines, even though chick biomass continues to increase. In late season (from 20 January) most chicks are too big to be preyed on by skuas, and at least for Cape Bird, by the end of January penguin colonies provide little food apart from krill and small fish spilled during penguin chick feeding. Thus, the most significant observation on the feeding ecology from this study, is that even in late January the skuas at Cape Crozier still appeared to be gaining all the food they needed from predation and kleptoparasitism at the penguin colony. From early January it was anticipated that a proportion of the breeding skuas would be feeding at sea, as happens at Cape Bird, and that towards the end of the month most if not all skuas would need to forage there. This simply did not occur. That is, under circumstances which allow skuas to forage throughout the colony a super-large penguin colony such as this one is able to support the local skua population during most of the breeding season - at least to late January or early February. The breeding cycles of the two species are, however, so far out of phase (Young 1963, 1994) that there is little chance of penguins being exclusively able to support the skuas up to chick fledging in mid to late February. Penguin chicks begin deserting breeding areas to congregate on the shore line from late January, and almost all will have left the colony by mid February. (Taylor 1962; Ainley *et al.* 1978). In February and March skuas must revert to foraging at sea.

It is worth stressing that the chicks being eaten by skuas in January were all freshly killed and that the skuas took little interest in the dead and flattened carcasses that accumulated in the larger breeding groups during the season and became available to them as chicks crèched.

The association described at Cape Crozier in which any of the local skuas can gain food from the penguin colony is so different from that described at the other colonies on Ross Island where the penguins can only be exploited by territorial skuas that one would expect that the predator/prey ratios would differ significantly. The ratios are, however, surprisingly similar (Table 1). The simplest explanation for this equivalence is that by chance the area suitable for breeding at Cape Crozier has limited the skua numbers there proportionally to those occupying the penguin colonies at the other two sites. This similarity does, however, suggest that Crozier skuas can gain all the food needed for breeding in January not through a more favourable ratio to prey but because of wider access and kleptoparasitism.

Impact of local food abundance on skua breeding success

The opportunity to gain food quickly through predation, but especially through kleptoparasitism, has important implications for skua breeding. If they are sufficiently determined parents can immediately break into the feeding cycle on a penguin

TABLE 1 - Numbers of skua pairs in relation to accessible pairs of breeding penguins at different penguin colonies on Ross Island.

	Skua pairs with access to penguins	Numbers of pairs of penguin	Ratio of skua pairs to penguin pairs
Cape Royds ¹	6	1405	1: 234
Cape Bird, Northern Colony ²	80	25 000 (1965-66) 15 000 (1967-68)	1: 310 1: 190
Cape Crozier	1000 ³	177 000 ⁴	1: 177

¹ Young (1963).

² Young (1994, pages 24 and 30).

³ Wood (1971).

⁴ Taylor *et al.* (1990)(total east and west colonies, 1987).

Counts of penguins at minimum nest number in early to mid December.

carcass to get food. Gaining food quickly benefits the chicks in two ways. First, through higher nest attendance, they should be better protected against predatory skuas; and second, they are less likely than with parents foraging at sea or among a few penguins within a territory to suffer intense hunger - affecting survival directly or through stimulating sibling aggression. Siblicide, causing the loss of younger chicks of pairs, is the major cause of early chick mortality in high latitude skua colonies (Procter 1975; Spellerberg, 1971; Young 1994). Very few second-hatching chicks at these colonies survive more than 10 days; most succumb within a day or two of hatching.

Numerous studies of skua breeding on Ross Island have recorded a very low breeding success for these populations. Cape Crozier was distinguished from the others, however, because, in contrast to them, a significant proportion of pairs there raise both chicks. Wood (1971) recorded that 9% of 168 successful pairs raised both chicks. In the present study over half the chicks surviving to the end of January from two-egg clutches were in pairs. Skuas breeding in colonies around the fringes of the continent and on the Antarctic Peninsula typically raise both chicks but this is rare in southern Ross Sea colonies. In five seasons at Cape Bird monitoring c. 250 pairs each year only three pairs of chicks survived to the end of January (Young, pers obs). Although topography and climate have an important role in determining chick survival it seems more likely that it is the parents' ability to gain food quickly that is the major contributing factor to the higher survival of pairs of chicks at Cape Crozier.

Proximity to an attractive food resource, however, is not without its drawbacks. As recorded at Cape Bird (Young, 1994), some skuas are so attracted to the food on penguin colonies that brood defence is neglected. At Cape Bird these obsessed skuas remained in their territories, so that during many hundred hours of observation no chicks were seen entirely deserted by parents. In contrast, at Cape Crozier these skuas left the territory so that undefended chicks were routinely discovered and chick predation by outside skuas was commonly recorded. Leaving young

chicks alone on the territory is always risky in a skua colony (Furness 1987; Hamer *et al.* 1991) and was especially hazardous at Cape Crozier where flight paths to and from the penguin colony traversed so many territories. In these two respects - in the higher proportion of pairs of chicks raised, and in the way some parents left their chicks alone on the territory - the behaviour of these breeding skuas is different from those studied at Cape Bird and is attributed to their different feeding behaviour.

Ainley *et al.* (1990) consider that the Cape Crozier environment is unique on Ross Island because of its high incidence of southerly storms. They argue that these storms confer advantage to the breeding birds there through keeping the immediate sea area ice-free (forming a substantial and nearly permanent polynya) (Ainley *et al.* 1978) but are also strongly disadvantageous as they often cause mass mortality of skua chicks in late summer. There is no doubt from the observations made during the present study that the storms can have a devastating impact on skua breeding, but this study suggests that their direct impact (through high winds and blown snow) is only part of the story. Significant also is the behaviour of these parents, specifically their propensity to leave chicks undefended while foraging on the penguin colony. During severe weather when all foraging is difficult, and especially difficult in late summer when the maturing penguin chicks are hard to kill, skuas find undefended skua chicks an easy alternative prey. Thus, it is likely that the combination of storms and a feeding behaviour facilitating skua predation act in concert to cause the often high fledgling skua mortalities for which Cape Crozier is noted.

CONCLUSIONS AND FUTURE RESEARCH

This study has shown that at least in late December and throughout January the majority of the western penguin colony at Cape Crozier is not defended in territories by breeding skuas and could be exploited for food by any of the local birds. Attacks on nesting penguins and chicks were not by groups of skuas but by individuals, but through kleptoparasitic behaviour several other birds could obtain food from each predated carcass. In contrast to the situation at Cape Bird and Cape Royds, these skuas appeared to be able to obtain all the food they needed at the penguin colony throughout January. No foraging at sea was recorded in this month. These observations suggest that it would be useful to examine other large penguin colonies to determine if these might also be able to support all the local skuas during this part of the breeding season.

Although the study has confirmed that any skua can forage on the colony an earlier statement which contrasted foraging in open and territorial areas as "between hordes of skuas flocking about the breeding group harassing the penguins in turn from every side, compared with the sheltered protection within the territory of a benign pair" (Young 1994, page 411) is now seen to be fanciful. Even in open areas of the Cape Crozier colony the skuas attacked penguins individually and did not form attacking coalitions as hypothesised in this pronouncement.

It is possible that the availability of abundant penguin food close to the skua breeding areas is a significant factor in the higher proportion of pairs of chicks

raised at this skua colony compared with that found elsewhere on Ross Island. The allure of penguin food, however, appeared to encourage higher levels of territory desertion by foraging skuas, leaving the chicks unprotected and exposed to skua predation. These aspects of parental care would repay further research.

It was not possible in this study to determine how the centre of the colony ended up without being claimed or defended by breeding skuas, nor if individual skuas breeding elsewhere established foraging-only territories on it. These aspects of the association between the two species, critically important in shaping the feeding ecology of skuas here, require detailed examination.

ACKNOWLEDGEMENTS

Funding to undertake this research was provided by the University of Auckland Research Committee. Support in Antarctica was by the New Zealand Antarctic Programme. The figure was prepared by Vivian Ward, School of Biological Sciences, Auckland University.

LITERATURE CITED

- AINLEY, D.G.; LERESCHE, R.E.; SLADEN, W.J.L. 1983. Breeding biology of the Adélie Penguin. University of California Press, Berkeley.
- AINLEY, D.G.; RIBIC, C.A.; WOOD, R.C. 1990. A demographic study of the South Polar Skua *Catharacta maccormicki* at Cape Crozier. *J. Anim. Ecol.* 59: 1 - 20.
- AINLEY, D.G.; WOOD, R.C.; SLADEN, W.J.L. 1978. Bird life at Cape Crozier, Ross Island. *Wilson Bull.* 90:492-510.
- FURNESS, R.W. 1987. The Skuas. Poyser, Calton.
- HAMER, K.C.; FURNESS, R.W.; CALDOW, R.W.G. 1991. The effects of changes in food availability on the breeding ecology of great skuas *Catharacta skua* in Shetland. *Journal of Zoology London* 223: 175 - 188.
- MÜLLER-SCHWARZE, D.; MÜLLER-SCHWARZE, C. 1973. Differential predation by South Polar Skuas in an Adélie Penguin rookery. *Condor* 75: 127 - 131.
- MÜLLER-SCHWARZE, D.; MÜLLER-SCHWARZE, C. 1977. Interactions between South Polar Skuas and Adélie Penguins. In: Llano, G.A. (ed) Adaptations within Antarctic ecosystems. Smithsonian Institution, Washington, pp 619 - 646.
- OELKE, H. 1975. Breeding behaviour and success in a colony of Adélie Penguins, *Pygoscelis adeliae* at Cape Crozier, Antarctica. In: Stonehouse, B. (ed) The Biology of Penguins. Macmillan, London, pp 363 - 395.
- PIETZ, P.J. 1986. Daily activity patterns of South Polar and Brown Skuas near Palmer Station, Antarctica. *Auk* 103:726 - 736.
- PROCTER, D. L. C. 1975. The problem of chick loss in the South Polar Skua *Catharacta maccormicki*. *Ibis* 117: 452 - 459.
- SCHLATTER, R. P. 1972. Social organisation of non-breeding South Polar Skuas at Cape Crozier, Antarctica. Unpublished PhD dissertation, Johns Hopkins University, Baltimore, Maryland.
- SPELLERBERG, I. F. 1971. Breeding behaviour of the McCormick Skua *Catharacta maccormicki* in Antarctica. *Ardea* 59: 189 - 229.
- TAYLOR, R. H. 1962. The Adélie Penguin *Pygoscelis adeliae* at Cape Royds. *Ibis* 104: 176 - 204.
- TAYLOR, R. H.; WILSON, P. R.; THOMAS, B. W. 1990. Status and trends of Adélie Penguin populations in the Ross Sea region. *Polar Record* 26: 293 - 304.
- TRILLMICH, F. 1978 Feeding territories and breeding success of South Polar Skuas. *Auk* 95: 23-33.
- TRIVELPIECE, W.; VOLKMAN, N. J. 1982. Feeding strategies of sympatric South Polar *Catharacta maccormicki* and Brown Skuas *C. lonnbergi*. *Ibis* 124: 50 - 54.
- WOOD, R. C. 1971. Population dynamics of breeding South Polar Skuas of unknown age. *Auk* 88: 805 - 814.
- YOUNG, E. C. 1963. Feeding habits of the South Polar Skua *Catharacta maccormicki*. *Ibis* 105: 301-318.
- YOUNG, E. C. 1994. Skua and Penguin. Predator and Prey. Cambridge University Press, Cambridge.