POLISH POLAR RESEARCH (POL. POLAR RES.) POLSKIE BADANIA POLARNE	5	1–2	5–16	1984

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Distribution, numbers and breeding preferences of penguins in the region of the Admiralty Bay (King George Island, South Shetland Islands) in the season 1979/1980 *)

ABSTRACT: The number of breeding pairs of penguins nesting in the Admiralty Bay region during the 1979/1980 summer was as follows: *Pygoscelis papua* — 3703, *P. adeliae* — 32918, *P. antarctica* — 8237. Due to diverse preferences in selection of the breeding-site environment and varying numerousness and structure of the colonies of these species the conditions of the outflow of faeces to the sea varied considerably. Long period records of the populations of penguin colonies around Pt. Thomas and Llano Pt. show increase in the number of breeding pairs of *P. papua* and *P. antarctica* and an increase in the number of *P. adeliae* at Llano Pt., while at Pt. Thomas the data approximate the records for the summer 1909.

Key words: Antarctic, penguins

1. Introduction

The problem of quantitative evaluation of penguins in the Admiralty Bay region was the subject of studies of many authors: Gain (1914); Conroy (1975); C. Müller-Schwarze and D. Müller-Schwarze (1975); Croxall and Kirkwood (1979); Trivelpiece and Volkman (1979); Volkman and Trivelpiece (in press). The results from those studies show great changes in the distribution and abundance of various species of the genus *Pygoscelis* occurring throughout the last 70—80 years. The aim of this study is to illustrate the actual state of distribution and numbers of penguins in the region of Admiralty Bay and to describe in detail

*) These studies were carried out in the course of the Third. Fourth and Fifth Polish Expedidions to the H. Arctowski Station during the years of 1978—1981. The expeditions were organized by the Institute of Ecology, Polish Academy of Sciences.

the environment of their breeding sites. These observations were a part of complex ecological researches carried out in this area during the summer 1979/1980.

2. Investigation area and methods

Materials for this study were collected from December 10th 1979 till the end of February 1980. Data from the 1978–1979 observations (Jabłoński, in prep) and 1980–1981 (materials unpublished) are included in the discussion hereinafter. The area of the investigations covered a 90-kilometre-long stretch of the coast between the Harnasie Hill and the Red Hill. The names of the characteristic features of the terrain are used after Birkenmajer (1980a). The analysis of geographical and meteorological conditions of the Admiralty Bay region was made by Rakusa-Suszczewski (1980). Characteristic of the environment of penguin breeding sites is based on the analysis of the structure of the substrata of nest-sites and inclination of the slopes, using a detailed geological description of that region (Birkenmajer 1980b, c) c). The following types of environment were distinguished:

1. Storm-ridges — elevated from 1 up to 3 m high above mean sea level. They were formed of pebbles and run parallel to the shoreline, at a distance from the sea, ranging from a few up to 30 m. Nests were found mostly on the protruding part of the ridge, omitted by the run-offs from the melting snow. The washed out faecal matter sinks promptly into the soil through permeable substratum (pebbles, gravel). Penguins occurred in very large numbers in that type of environment, especially at Llano Pt.

2. Raised terraces and cliffs covered with small rubble, bordered on one side by a steep wall rising 10-30 m high above sea level. Nesting-sites were located on a gently inclined ledge covered with a layer of small stones on a rock-bed. The outflow of water from the breeding area into the sea run in one or several directions. The length of the run-offs ranged from 20 to 450 m. This type of environment was found on the hill between Halfmoon Cove and Rakusa Pt. and in the region of the Rescuers Hills near Llano Pt.

3. Dry moraines on weathered lava flows. This environment was formed by top fragments of moraines deposited on impermeable lava-flow bedrock, raised 20-30 m above mean sea level and about 250 m distant from the sea. Washed away penguin faeces permeate through morainic debris and stream along over large sheets of flows towards the beach. This type of environment was observed at Llano Pt.

4. Dry moraines — near to shore, not frozen at the base, overgrown

with lichen and tufts of *Deschampsia antarctica* were raised up to about 3 m above the level of the storm-ridge. Nest-sites on this type of moraines were observed in the vicinity of the Ecology Glacier.

5. Flat or gently inclined terraces and cliffs with protruding fragments of rocky shelves. Small areas of this type of environment occurred usually on the border of the Environment No. 2, described-above or on small monadnocks between the beach and raised terraces.

6. Weathered monadnocks in columnar and tabular strata and lava flows; flat, elevated tract of land. This type of environment occurred in close proximity of the sea on narrow socky promontories (e.g. rookeries at Uchatka Pt. and Patelnia Pt.). Nests were located on the rocky surface, from which water ran quickly away along the fissures in the steep rocks.

7. Steep slopes of magma intrusions, lava plugs and lava flows (blocks, slabs). This type of environment occurred also in close proximity of the sea and was characterized by a one-way direction of the outflow of water (rookeries at Demay Pt., Chabrier Rock and Shag Rocks).

The number of breeding pairs was determined on the basis of the number of nest occupied by breeding birds. In consideration of a very differentiated density of nest-sites of the investigated species of penguins (C. Müller-Schwarze and D. Müller-Schwarze 1975) different methods of counting were used for particular species.

The abundance of *Pygoscelis papua* (Forster) breeding pairs was determined on the basis of 5 counts performed at different times in the same breeding colonies. Compact aggregations of breeding groups of this species more than 30 pairs were divided into subsequent sectors to avoid repeated counting of the same nests.

The abundance of breeding colonies of *Pygoscelis adeliae* (Hombron and Jacquinot) and *Pygoscelis antarctica* (Forster) was determined on the basis of photographs taken from the cliffs and counts in one-metre-wide strips of the nesting ground. For estimation of breeding colonies of more than 500 nests the method of experimental surface areas was used.

In sum, the following number of counts of the investigated penguin species was carried out in various rookeries: *P. adeliae* — large colonies of more than 1000 breeding pairs were counted four times, smalle colonies — six times; *P. antarctica* — at Shag Rock and Chabrier Rock — twice, in the region of Pt. Thomas and Llano Pt. — six times, at Demay Pt., — Uchatka Pt. and Patelnia Pt. — four times. A detailed description of these methods is given elewshere (Jabłoński in prep.). The experimental surface areas in the region of Pt. Thomas made up 38.4% of the total areas of large colonies; in the region of Llano Pt. — 19.5%; at Chabrier Rock — 68.4%; and between Demay Pt. and Patelnia Pt. — 72%.

3. Results

P. papua nested in 3 rookeries (Fig. 1, Table I). The total number of breeding pairs was 3703, out of which 182 pairs (4.9%) nested together with *P. adeliae*. There were two rookeries of *P. adeliae* in the same regions of Admiralty Bay (Fig. 1, Table I). Of the total number of 32918 nests of *P. adeliae* only 10 were located within *P. papua* breeding colony, while 2492 (7.6%) were found on the border of *P. papua* colonies. *P. antarctica* nested more frequently in one-species rookeries (Patelnia Pt., Uchatka Pt., Demay Pt., Chabrier Rock, Shag Rocks) than in mixed-species rookeries in the company of *P. adeliae* (Llano Pt., Pt. Thomas) (Fig. 1, Table I). *P. antarctica* of the Admiralty Bay region did not form mixed-species colonies with *P. papua*. This was due to dissimilar preferences of these species in selection of nesting sites (Table II). *P. antarctica* nested for the most part in places with impermeable substrata (rocky blocks,

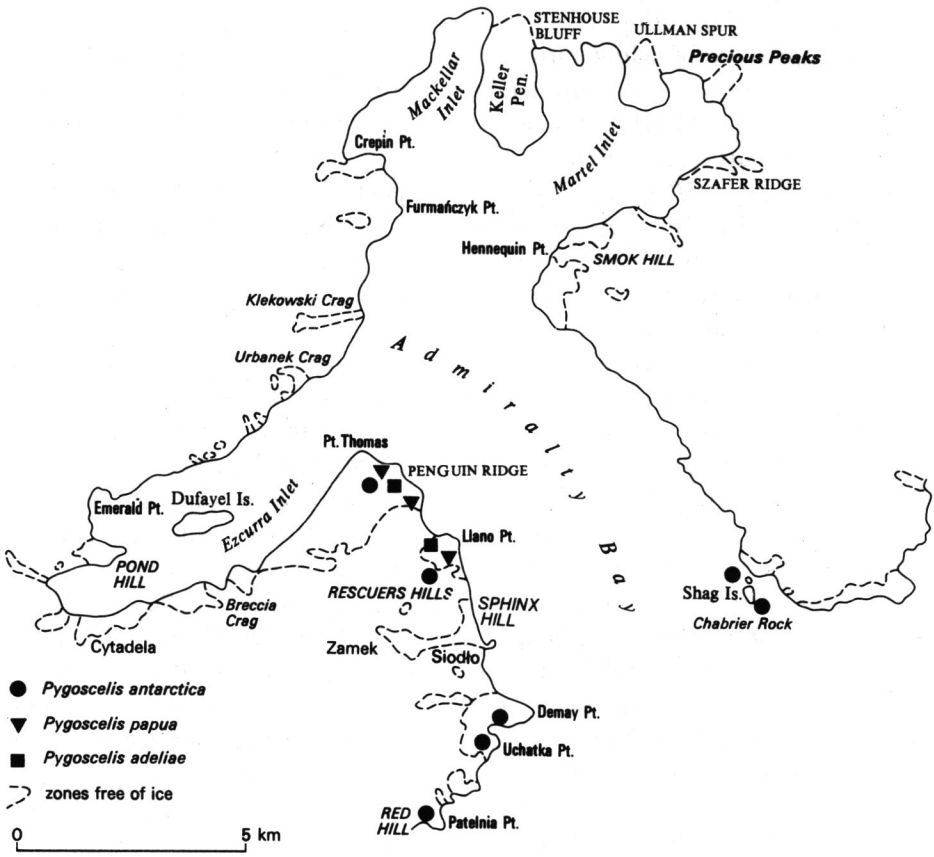

Fig. 1. Breeding colonies distribution of three penguin species in the Admiralty Bay region

Table I

Distribution and abundance of penguin rookeries in the Admiralty Bay region, 1979/1980

Species	Location	Number of pairs	Number of colonies
Pygoscelis papua	Llano Pt.	3008	44
	Pt. Thomas (E-Ecology Glacier)	243	4
	Pt. Thomas (W)	452	15
Pygoscelis adeliae	Llano Pt.	15013	20
	Pt. Thomas	17905	9
Pygoscelis antarctica	Patelnia Pt.	2252	5
	Uchatka Pt.	2104	2
	Demay Pt.	652	2
	Llano Pt.	314	7
	Pt. Thomas	390	5
	Shag Island	486	1
	Chabrier Rock	2039	2

lava flows, etc.). Breeding pairs of *P. antarctica* nesting on raised terraces in the vicinity of *P. adeliae* rookeries built their nests on rocky substrata. These birds made up barely 1.6% of the total number of *P. antarctica* breeding pairs. *P. papua* nested in greatest numbers on storm-ridges (Table II), avoided by the run-offs from the glaciers. An earlier development of young birds observed in the colonies located on dry moraines, weathered lava flows, raised terraces and cliffs suggests that these types of environments were occupied by breeding pairs much earlier than storm-ridges.

Differences in altitude did not play a decisive role in the nest-site selection by *P. papua* and *P. antarctica* since as many nests of these species were found on the sea-shore as on the elevations of more than 30 m above mean sea level. The most numerous breeding colonies of *P. adeliae* were found at the height of 20-30 m above sea level but maybe it occurred in result of the presence of vast, flat surfaces of the ground most often selected by this species for nesting.

Some differences may be observed in the selection of slopes with different angle of inclination for nesting sites. The maximum inclination of the slopes within the breeding sites of *P. papua* and *P. adeliae* was in the range of 40-50°, and for *P. antarctica* 60-80°. In all likelihood, these preferences may be justified by differences in the movement possibilities of these birds. *P. antarctica* are able to jump quite well across blocks of rock, whereas *P. papua* and *P. adeliae* are merely able to walk on smooth surfaces. In fact, some of the ways of *P. adeliae* access to the rookery led indeed

Table II.

Environmental preferences of penguins in nest-site selection in the Admiralty Bay region

Environment	Number and percent of breeding pairs		
	Pygoscelis papua	*Pygoscelis adeliae*	*Pygoscelis antarctica*
Storm-ridges	1564 — 42.2%	1278 — 3.9%	—
Raised terraces and cliffs covered with fine debris	817 — 22.0%	314 — 0.9%	—
Dry moraines on weathered lava flows	1036 — 28.0%	31216 — 94.8%	133 — 1.6%
Dry moraines (near-shore)	243 — 6.6%	—	—
Flat or gently inclined raised terraces and cliffs with protruding fragments of rock slabs and blocks; small monadocks	43 — 1.2%	110 — 0.3%	572 — 6.9%
Monadocks and lava flows weathered in columnar and tabled strata; level land, elevated	—	—	4356 — 52.9%
Steeps slopes of magma intrusions, lava plugs and lava flows	—	—	3177 — 38.6%
Total	3703	32918	8237

across snowdrifts inclined about 70°, but these pathways were smooth and without obstacles high enough to make jumping over inevitable. Thus, too steep inclination of the slopes and the presence of rock boulders are the factors limiting the range of *P. adeliae* and *P. papua* nesting-sites.

P. papua nested in 63 breeding colonies consisting on the avearge of 63 nests, each (Table III). Breeding groups of up to 30 nests made up in sum 49% of all the breeding colonies. On the basis of the phenology of reproduction it may be assumed that nest-sites with large breeding colonies were occupied earlier. The characteristic feature of the breeding grounds on storm-ridges and moraines is the convex surface of these areas. 82% of all the nests were located in this region. Due to this type of land configuration faecal matter was carried off in two directions — to the sea shore and to the depressions of the land between moraines or cliffs, where small bodies of water occur periodically.

P. adeliae nested in 29 breeding colonies (Table III), consisting on the average of 1135 nests, each. Breeding groups of 100 up to 500 nests made up 41% of all the breeding colonies. The four largest breeding groups

Table III.

Structure of penguin nesting colonies in the Admiralty Bay region

Number of birds in a colony	*Pygoscelis papua*		*Pygoscelis adeliae*		*Pygoscelis antarctica*	
	Number of nests	Number of colonies	Number of nests	Number of colonies	Number of nests	Number of colonies
1 — 10	54	8	17	3	16	3
11 — 20	192	12	17	1	28	2
21 — 30	270	11	26	1	21	1
31 — 40	130	4	34	1	75	2
41 — 50	227	5	—	—	41	1
51 — 60	315	6	53	1	—	—
61 — 70	270	4	—	—	—	—
71 — 80	300	4	—	—	79	1
81 — 100	252	3	262	3	170	2
101 — 200	423	3	813	5	340	2
201 — 500	736	2	2276	7	1822	5
501 — 1000	534	1	948	1	2194	3
1001 — 2000	—	—	1947	1	3451	2
2001 — 3000	—	—	2488	1	—	—
3001 — 4000	—	—	6291	2	—	–
> 4000	—	—	17746	2	—	–
Total	3703	63	32918	29	8237	24

were located on the slopes of the raised terraces and cliffs covered with fine rock debris. Due to the configuration of the land the outflow of organic matter from large *P. adeliae* colonies in the region of Llano Pt. was carried off by one road towards the sea, whereas in the region of Pt. Thomas in three different ways: through a small lake separated from the sea by a storm-ridge, through a peat-bog and small lake, and directly into the sea.

P. antarctica nested in 24 breeding colonies (Table III), consisting on the average of 343 nests, each. Breeding groups of 200 up to 1000 nests made up 33% of all the breeding colonies. Small breeding colonies of this species occurred usually on the outskirts of the breeding groups of *P. adeliae* in the places where raised terraces and cliffs covered with fine rock debris ended in rock blocks or slabs. Abundance of these small groups of birds was conditioned by the surface area of rocky substratum. 33% of the nests of this species were located on the steep slopes of cliffs with a wide, one-way outflow of faecal matter into the sea, 45% of nests were located on rocky promontories sloping both ways towards the sea.

4. Discussion

Three species of penguins nesting in the region of Admiralty Bay are characterized by dissimilar preferences in nest-site selection, which makes

possible to occupy small ice-free areas to the full and form mixed rookeries. Greatest differences in the nest-site selection occurred between *P. papua* and *P. antarctica* and consequently these two species did not form mixed colonies in that region. Large *P. adeliae* colonies of several thousand birds occurred also in other places with configuration of the land different from that of the sites occupied by *P. papua* and *P. antarctica,* whereas smaller *P. adeliae* colonies of several hundred birds nested in the immediate vicinity of *P. papua* colonies. A few cases of *P. papua* nesting within the range of *P. adeliae* breeding groups were observed as well as *P. adeliae* nesting within the range of *P. papua* breeding groups. In the peripheral areas of large *P. adeliae* colonies *P. antarctica* was observed nesting in mixed species groups. Trivelpiece and Volkman (1979) described numerous cases of direct competition between different species nesting in mixed rookeries, which gave in result less effective hatch. The peripheral character of these competitive processes has no broader biocenotic aspects, since they occur in an additional nesting space (Jabłoński 1967).

The collected materials allow to surmise that the size of the surface with an adequate substratum is a decisive factor in selection of penguin nest-sites. In the case of *P. papua* and *P. adeliae* the angle of the inclination of the slope and the character of rock debris may also play a role of a limiting factor, since they are connected with differences in movement possibilities of these penguin species. According to Syroečkovskij (1959, 1966) rock boulders more than 50 cm high make the passage of *P. adeliae* impossible. Observations from Cape Crozier (Oelke 1975, 1979) corroborate the assumption that altitudes do not play any important role in the selection of nesting-sites. The above materials and other (Starck 1980) suggest however that the size and structure of *P. adeliae* breeding colonies may be limited by environmental conditions. At Cape Crozier where only small ice-free areas suitable for nesting were found the greater part of *P. adeliae* breeding groups numbered up to 200 pairs of birds. In the Admiralty Bay region this species nested in much more numerous groups since the available nest-sites on raised terraces and cliffs were much larger.

Differences in configuration of the land and in number of penguin populations suggest that these three species may play a different part in the organic matter circulation between the land and the sea. It seems that dead organic matter brought by birds ashore returns to the sea in the quickest way from *P. antarctica* nest-sites, owing to their location on impermeable substrata, in immediate vicinity to the shoreline and quite often on steep slopes. *P. adeliae* occurred in greatest numbers in the Admiralty Bay region and showed the highest density of population in their rookeries.

The hitherto literature data dealing with penguins of the genus *Pygoscelis* in the Admiralty Bay region qualify for verification of the names of particular

rookeries and a thorough study of the tendencies of the long-period changes in penguin populations. It seems that in accordance with historical tradition the name "Point Thomas" should be retained as the definition of the rookery localized in the vicinity of the H. Arctowski Station (Croxall and Kirkwood 1979). A group of rookeries in the region of Sphinx Hill is separated from that rocky hill by a glacier extending over an area of about 1 km^2 (Croxall and Kirkwood 1979). It would be more exact, therefore, to name that particular group of rookeries after a characteristic, nearer-by topographic spot, i.e. Llano Point. No traces of *P. antarctica* rookeries were found in the region of Point Hennequin (as described by Croxall and Kirkwood 1979). Only small groups of these birds were observed over there in the moulting season. At Chabrier Rock merely *P. antarctica* rookery was observed in the years 1978-1981. The present configuration

Table IV.

Changes in penguin populations in the Admiralty Bay region

Location	Dates of counts	Number of breeding pairs		
		P. papua	*P. adeliae*	*P. antarctica*
Pt. Thomas	1909 (Gain 1914)	100	10000	—
	1957 (Stephens 1957 after: Croxall and Kirkwood 1979)	200	1000	500
	1966 (White 1966 after: Croxall and Kirkwood 1979)	1420	8600	200
	1977/87 (Trivelpiece and Volkman 1979)	700	11000	750
	1978/79 (Jabłoński in prep.)	804	8250	665
	1979/80 (Jabłoński unpublished data)	695	17905	390
	1980/81 (Jabłoński unpublished data)	623	9310	526
Llano Pt.	1957 (Stephens 1957 after: Croxall and Kirkwood 1979)	100	500	250
	1966 (White 1966, after: Croxall and Kirkwood 1979)	732	1600	40
	1977/78 (Trivelpice and Volkman 1979)	1900	7000	290
	1978/79 (Jabłoński in prep.)	2334	13520	321
	1979/80 (Jabłoński unpublished data)	3008	15013	314
	1980/81 (Jabłoński unpublished data)	1510	7095	349

of the land excludes the possibility of *P. adeliae* nesting in that area, though they occurred in that region in 1909 (Gain 1914). In the Demay Pt. region two breeding colonies of *P. antarctica* were observed nesting, but in much smaller numbers than in 1977/1978 (Croxall and Kirkwood 1979). During a three-year period of observations no rookeries of *P. antarctica* were found in the region of Telephone Rock (Croxall and Kirkwood 1979). Instead of that, two rookeries of this species were located at a distance of about 2 km N and NNE of Telephone Rock (two colonies at Uchatka Pt.) and at a distance of about 1 km WSW (five colonies at Patelnia Pt.).

Due to the lack of exact information on the location of various rookeries in previous years it is just possible to make a thorough study of the long-period changes in penguin populations of merely two best known regions, i.e. Point Thomas and Llano Point — Sphinx Hill. Data from Table IV indicate increases in *P. papua* and *P. antarctica* populations throughout the last 70-80 years. In the case of *P. adeliae* populations the situation is a little more complicated. At the Pt. Thomas region the number of breeding pairs in the summer 1980/1981 (unpublished data) reached the level of the records for 1909. On the other hand, a marked increase in this species populations was observed in the region of Llano Pt.

These observations indicate a possibility of the occurrence of great changes in the numbers of birds in various breeding seasons. It may be assumed that irrespective of the general long-period tendencies towards increases in the total number of penguin populations occupying large areas (Sladen 1964; Conroy 1975; Croxall and Kirkwood 1979; Croxall and Prince 1979) sometimes a regional decrease in populations occurs, caused mainly by meteorological conditions. Such situation was observed in the 1980/1981 breeding season (unpublished) data when deep snow cover made nesting impossible on the mildly inclined slopes. On the face of those facts there is an urgent need for regular long-period studies on penguin distribution and frequency in the same regions of observations.

My thanks for the facilities enabling my researches at the Arctowski Station are due to Professor Dr. St. Rakusa-Suszczewski, Dr. A. Myrcha, and Prof. Dr. K. Birkenmajer (Heads of the Third, Fourth and Fifth Antarctic Expeditions of the Polish Academy of Sciences). I am grateful to Prof. Dr. K. Birkenmajer for his help in the environmental analyses of penguin breeding sites. My thanks are also due to Dr. F. Buchholtz, Dr. W. Krzemiński, Dr. R. White, Dr. K. Zdzitowiecki, Dr. W. Nurkiewicz, Dr. R. Ochyra, Dr. J. Różyński, A. Cieślak and E. Dibowski and other members of the Expeditions for their help in field operations under hard conditions.

5. Резюме

В выводковый сезон 1979/1980 в районе залива Адмиралти гнездовали 3703 пары *Pygoscelis papua*, 32918 пар *P. adeliae* и 8237 пар *P. antarctica* (таблица I). Эти виды концентрировались в зонах с разными условиями среды (таблица II): *P. papua* на штормо-

вых хребетах, сухих моренах, осажденных на выветрившихся (дресвязных) потоках лавы, а также на покрытых россыпью террасах, находившихся на разном расстоянии от моря; *P. adeliae* главным образом на покрытых россыпью склонах высоко поднятых террас, отдаленных от моря на несколько десятков метров; *P. antarctica* на скальном грунте лавового происхождения — крутых склонах или высоких вершинах у самого края береговой линии. Отличная преференция выводковых мест (таблица II), а также дифференцированная численность (таблица I) и структура обитания (таблица III) обусловили разные обратные пути к морю мертвой органической материи, выносимой этими птицами на сушу.

Анализ многолетних изменений численности пингвинов в районе Томас поинт и Лано поинт указали с одной стороны на рост численности *P. papua* и *P. antarctica*, а также *P. adeliae* на Лано поинт, с другой же — на значительные колебания численности в очередные годы в последствии атмосферных условий (таблица IV).

6. Streszczenie

W okresie lęgowym 1979/1980 gnieździły się w rejonie Zatoki Admiralicji 3703 pary *Pygoscelis papua*, 32918 par *P. adeliae* i 8237 par *P. antarctica* (tabela I). Gatunki te koncentrowały się w odmiennych warunkach środowiskowych (tabela II); *P. papua* na wałach burzowych, suchych morenach osadzonych na zwietrzałych potokach lawowych oraz na pokrytych rumoszem tarasach, w różnym oddaleniu od morza, *P. adeliae* głównie na skłonach pokrytych rumoszem wysoko podniesionych tarasów, oddalonych od morza kilkadziesiąt metrów, *P. antarctica* na skalistym podłożu lawowym o stromych stokach lub wysokich cyplach przy skraju linii brzegowej. Odmienna preferencja miejsc lęgowych (tabela II) oraz zróżnicowana liczebność (tabela I) i struktura zasiedlenia (tabela III) uwarunkowały też odmienną drogę powrotu do morza martwej materii organicznej, wynoszonej przez te ptaki na ląd.

Analiza wieloletnich zmian liczebności pingwinów w rejonie Point Thomas i Llano Point wykazała z jednej strony wzrost liczebności *P. papua* i *P. antarctica* oraz *P. adeliae* na Llano Pt., z drugiej zaś jej wysokie wahania w kolejnych latach na skutek zmiennych warunków atmosferycznych (tabela IV).

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Paper received 12 September 1980