

Distribution and ecology of *Ophionotus victoriae* Bell, 1902 (Ophiuroidea, Echinodermata) in the South Shetland Islands area (Antarctica)

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ABSTRACT

We present a distribution analysis for *Ophionotus victoriae* Bell, 1902, based on abundance data obtained during the Bentart 95 Expedition, on a macrozoobenthos sampling transect from north of Livingston Island to the Antarctic Peninsula, with 24 Agassiz trawls carried out at depths of 40-850 m.

This ophiuroid seems characteristic of the macrobenthic assemblages south of Livingston Island and Deception, where the species represents 60-90 % of numerical abundance and 40-80 % of biomass for the total epifauna.

Pearson and Spearman coefficients correlation showed interesting results which could explain the success of *O. victoriae* in this area. The highest *O. victoriae* abundances were related to acidic and carbonated sediments, as well as to mysid density; moreover, the presence of the largest specimens was apparently related to euphasids, and we also found a negative relationship with a filter-feeder biomass.

Keywords: Abundance, *Ophionotus victoriae*, sediment parameters, suprabenthic crustaceans, filter-feeder biomass, South Shetlands, Antarctica.

RESUMEN

Distribución y ecología de *Ophionotus victoriae* Bell, 1902 (Ophiuroidea, Echinodermata) en el área de las islas Shetland del Sur (Antártida)

Durante la Campaña Bentart 95 se muestreó el macrozoobentos en 24 estaciones con draga de arrastre Agassiz y a profundidades comprendidas entre 40 y 850 m, sobre un recorrido que cubrió desde el norte de la isla Livingston hasta la península Antártica. A partir de los datos de abundancia obtenidos se analiza la distribución de *Ophionotus victoriae* Bell, 1902. Esta ofiura parece caracterizar las comunidades macrobentónicas en las zonas al sur de Livingston y en la isla Decepción, donde constituye entre el 60 y el 90 %, y del 40 al 80 % de la abundancia numérica y la biomasa, respectivamente, del total de la epifauna.

La aplicación de las correlaciones de Pearson y Spearman arroja resultados interesantes que podrían explicar el éxito de *O. victoriae* en esta región. Las mayores abundancias de *O. victoriae* se relacionarían con los sedimentos acidificados y con la mayor concentración de carbonatos, así como con la densidad de misidáceos; mientras, se observa una relación negativa con la biomasa de filtradores, y la presencia de ejemplares de mayor tamaño parece relacionada directamente con la presencia de euphasiáceos.

Palabras clave: Abundancia, *Ophionotus victoriae*, variables del sedimento, crustáceos suprabentónicos, filtradores de biomasa, Shetlands del Sur, Antártida.

INTRODUCTION

Ophiionotus victoriae Bell, 1902 is an echinoderm belonging to Ophiuroidea Class (Family Ophiuroidea, Subfamily Ophiurinae) which was described by Bell in 1902 and later by Koehler (1912, 1922).

The species is endemic to Antarctic waters, where it shows a circumpolar distribution and is found within a wide bathymetric range (from depths of 5-1 266 m) and on all substratum types. Its presence has been cited both off Continental Antarctica, in the Ross, Weddell and Lazarev Seas, and on the Antarctic Peninsula and surrounding islands (Peter I Island, Bouvet Island, and the South Sandwich and South Shetland Islands), among others (Koehler, 1912; Hertz, 1927; Grieg, 1929; Clark, 1951; Fell, 1961; Madsen, 1967; Gallardo *et al.*, 1977; Voss, 1988; Gallardo, 1992; Dahm, 1996; Piepenburg, Voss and Gutt, 1997; Saiz-Salinas *et al.*, 1997; Arnaud *et al.*, 1998; Smirnov and Dahm, 1999).

Due to its abundance, *O. victoriae* is considered, at a biological level, among the best known species of the Antarctic benthos. This ophiuroid is characterised, as are many other Antarctic invertebrates (Arntz, Brey and Gallardo, 1994; Dayton, 1990), by a slow growth rate and high longevity, with an estimated maximum age of 22 years (Dahm, 1996; Dahm and Brey, 1998).

Among the biological factors which could be responsible for its wide distribution throughout benthic ecosystems, the most prominent -in addition to its eurybathy and low selectivity for bottom type- are its life strategies regarding feeding and reproduction. Thus, *O. victoriae* is an opportunistic generalist species with a high dietary plasticity, as shown by its feeding strategy, which ranges from active predation on water column crustaceans to a detritivorous or necrophagous regime, feeding on a total of 13 phyla; however, suspension-feeding has not been reported (Arnaud, 1970; Dearborn, 1977; Kellogg and Kellogg, 1982; Fratt and Dearborn, 1984; Presler, 1986; Arntz, Brey and Gallardo, 1994; McClintock, 1994; Pawson, 1994). As to reproduction, *O. victoriae* does not develop directly, unlike many Antarctic benthic invertebrates (Picken, 1980; Pearse, McClintock and Bosch, 1991), but has long-developing pelagic planktotrophic larvae (Poulin, Palma and Féral, 2002).

In the present paper, data on *O. victoriae* abundance obtained during Bentart-95 Survey are analysed in order to establish the physical and bio-

logical parameters responsible for its dominance in the communities of the South Shetlands Islands zone.

MATERIALS AND METHODS

During the Bentart 95 Expedition, a total of 24 operations were carried out with an Agassiz trawl at depths of 40-850 m in a transect covering the north of Livingston Island to the Antarctic Peninsula and including the inner waters of Deception Island (figure 1).

At each station, a subsample of 50 l was taken randomly, and sieved using three mesh sizes: 10, 5 and 1 mm (Arnaud *et al.*, 1998). The ophiuroids retained on the largest mesh were counted and weighed, and preserved for later study.

The present paper summarises data on numerical abundances, fresh weight and individual mean weight of *O. victoriae*. Pearson's and Spearman's correlation coefficients were applied to study the relationship between the abundance values and some abiotic and biotic parameters which could be responsible for *O. victoriae* abundances in the communities sampled.

Table I lists abiotic factors (latitude south, depth, sediment type, median particle size, sorting coefficient, % organic matter, % carbonates, pH and redox potential) and biotic parameters, such as filter-feeder weight, number of suprabenthic crustaceans (Mysidacea, Euphasiacea and Amphipoda), and meiobenthos density at these stations.

Before the correlation analysis, a Kolmogorov-Smirnov test was applied to different variables in order to determine their normality.

RESULTS

In the South Shetlands and Antarctic Peninsula areas, Ophiuroidea species seem to play an important ecological role, contributing 33 % to the total numerical abundance of epifauna, and 17 % to its biomass (Arnaud *et al.*, 1998). Among these *O. victoriae* represented 21 % of numerical abundance and 8 % of epifauna biomass.

The species shows a markedly differential distribution regarding depth and geographical area: it is completely absent at less than 100 m, as well as north of Livingston Island and the Antarctic Peninsula, while it appears in high abundances in

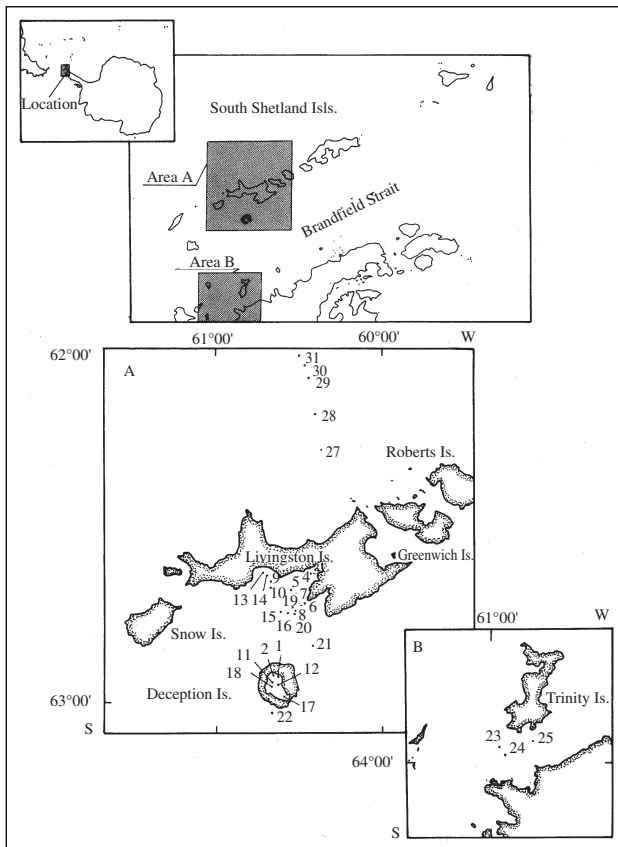


Figure 1. Position of the Bentart 95 sampling stations around the South Shetland Islands and Bransfield Strait (Antarctic Peninsula)

inner Deception waters and, especially, in southern Livingston waters (figure 2), where we found values per station of more than 9 000 individuals and 17 kg fresh weight, accounting for nearly 90 % of total epifauna abundances (table I, figure 3). However, *O. victoriae* was found in much greater numbers south of Livingston than off Deception.

Distribution differences were also apparently found regarding the mean weight (sizes) of individuals. As shown in figure 4, the largest or smallest specimens (juveniles) seemed to be concentrated at some stations.

Pearson's and Spearman's rank correlations calculated between the abundance of *O. victoriae* and other taxa, such as suprabenthic crustaceans, sessile filter-feeders, and meiobenthos, as well as some abiotic variables, were not generally found to be statistically significant (table II).

However, some significant correlations ($P < 0.05$) did appear. When Pearson's coefficient was applied, a positive relationship (at level of 60 %) was found between *O. victoriae* abundance and carbonate rates

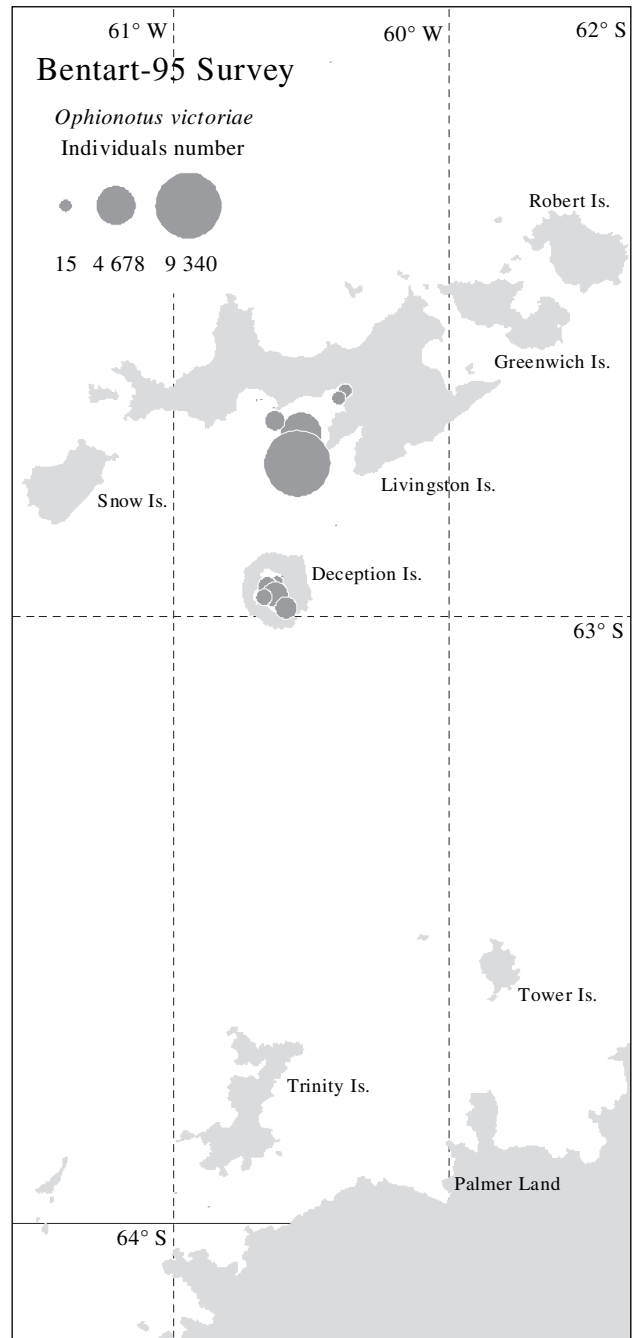


Figure 2. Spatial distribution of the *O. victoriae* numerical abundances

in the sediment. Moreover, an identical positive correlation was observed between *O. victoriae* individual mean weight and Euphasiacea numerical abundance.

On the other hand, Spearman's rank correlations show that numerical abundance, biomass and individual mean weight of *O. victoriae*, and filter-feeder biomass are all negatively associated; in addition, this numerical abundance is negatively re-

Tabla I. Station list with abundance of *O. victoriae*.- number, weight, and individual mean weight in grams (IMW). Location.- latitude S (Lat. S); (D): depth in metres. Environmental parameters.- (ST): sediment type- (1): mud, (2): sand, and (3): hard bottom; (Mz): median particle size in mm; (SC): sorting coefficient; (MO): organic matter in %; (CA): carbonates in %; (pH); (RP): redox potential in mV. Abundance of some main taxa.- (FfW): filter-feeders weight in g; (MysN): Mysidacea number; (EupN): Euphasiacea number; (AmpN): Amphipoda number. Density of meiobenthos in number by 10 cm².- (MeioN): meiofauna number. Stations.- (D): Deception Island; (SL): South Livingston Island; (B): Bransfield Strait; (NL): North Livingston Island

Station	Number	Weight	IMW	Lat. S	D	ST	Mz	SC	MO	CA	pH	RP	FfW	MysN	EupN	AmpN	MeioN
1D	0	0	0	62.93	40	3	45.8	2.6	4.7	3.1	7.3	248	22 505				2 224
2D	29	526	18.1	62.94	146	1	22.9	2.8	4.2	3.1	7.0	-40	324	937	303	161	538
3SL	243	2 350	9.7	62.63	92	1	13.8	2.8	7.5	3.1	7.1	-24	6970	102	0	472	560
4SL	175	1 325	7.6	62.64	161	1	9.4	2.3	9.9	3.9	7.3	-19	561	446	6	503	600
5SL	4967	17 375	3.5	62.70	256	1	9.9	2.3	9.2	39.1	7.2	-16	26	896	1	74	164
6SL	0	0	0	62.72	49	1	7.3	2.2	8.2	3.1	7.1	-100		3	0	1 720	475
7SL	0	0	0	62.74	80	1	9.9	2.6	7.2	3.9	7.3	-75	10 001				714
9SL	0	0	0	62.66	162	1	27.4	3.2	7.4	39.1	7.1	-83		967	7	1 240	5 842
10SL	1 232	7 375	6	62.68	220	1	13.7	2.7	9.7	39.1	7.2	-72		94	0	129	1 623
11D	1 140	5 720	5	62.95	167	1	10.2	2.4	5.8	4.7	6.3	-97	703	566	12	287	7
12D	2 210	6 620	3	62.96	167	1	12.3	2.3	9.1	3.1	6.1	-219	507	414	178	85	6
15SL	15	68	4.5	62.75	335	1	12.9	2.5	8.1	3.9	7.3	182		442	8	166	5 393
16SL	9 340	6 350	0.7	62.75	429	1	13.7	2.7	8.1	39.1	7.2	127		235	8	268	4 931
17D	1 560	1 140	0.7	62.99	106	2	24.5	2.4	4.3	3.1	6.4	88	3 305	0	155	5 305	467
18D	531	446	0.8	62.73	109	2	10.5	2.3	5.2	3.9	5.7	169	5 432	56	17	25	542
19SL	0	0	0	62.72	214	1	12.3	2.6	9.2	3.1	7.6	5	1 761	61	18	1 590	4 474
22B	0	0	0	63.06	330	3	181.0	1.3	2.0	3.9	7.6		394	16	3	153	
23B	0	0	0	63.95	141	3	10.0	2.6	11.3	18.8	7.4	113	21 196	0	0	21	
24B	0	0	0	63.97	234	3							7 827				
27NL	0	0	0	62.34	70	3							9 521				
28NL	0	0	0	62.20	125	1							16 937				
29NL	0	0	0	62.09	237	1	38.9	3.7	3.6	3.1	7.1	101	343	20	2	285	34
30NL	0	0	0	62.02	710	1							979				
31NL	0	0	0	62.02	850	1											

lated to sediment pH, and there is a positive correlation between ophiuroid biomass and Mysidacea numerical abundance.

DISCUSSION

Echinoderms represent one of the main motile elements in benthic Antarctic ecosystems at many localities. As shown by Arnaud *et al.* (1998), in the South Shetland Islands and Antarctic Peninsula region they represent one of more important taxa, constituting 45 % of the epifauna in terms of both numerical abundance as weight; among them, ophiuroids represent 75 % of total numerical abundance and 36 % of total weight.

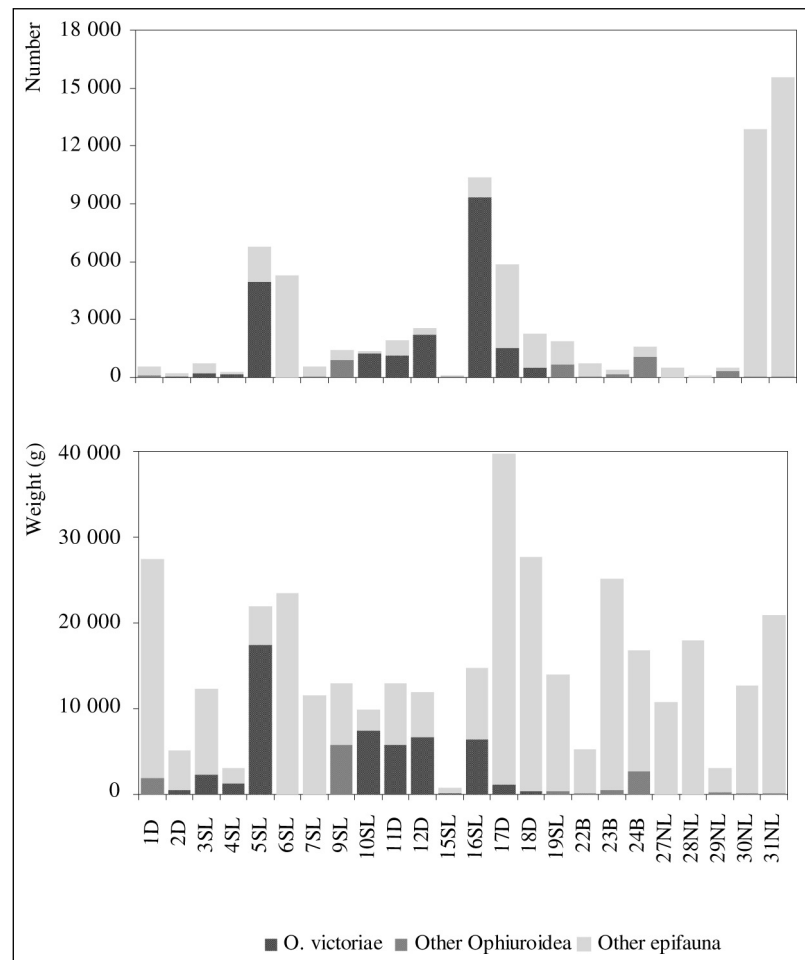
Among the 18 Ophiuroidea species found in this area, *O. victoriae* is clearly dominant (Manjón-Cabeza, Ahearn and Hottenrott, in press). In spite of its distribution pattern, showing marked differences from one geographical area to another, its strong dominance and the key role that the species

seems to play in structuring some epibenthic communities in the study area have hitherto not been reported for other Antarctic localities.

It could be interesting to analyse the reasons for *O. victoriae* abundance in the southern waters off Livingston Island and in Foster Bay (Deception Island) and its complete absence in other zones.

This complete absence north of Livingston and areas closest to the Antarctic Peninsula, at least in the shallowest stations (to approx. 100 m), can be explained by the clear dominance of sessile filter-feeders (mainly ascidians) at depths lower than the photic influence layer (Saiz-Salinas *et al.*, 1997, 1998; Arnaud *et al.*, 1998). Our data explains this, at least in part, through the negative Spearman correlation found between the species's abundance and filter-feeder biomass (table II). Previous studies have shown that suspensivore dominance seems to exclude the presence of other benthic invertebrates with different trophic strategies (Saiz-Salinas *et al.*, 1997, 1998; Arnaud *et al.*, 1998). Following this reasoning, *O. victoriae*, thanks to its opportunistic habits

Figure 3. Number and weight (g) of *O. victoriae*, other Ophiuroidea, and the rest of epifauna taxa at the 24 stations. Stations: (D): Deception Island; (SL): South Livingston Island; (B): Bransfield Strait; (NL): North Livingston Island



and dietary plasticity, which excludes a suspension-feeder regime (Fratt and Dearborn, 1984; Arnaud, 1985), avoids competition with ascidians, sponges and bryozoans, occupying bottoms deeper than 100 m (Saiz-Salinas *et al.*, 1997, 1998).

The absence of correlations between *O. victoriae* abundance and most abiotic variables (table II) indicates that this ophiuroid is basically a eurybathic, non-selective species insofar as bottom type is concerned. However, two variables seem to affect its distribution: carbonate rates and sedimentary pH. The higher carbonate proportions found in sediments south of Livingston could explain in a 60% the fact that *Ophionotus* abundance is higher in this area, as the Pearson correlation suggests; this is logical, because carbonates are a limiting factor for the growth of invertebrates with calcareous skeletal structures (Arnaud, 1985) in a habitat where the carbonate contents of sediments are low (Dayton, 1990).

Regarding pH, there is an inverse correlation between this variable and the numerical abundance

of the ophiuroids; pH values below 7.0 at the Deception stations indicated acidic conditions induced by volcanic activity. Historical data show that *O. victoriae* was already very abundant in the island, together with the sea urchin *Sterechinus neumayeri* (Meissner, 1900), at the beginning of the 20th century (Koehler, 1912), before the 1967 volcanic eruptions. After these geological events, this ophiuroid has had absolute success in the recolonization of disturbed bottoms (Retamal, 1981; Retamal, Quintana and Neira, 1982; Gallardo, 1987).

On the other hand, our correlation analysis shows that *O. victoriae* abundance is affected positively by mysid density (table II); moreover, the individual mean weights are positively related (in a 60%) to euphasid numbers, and therefore large specimens are found at the stations where euphasid densities are greatest. It had been previously established that mysids are the second taxa in order of abundance in suprabenthic communities of the South Shetland Islands region, and that euphasids are also impor-



Figure 4. *O. victoriae* individual mean weight in grams (weight/number) by station. (D): Deception Island; (SL): South Livingston Island; (B): Bransfield Strait; (NL): North Livingston Island

Tabla II. Pearson and Spearman rank order correlations between the number, weight, and individual mean weight of *O. victoriae*, and the number or biomass of some benthic organisms and physical parameters (see table I for descriptors). Bold numbers: $P < 0.05$

Pearson coefficient	Number	Weight	Mean Weight
Sediment type	-0.21	-0.29	-0.34
Median particle size	-0.16	-0.22	-0.18
Carbonates (%)	0.60	0.59	-0.10
Euphasiacea number	-0.05	-0.07	0.57
Amphipoda number	-0.07	-0.23	-0.25
Spearman coefficient	Number	Weight	Mean Weight
Latitude S	0.21	0.15	0.11
Depth	0.13	0.14	0.03
Sorting coefficient	-0.18	-0.12	0.04
Organic matter (%)	0.19	0.31	0.17
pH	-0.51	-0.43	-0.39
Redox potencial	-0.06	-0.21	-0.16
Filter-feeder weight	-0.47	-0.51	-0.50
Mysidacea number	0.27	0.55	0.02
Meiofauna number	-0.33	-0.34	-0.20

tant, together with mysids and amphipods, among the near-bottom crustacean fauna at Deception Island (San Vicente *et al.*, 1997). This distribution of suprabenthic peracarids is in accordance with the work of Dearborn (1977) and Fratt and Dearborn (1984), who pointed out the importance of euphausiids and mysids in the *O. victoriae* diet, as well as live prey from the water column and detritus material found on bottoms.

In conclusion, this high adaptability to all depths and bottom types (Madsen, 1967; Dearborn, 1977; Fratt and Dearborn, 1984), and the fact that its long-developing planktotrophic larvae (Pawson, 1994; Poulin, Palma and Féral, 2002) foster the species's dispersion, can be considered responsible for the

wide distribution of *O. victoriae* in Antarctic benthic communities. However, in spite of its wide distribution all around Antarctica and its significance in the Weddell Sea shelf communities (Voss, 1988; Dahm, 1996), the important ecological role that *O. victoriae* seems to play as a key species in the structuring of benthic communities has only been demonstrated in the South Shetlands regions (Gallardo, 1987; Saiz-Salinas *et al.*, 1997; Arnaud *et al.*, 1998; Manjón-Cabeza, Ahearn and Hottenrott, in press). Its complete success in this region could be due to the development of a perfect opportunistic strategy which, on one hand, avoids direct competition for space and food with other epibenthic groups (e.g. filter-feeding fauna), and, on the other hand, takes advantage of certain abiotic and biotic characteristics. These include the existence of carbonated sediments that do not limit its growth (south of Livingston), and its capacity to recolonise and adapt to disturbed and acidified environments (e.g., Deception Island), where it would triumph over more selective species.

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