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Article

Diet and Feeding Behavior of the South Polar Skuas Stercorarius maccormicki Haswell Islands, East Antarctica

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Simple Summary: The South Polar Skua is an avian predator and scavenger that feeds on fish and penguins in continental Antarctica. Assessing the impact of skuas predation on populations of vulnerable seabird species in a changing climate is important for conservation management. Purpose of the study: to determine how South Polar Skuas used the abundance of living resources of the Haswell Archipelago (66°31' S, 93°01' E, Davis Sea, Southern Ocean). This study presents the final report of observations (1912–2016). South Polar Skuas are mostly fed on terrestrial resources. The dominant prey of skuas were vertebrates. Emperor and Adélie penguins make up the bulk of the skuas' diet during the pre-breeding and breeding periods. Surface feeding at sea was observed in the post-breeding period, when the availability of land-based food resources was reduced. Throughout history, kitchen waste supported the skuas population. Scavenging is the leading strategy for obtaining food. Predation (primarily on Adélie Penguin eggs and chicks) is of minor importance. South Polar Skuas did not affect the breeding success of Emperor Penguins if they fed on frozen chicks and eggs in their colony. Predation by skuas has affected the breeding success of Adélie Penguins and fulmarine petrels, but the extent of the impact has not been established.

Abstract: The diet and feeding behavior of South Polar Skuas (*Stercorarius maccormicki*) are well studied within the species' breeding range, but are poorly understood on the Haswell Islands. Goal: to establish how South Polar Skuas used the abundance of living resources of the Haswell Archipelago (66°31' S, 93°01' E, Davis Sea, Southern Ocean) under conditions of prolonged human activity. Methods: direct observations, study of pellets, spontaneous regurgitation and stomach contents of feathered birds. South Polar Skuas fed primarily on terrestrial resources. The dominant prey of skuas were vertebrates. Emperor Penguins (*Aptenodytes forsteri*) and Adélie Penguins (*Pygoscelis adeliae*) make up the bulk of the skuas' diet in the pre-breeding and breeding periods. Surface feeding at sea was observed in the post-breeding period, when the availability of land-based food resources was reduced. Throughout history, kitchen waste supported the skuas population. Scavenging is the dominant strategy for obtaining food. Predation (primarily on Adélie Penguin eggs and chicks) is of minor importance. South Polar Skuas do not affect the breeding success of Emperor Penguins if they feed on frozen chicks and eggs in their colony. Skua predation influences breeding success of Adélie Penguins and fulmarine petrels, but the extent of the impact is unknown.

Keywords: predator; pellets; regurgitates; stomach; feces; macroplastic; prey remains; scavenging; kleptoparasitism

1. Introduction

The study of diet is central to understanding the adaptations of seabirds to the marine environment [1]. South Polar Skua (*Stercorarius maccormicki*) breed around Antarctica and well-adapted to the extreme Antarctic environment [2,3], where the continental coast of the ice continent provides maximum diversity of its prey [4]. In East Antarctica, it is the only avian predator that

and penguins in continental Antarctica, but feed mainly on fish in the zone of overlap with the Brown Skua (*Stercorarius antarctica*) [4].

The South Polar Skua is a food generalist, top predator, seasonal resident, using up to 8 islands of the Haswell Archipelago for breeding (for example, [7–11]). This opportunistic predator breeds in single pairs and small groups on the small islands of the archipelago or in a loose colony on Haswell Island. The core breeding population is located on Haswell Island near the Adélie Penguin (*Pygoscelis adeliae*) colonies and the Emperor Penguin (*Aptenodytes forsteri*) colony on fast ice (e.g. [7,8,12]. This is one of the few bird species on the archipelago, the number of which, after the depression of the 1999/2000 breeding season [13], increased significantly in the next 2 decades [10,14,15]. During the historical period, the total size of the breeding population of South Polar Skuas varied from 18 to 83 pairs [13,14]. Skuas' feeding habitats include land, sea, sea and continental ice. In general, birds patrol the entire surface of the water area, including the Haswell Islands and fragments of the mainland coast.

Skuas arrive on the islands of the archipelago in October, when the width of the fast ice is maximum, and leave them in March–April [7–10,16–19] when the water area freezes. Thus, they spend approximately half of their annual cycle in their breeding areas. After the marine stage of the annual cycle (migrations and wintering) and a sharp change from one habitat (sea) to another (land and sea ice), skuas switch to terrestrial food resources. A change in habitat is accompanied by a change in their food habits. In October–December, support for the skua population on the archipelago is provided by an abundant food supply in the form of frozen eggs, chicks and single adult Emperor Penguins. During October–November, Weddell seals (*Leptonychotes weddellii*) in the study area produce up to 10 pups annually [20], and the placenta of these seals is used as a food resource by skuas [8,17]. Skuas also occasionally eat the feces of Weddell seals hauled out onto the fast ice (Figure 1), and fish at fishing points.



Figure 1. South Polar Skuas (*Stercorarius maccormicki*) feeding on Weddell seal (*Leptonychotes weddellii*) feces. Haswell Archipelago. 11 December 2012.

With the reduction in food availability in the Emperor Penguin colony, skuas switch to fresh Adélie Penguin eggs and chicks [8]. Fulmarine petrels are less frequently used by skuas as food during this period (for example, [8,17,21–24]. Starting from February [16] and in March, as terrestrial food resources on the islands become scarcer and more accessible, skuas often feed at sea. Skuas are reluctant to obtain food in water [7]. At the end of March – beginning of April, against the background of lowering air temperatures and increasing katabatic winds, feeding conditions for South Polar Skuas become very limited. They stop feeding on the ground and on the ice, which coincides with the end of their autumn migrations in the study area and their stay here (author's observations). It

should also be noted that from October to March, South Polar Skuas visited the Mirny Station food waste dump [10–12,16,19]. The lack of knowledge about the diet of seabirds at sea outside the breeding season is a major problem in research on their diet [25]. In this regard, the Haswell Islands population of South Polar Skuas is no exception.

On land, the diet of the South Polar Skua is comparatively well studied in many places in its breeding range [26]. However, detailed studies of the diet and feeding behavior of this bird species from the Haswell Archipelago have rarely been the focus of specific research interest among biologists [8,11,12], and thematic information has been scattered among various publications. They mainly contained fragmentary data on the use of certain food resources or brief reports on the feeding behavior of skuas.

Understanding what food resources and to what extent the breeding population of South Polar Skuas uses for annual reproduction is relevant in monitoring and local environmental management. In this regard, assessments of the impact of skua predation on populations of vulnerable and endangered seabirds in a changing climate are critical. This work is a summary document that synthesizes recent and historical data (1912–2016) from dietary studies and observations of feeding ecology in the Haswell Archipelago population of South Polar Skuas. The purpose of the study was to answer the question of how South Polar Skuas exploited the locally high diversity and abundance of living resources in the Haswell Islands, including in the face of long-term, year-round human activity in the area. Objectives: compile and analyze relevant historical and recent data on the qualitative and quantitative composition of the diet of South Polar Skuas. Secondary research questions: what feeding strategies do skuas use to obtain food; whether predation by skuas could influence the reproductive success of their prey; whether there was individual specialization in the prey of skuas.

2. Materials and Methods

2.1. Study Area

The Haswell Archipelago (66°31' S, 93°01' E) is located in the Davis Sea basin in Treshnikov Bay (Indian sector of the Southern Ocean) off the coast of Antarctica (Queen Mary Land). It includes 17 islands and 4 coastal nunataks. The islands and nunataks are located in a strip about 2.5 km wide and up to 3.5 km long. This strip is oriented in a northeast direction. The size of most islands is small. The largest rock in the archipelago is Haswell Island. Its area is 0.82 km², altitude – 93.1 m above sea level. The absolute altitudes of most islands do not exceed 35 m above sea level [27,28]. For the remainder of this study, all islands of the Haswell Archipelago except Haswell Island will be referred to as minor islands.

The weather pattern of the area is determined by frequent snowstorms, especially in winter, as well as strong katabatic winds. The average wind speed is 11.2 m/s, the maximum is 56 m/s. During the year, on average 204 days, the wind speed in the area of the Mirny Station exceeds 15 m/s. The maximum number of days with gale force winds is 247 and about 20–25 days with hurricanes. The predominant wind direction is east-southeast. The average annual air temperature is –11.3 °C, maximum 6.8 °C, minimum –40.3 °C. The area is rich in grounded icebergs. For most of the year the sea is covered with fast ice. In the Davis Sea, the maximum width of fast ice in September–October reaches 30–40 km [29].

Russian Antarctic research station Mirny (66°33′11″ S; 93°00′35″ E) served as a base for year-round zoological observations in the research area. It is located on the Mirny Peninsula (Pravda Coast) on rocks (nunataks) free of continental ice. Nunataks in some places contain sparse vegetation – mosses, lichens and algae. The average altitude of the station location is 39.9 m above sea level. Station opening date: 13 February 1956 [28,29].

An abundance of life characterizes the study area [30]. Various species of the genus Trematomus live in the coastal waters of the Davis Sea in the vicinity of the Mirny Station. Less common are the Antarctic toothfish and the Antarctic silverfish. The abundance of crustaceans, mollusks and fish supports a large number of breeding birds [28]. Nine seabird species breed at the Haswell Islands: Emperor Penguin, Adélie Penguin, Southern Fulmar (Fulmarus glacialoides), Antarctic Petrel

(Thalassoica antarctica), Cape Petrel (Daption capense), Snow Petrel (Pagodroma nivea), Wilson's Storm Petrel (Oceanites oceanicus), South Polar Skua and subspecies of Brown Skua (S. a. lonnbergi) [11]. Three species of cetaceans (sei whale (Balaenoptera borealis), Antarctic minke whale (Balaenoptera bonaerensis), killer whale (Orcinus orca) and 5 species of pinnipeds (southern elephant seal (Mirounga leonina), Weddell seal, crabeater seal (Lobodon carcinophaga), leopard seal (Hydrurga leptonyx) and Ross seal (Ommatophoca rossii)) have been recorded here. However, only the Weddell seal is the most abundant year-round resident species of seals of the archipelago breed annually [20]. Long-term and year-round activity people at the Mirny Station and in its environs involved activities to study and preserve the unique coastal ecosystem of the Haswell Islands. Therefore, Antarctic Specially Protected Area № 127 "Haswell Island and adjacent Emperor Penguin rookery on fast ice" (hereinafter ASPA № 127 "Haswell Island") [31] became the focus of periodic research activity of biologists.

2.2. Material and Research Methods

I made opportunistic observations of the feeding behavior of South Polar Skuas and collected food samples between 8 January 2012 and 7 January 2013 as well as between 9 January 2015 and 14 January 2016. This corresponded to the pre-breeding, breeding and post-breeding periods of the annual cycle of the South Polar Skuas. Observations were carried out in a sea area free of fast ice, on continental and sea ice, on islands and nunataks of the Antarctic coast. In 2012, 46 and in 2015, 15 hiking trips were made from the Mirny Station to the islands and to the Emperor Penguin colony. Each trip usually involved at least 2 people. In the Mirny Station, daily observations were carried out on the nunataks Radio, Komsomolsky and between them on the continental ice. The duration of work on the islands and on fast ice ranged from 3 to 5 hours, at the Mirny Station – from 1 to 8 hours a day. The area covered by the survey from the Mirny nunataks was about 8 km², but sometimes increased up to 12 km². The total area studied was about 17.5 km². Islands and sea ice were visited on foot during the fast ice period (April–December).

The focus of the study was immature and adult non-breeding and breeding birds. The diet of downy skuas chicks has not been studied. Unpublished and published historical data, based primarily on observations, served as an important additional information resource.

The author's sampling technique included direct observation of the feeding behavior of South Polar Skuas and their prey, collection of prey remains – pellets and regurgitates (spontaneous regurgitations), and stomach contents of dead birds. In the study area, the author collected and examined 55 pellets, 3 spontaneous regurgitates and the stomachs of 2 dead feathered individuals. Prey remains of South Polar Skuas (mainly the carcasses of penguins and petrels or their fragments) were also recorded, but the total number of samples detected was not recorded.

Determination of the qualitative composition of prey remains (bird corpses and their fragments) was carried out by direct year-round observations in the field in the places where they were found. Pellet, spontaneous regurgitation and stomach contents of dead birds were identified in the laboratory. The pellets were collected in plastic bags. Under station conditions, the pellets were measured and air dried. Samples were stored in a dry and dark place. Before a detailed study of the samples in the laboratory, the contents of the pellets were soaked in water, fragmented into small components and identified. Prey of avian species was identified to the species level, although some components (chick down or petrel bones) in pellets were sometimes identified to a higher taxonomic rank, such as order (n = 6). Fish bones and scales and cephalopod beaks were not identified to species rank (n = 6).

Qualitative and some quantitative parameters of the diet were analyzed. The research approach and terminology in studying the diet of skuas was based on the review by K. Reinhardt and colleagues [4] with modifications by the author. The determination of the foraging mode status of South Polar Skuas, based on the author's data, was carried out through numerous recordings of their feeding behavior, including the use of digital cameras. Identification of the feeding status of each prey category (e.g., adults, chicks, eggs) of a particular species, higher-ranking taxon, or other inclusions (kitchen refuse) contained in the historical data was made by the author based on details

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of observations and researcher interpretations of relevant publications. The analysis of the diet of South Polar Skuas did not use historical data containing general phrases that do not convey specific, valuable scientific information about the subject of the study. For example, it is not clear from which colonies of Emperor and Adélie penguins in East Antarctica E.S. Korotkevich [7] presented observations of the feeding behavior of South Polar Skuas. The frequency of occurrence (FO) was calculated by the formula FO = $(f_i/N) \times 100$, where f_i is the number of pellets with item i and N is the total number of pellets [32].

In 2012, the number of frozen eggs and chicks of Emperor Penguins, an important food source for South Polar Skuas during the pre-breeding and breeding periods, was determined using the cumulative method [33], i.e., periodic counts of frozen eggs and chicks. The size of the skuas breeding population in 2012 was determined by direct counts of active nests. A pair with a clutch of eggs or chick(s) was identified as a breeding pair.

2.3. Equipment

In the field, the feeding behavior of South Polar Skuas was observed using 8 × binoculars. Digital images and videos were obtained using a hand-held Canon 60D digital camera fitted with Sigma 50–500 mm zoom lens and with a portable digital camera Sony Cyber-shot DSC-WX220 Black. A Garmin eTrex 30^{TM} GPS recorder was also used to record geographic coordinates. Digital image processing was carried out at the station on a laptop computer. Linear dimensions of pellets and spontaneous regurgitation (their length and width) measured to \pm 1.0 mm using Vernier calipers. Data visualization and statistical analysis were carried out in 3 programs: Google Earth Pro 2022 (USA); Adobe Photoshop CC 2015.0.0 Portable Version (USA); Microsoft Excel 2013 (USA).

3. Results

In this section, the research results are presented with historical information and data from the author. A compilation of historical data on the qualitative composition of the diet of South Polar Skuas contains information from individual researchers on the name and status of prey, feeding mode, and sampling technique (Table 1).

Table 1. Historical data on the qualitative composition of the diet of South Polar Skuas (*Stercorarius maccormicki*) of the Haswell Archipelago, 1912–2011.

Name of species/status of preyForaging modeSampling techniqueReferences			
	Mammals		_
Leptonychotes weddellii			
Adults	S	O	[16,34]
Placenta	S	O	[8,17]
Birds			
Aptenodytes forsteri			
Adults	S	Ο	[8,33]
Chicks	S,P	O	[8,17,33–35]
Eggs	S	O	[8,33]
Pygoscelis adeliae			
Adults	S,P	O	[12,16]
Chicks	S,P	O	[8,12,16,36]
Eggs	S,P	O	[8,16,30,36]
Fulmarus glacialoides			
Adults	?	O	[16]
Chicks	S	O	[8,23]
Eggs	S	O	[8,17,23]
Thalassoica antarctica			
Adults	?	Ο	[16]

Eggs	P	Ο	[21]
Daption capense			
Adults	?	O	[16]
Chicks	S,P	O	[24]
Pagodroma nivea			
Chicks	?	O	[24]
Oceanites oceanicus			
Chicks	?	O	[22]
Stercorarius maccormicki			
Chicks	S,P	O	[8]
Eggs	S	O	[8]
Fish			
Unidentifi fish items	?	?,C	[12,16]
Invertebrates			
Crustaceans	?	?	[16]
Cephalopods	?	?	[16]
Anthropogenic items			
Kichen refuse	S	O,C	[12,16]

Captions for Table 1. The foraging strategy of skuas: scavenging (S); predation (P); ? – feeding strategy is not clear. Sampling technique of the observer: direct observation (O); stomach contents (C); ? – sampling technique is not clear. In flying birds (tube-nosed birds and skuas), the category "chick" includes individuals that have not reached the flight stage. Fully feathered and flying birds are treated as adults (mature and immature). In penguins, chicks are called individuals in downy plumage.

The author's data (2012–2016) include information on the qualitative (direct observations, studies of pellets, spontaneous regurgitation and stomachs of dead birds) and quantitative (pellets) composition of food samples of South Polar Skuas (Tables 2 and 3).

Table 2. Data on the qualitative composition of the diet of South Polar Skuas (*Stercorarius maccormicki*) of the Haswell Archipelago, 2012–2016.

Name of species/status of prey	Foraging mode	Pellets, n=55	Regurgitations, n=3	Stomach contents, n=2
MAMMALS				
Leptonychotes weddellii				
Feces	S	_	_	_
BIRDS				
Aptenodytes forsteri				
Chicks	S	+	_	_
Eggs	S	+	_	_
Spontaneous regurgitation in adults	S	_	_	_
Pygoscelis adeliae				
Adults	S,K	+	+	+
Chicks	?	+	_	_
Eggs	P	+	_	+
Fulmarus glacialoides				
Adults	P?	+	_	_
Daption capense				
Adults	P?	_	_	_
Pagodroma nivea				
Adults	?	+	_	_
Unidentifi fulmarine items	?	_	+	_

Stercorarius maccormicki				
Adults	?	+	_	_
FISH				
Unidentifi fish items	S	+	_	_
INVERTEBRATES				_
Cephalopods	?	+	_	_
MINERAL ITEMS				_
Stone and gravel fragments	?	+	_	+
ANTHROPOGENIC ITEMS				_
Kichen refuse	S,K	+	_	_
Station garbage	?	+	+	_

Captions for Table 2. The foraging strategy of skuas: scavenging (S); predation (P); feeding strategy not established, but predation is assumed (P?); feeding strategy not established (?); kleptoparasitism (K). "+" – the prey category is present in the sample, "—" – the prey category is absent in the sample.

Table 3. Quantitative representation of prey categories (n) and frequency of occurrence of food samples (FO%) in 55 pellets of South Polar Skuas (*Stercorarius maccormicki*) of the Haswell Archipelago, (2012, 2015).

Prey category	n I	FO (%)
Antarctic penguins	42	76.3
Fulmarine petrels	13	23.6
Skuas	2	3.6
Fish	5	9.0
Cephalopods	1	1.8
Stone and gravel fragment	ts21	38.1
Kichen refuse	5	9.0
Station garbage	2	3.6

Sample size of pellets, mm, m \pm SD (min – max), n = 31: 51 \pm 14.3 (30–84) \times 30 \pm 7.0 (17–42), median size 49 \times 29. The largest stone in the examined pellets had size 17 \times 28 mm. Three spontaneous regurgitation samples found in February and March 2012 contained feathers, skin, bones and muscle tissue from adult Adélie Penguins, as well as bones from tube-nosed birds. A piece of glass was found in one of the three samples. Size of one sample: 111 \times 38 mm. In November 2012, the shell and feathers of an Adélie Penguin were found in the stomach of one dead individual of the South Polar Skua; the stomach of the second dead individual was empty. Both stomachs contained gravel.

In general, among vertebrate animals, South Polar Skuas used as food 1 species of seal (Weddell seal), 8 species of birds (Emperor Penguin, Adélie Penguin, Southern Fulmar, Antarctic Petrel, Cape Petrel, Snow Petrel, Wilson's Storm Petrel, South Polar Skua) and fish. Five non-breeding bird species of the archipelago (Chinstrap Penguin (*Pygoscelis antarctica*), Macaroni Penguin (*Eudyptes chrysolophus*), Southern Giant Petrel (*Macronectes giganteus*), Pomarine Jaeger (*Stercorarius pomarinus*), Kelp Gull (*Larus dominicanus*) and 1 subspecies of Brown Skua, which breeds in mixed pairs with the South Polar Skua on Haswell Island) were not recorded in the diet. Invertebrates in the skua's diet consisted of cephalopods and crustaceans. Native vegetation (mosses and lichens) was not present in food samples and was not confirmed by direct observations. In addition, plant components of anthropogenic origin (vegetable and fruit remains) were consumed if skuas visited the food waste dump at the Mirny Station ([16], author's observations). Stone and gravel fragments were a mineral component of some food samples. Anthropogenic components (station garbage and kichen refuse) were also identified in some pellets and 1 sample of spontaneous regurgitation. Thus, the composition of the diet of South Polar Skuas included animal (vertebrate and invertebrate organisms), plant, mineral and anthropogenic components.

Antarctic penguins dominated in the frequency of occurrence of samples in the 55 studied pellets, where Adélie Penguin samples were found in 35 (63.6%) pellets, and Emperor Penguin

samples in 7 (12.7%). Procellariiforms were recorded approximately 3 times less often in the samples. Occurrence rates of other prey categories of South Polar Skuas were low, but were dominated by fish and kitchen refuse. Cephalopods and station garbage were minimally represented in the samples. Stone and gravel fragments turned out to be an important component of pellets and in terms of frequency of occurrence of samples they were second only to samples from Antarctic penguins.

4. Discussion

The results of the research established that the diet of South Polar Skuas consists of a wide range of consumed foods. The results of research and observations confirm the critical role of eggs and chicks of Emperor and Adélie penguins as a food resource in maintaining the skua population [37] during pre-breeding and breeding periods. For example, in 2012, 1010 eggs and 169 chicks froze in the Emperor Penguin colony alone. And by the end of the second ten days of December, almost all the eggs and chicks were eaten by skuas. It should be noted that the proximity of the Emperor Penguin colony, where skuas receive abundant food, is a distinctive feature of the diet of the Haswell population of these predators.

The author's data also confirms the conclusion of M.E. Pryor [8] that in the study area the South Polar Skua uses abundant bird species (Emperor Penguin, Adélie Penguin and Southern Fulmar) for food. Although, for example, the contribution of other breeding bird species on Haswell Island to the food supply of skuas is small [8]. The conclusion about the minor importance of fulmarine petrels in the diet of skuas [8,21] was supported by subsequent observations [22,24] and in studies of pellets collected in 2012 and 2015. Elsewhere in East Antarctica, on the coast or some distance from it, the diet of South Polar Skuas is also based on the most abundant bird species – Antarctic penguins and fulmarine petrels. However, the proximity of Antarctic stations contributes to the significant dependence of skuas on kitchen waste [38–47].

Fish, crustaceans and cephalopods have been present in the diet since February [16], when the sea was free of fast ice. Native fish were rarely present in the diet of skuas. In pellets, it could have come from the sea, from the contents of the stomachs of victims, and from a fast ice fishing point near Cape Mabus at the Mirny Station, where up to 40 South Polar Skuas gathered at the same time. Fragments of fish skeletons from the Mirny Station were not recorded in the pellets. Cephalopod beaks found in 1 skua pellet, containing mostly feathers and bones of an adult Snow Petrel, may have originated from the stomach of its petrel. Crustaceans were not represented in the samples, although E.E. Syroechkovsky [16] observed skuas feeding on crustaceans during the ice-free period. The above can be explained by the fact that all the studied samples belonged to the period preceding the feeding of skuas in the sea.

Kitchen waste was rarely found in pellets. There was no information in historical publications about the content of stone, gravel fragments and station garbage in the food of South Polar Skuas (for example, [8,12,16,17]). A study of the samples revealed the presence of station garbage (fragments of macroplastic) in 2 pellets [48] and a glass fragment in 1 sample of spontaneous regurgitation, as mentioned above. However, the presence of stone and gravel fragments in the digestive tract in almost half of the studied pellets and in the stomachs of 2 dead skuas indicates the importance of the use of mineral components during the assimilation of prey by South Polar Skuas.

The breeding population of South Polar Skuas in the Haswell Archipelago does not fly to the edge of fast ice to feed. While non-breeding individuals have been repeatedly observed flying northwards or from the north to the archipelago islands and nunataks of Antarctica. Skuas rarely use the surface of sea water to obtain pelagic resources, for example, the remains of Adélie Penguins, which were the result of leopard seal predation ([12,16], author's observations).

South Polar Skuas obtain food using 3 main feeding strategies: scavenging, predation and kleptoparasitism [4]. Carrion was used by skuas throughout their seasonal stay on the archipelago. This is the main way of obtaining food for South Polar Skuas [7,8,12,23,35,36,49].

Egg predation has not been observed in the Emperor Penguin colony because the Emperor Penguins complete egg incubation before the South Polar Skuas arrive at the breeding grounds. However, very rarely did South Polar Skuas resort to active predation on weakened Emperor

Penguin chicks [8,33,35], and skua predation did not affect brood survival [8]. There is only one poorly documented indication of successful predation by South Polar Skuas on healthy Emperor Penguin chicks [34].

In 2012, no cases of South Polar Skuas attacking Emperor Penguin chicks were recorded, although observations in the colony were made by the author relatively often. Apparently this was due to a significant abundance of frozen eggs and chicks and the availability of food resources for skuas after wintering. This circumstance could neutralize predation, although weakened Emperor Penguin chicks were occasionally observed in the colony.

Adélie Penguins suffered most from predation by skuas [8,17], but predation was rare in Adélie Penguin colonies [8]. Sick or injured (dog bites) adult Adélie Penguins became victims of skuas [16]. Chicks in the early stages of development were frequent victims of skuas [7,36]. Successful predation on large chicks was also recorded [16]. Predation of South Polar Skuas on Adélie Penguin eggs has been observed since 1912 [30]. During the 2012/2013 breeding season, predation by skuas on Adélie Penguin eggs was observed by the author on the small islands of the Haswell Archipelago.

I did not obtain direct evidence of skuas predation on fulmarine petrels, although the concentration of skua-eaten adult Cape Petrels (5 individuals) on an approximately 1 m² feeding table of one skuas on Haswell Island indirectly indicated clear predation. This is also true for adult Southern Fulmars. One of the pellets found on Haswell Island contained the feathers and bones of a Snow Petrel, which may have been the result of predation by a skua. Historical data also indicate repeated recordings of remains of adult Southern Fulmars, Antarctic and Cape Petrels on Haswell Island [16]. M.E. Pryor [8] noted that the Antarctic Petrel does not suffer much from predation by skuas, and egg losses from skua raids are negligible [21]. The fact of direct predation on a weakened Cape Petrel chick was established [24]. Thus, predation by skuas on fulmarine petrels occurs, but it is not the determining strategy for obtaining food. Predation of skuas on chicks of their own species (cannibalism) expelled from nests in neighboring territories has been observed frequently [8]. Hunting of South Polar Skuas in marine waters, possibly for fish and invertebrates, was very rarely observed before freeze-up.

Kleptoparasitism was observed from October to March. Intraspecific and interspecific (between South polar and Brown Skuas) kleptoparasitism was established on food waste from the Mirny Station. Intraspecific kleptoparasitism was also identified when the remains of Adélie Penguins, victims of the leopard seal, were disposed of at sea by a group of South Polar Skuas.

Individual specialization in feeding and feeding strategies of South Polar Skuas has not been established, but has been documented in the coastal breeding populations of Brown Skua in the Southern Hemisphere and Great Skua (*Stercorarius skua*) in the Northern Hemisphere [50]. However, individuals or pairs of South Polar Skuas from the Haswell Islands may have specialized in diet. An example in the 2012/2013 breeding season could be the discovery of 5 adult birds of this species in one of the subcolonies of Cape Petrels on Haswell Island, undoubtedly caught and eaten by South Polar Skuas, as mentioned above. At least 3 pairs of South Polar Skuas fed almost exclusively on eggs and young Southern Fulmars during the 1962/1963 breeding season [8,17].

To summarize, it should be noted that in the future it is very important to organize targeted research on the impact of South Polar Skuas on the breeding success of Adélie Penguin and fulmarine petrel populations. From a comparative point of view, the study of predation on skuas breeding on Haswell Island and the small islands of the Haswell Archipelago is of particular interest. Studying a larger number of pellets and combination of different nutrition research methods could expand the already known dietary spectrum of the species off the Davis Sea coast. The diet and feeding ecology of adult South Polar Skuas on the Haswell Islands during periods of strong fast ice breakdown and removal from the study area (usually January and early February), as well as the absence of fast ice (usually February–March) and the diet of downy chicks remain a gap in our knowledge. At the species level, the taxonomic composition of squid and fish consumed by skuas, partly fulmarine petrels, remains unknown. Finally, it is necessary to continue the quantitative recording of kitchen waste in pellets against the background of reduced access to it, and non-food waste from the Mirny Station. All of the above aspects require detailed verification in the future.

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5. Conclusions

1. In the ecological conditions of the Haswell Archipelago, the maintenance of the population of South Polar Skuas was ensured by feed on terrestrial resources, mainly on breeding bird species. Surface feeding at sea was observed in the post-breeding period, when the availability of land-based food resources was reduced.

- 2. The dominant prey in the diet of South Polar Skuas were vertebrates.
- 3. Antarctic penguins make up the bulk of the skuas' diet during the pre-breeding and breeding periods.
- 4. During the historical period, kitchen waste became an additional component of the diet that supported the skua population.
- 5. Scavenging is the leading strategy for obtaining food by South Polar Skuas. Predation is a minor food acquisition strategy. It was recorded mainly on eggs and chicks of Adélie Penguins. Kleptoparasitism has rarely been recorded on natural food resources, but is more common when skuas used food waste from the Mirny Station.
- 6. South Polar Skuas do not affect the breeding success of Emperor Penguins if they feed on frozen chicks and eggs in their colony, including live weakened chicks doomed to death. However, predation by skuas affects the breeding success of Adélie Penguins, fulmarine petrels and South Polar Skuas, but the extent of the impact has not been established.
 - 7. Individual specialization in diet is possible in individuals and pairs of South Polar Skuas.

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