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A network for long-term monitoring of vegetation in the area of Fildes Peninsula, King George Island

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Abstract Climate warming has become evident in the maritime Antarctic over the past decades, and has already influenced the growing season and the population size of two native vascular plants in Antarctica, *Deschampsia antarctica* and *Colobanthus quitensis*. Both vascular plant species are therefore regarded as good bioindicators of regional warming in west Antarctica. To carry out long-term monitoring of vegetation (mainly using *D. antarctica*) and build a comprehensive research platform for multi-disciplinary study (including botany, microbiology, ecology, and environmental science) for Chinese scientists, 13 permanent plots were established in January and February of 2013–2015 in the area of Fildes Peninsula (King George Island). Here we present the benchmark data of the first observations from these plots, including site characteristics, and the population and associates of *D. antarctica* in each plot. The basic data are important to understand the vegetation change, distribution range, and expansion of *D. antarctica* in Antarctica under future climate change scenarios.

Keywords **climate change, permanent plots, *Deschampsia antarctica*, South Shetlands**

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1 Introduction

Antarctic hairgrass, *Deschampsia antarctica* Desv. (Poaceae), is one of the two vascular plants native to Antarctica and is mainly distributed in the Antarctic Peninsula and Scotia Arc (Convey et al., 2011). The grass is perennial and generally grows in coastal habitats. It can tolerate harsh environmental conditions, such as extreme low temperatures, low soil water availability, low nutrients, and high salinity (Alberdi et al., 2002). The most favorable conditions for its growth occur in moist environments and in moderately fertilized areas near sites of bird and seal activity (Tatur et al., 1997; Smykla et al., 2007; Cannone et al., 2016). It is often found growing in moss-dominated communities, in particular, with *Sanionia uncinata* (Hedw.) Loeske (Fenton and Smith, 1982; Smith, 2003; Kozeretska et al., 2010), and it also occurs on bare ground, according to field observations by the authors (Figure 1) and previous studies (Fowbert and Smith, 1994; Gerighausen et al., 2003; Torres-Mellado et al., 2011).

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Climate warming has been evident in the maritime Antarctic for the past 50 years (Quayle et al., 2002; Vaughan et al., 2003). In recent years, Antarctic hairgrass and Antarctic pearlwort *Colobanthus quitensis* (Kunth) Bartl. (Caryophyllaceae) have received considerable research attention, and their rapid increase in population size and their colonization of new areas (Figure 2) are primarily interpreted as responses to warmer and longer growing seasons caused by regional warming. Manipulation experiments have also demonstrated that both species have positive responses to warming, with increased aboveground plant biomass, growth rate, water use efficiency, and flower and seed production (Day et al., 2008; Ruhland and Krna, 2010). Therefore, both vascular plant species are considered as good bioindicators of regional warming on Signy Island (South Orkney Islands) (Smith, 1990, 1994, 2003), Fildes Peninsula on King George Island (South Shetland Islands) (Gebauer et al., 1987; Gerighausen et al., 2003; Peter et al., 2008; Torres-Mellado et al., 2011), and the Argentine Islands (Fowbert and Smith, 1994; Parnikoza et al., 2009).

Fildes Peninsula is located in the southwest of King George Island and is the second largest ice-free area of the South Shetland Islands. It is easier to access compared with the Antarctic Peninsula. The terrestrial vegetation on Fildes Peninsula is largely dominated by mosses and lichens, with only one native vascular plant, *D. antarctica*. Although *C. quitensis*, the other vascular plant, was recorded on Fildes for the first time in 2000, we were not able to find it in 2013 according to the latitude and longitude provided by Gerighausen et al. (2003). To carry out long-term monitoring of vegetation (mainly *D. antarctica*) and study its response to climate change, and build a comprehensive research platform for multi-disciplinary study (botany, microbiology, ecology, and environmental science), 13 permanent plots were established in the area of Fildes Peninsula in January and February of 2013–2015. This paper presents the basic data of the first observations for these plots.

2 Materials and methods

2.1 Study site

The survey was performed mainly on Fildes Peninsula (61°51′S–62°15′S, 57°30′W–59°00′W), which is about 2–5 km in width and approximately 10 km in length, covering an area of about 25 km^2. The Fildes Peninsula is composed mainly of basalt, basaltic andesite, volcaniclastic sedimentary rocks, and pyroclastic rocks (Li et al., 1999). The climate is humid and relatively mild due to a strong maritime influence. According to the meteorological record during 1969–2000 from Bellingshausen Station, the mean annual summer (December–February) temperature is 1.2ºC. The average annual temperature and precipitation are –2.4ºC and over 500 mm, respectively (Gerighausen et al., 2003).

2.2 Field work

In total 13 permanent plots (Figures 1 and 2) were established in the area of Fildes Peninsula during the 29th, 30th, and 31st Chinese National Antarctic Research Expeditions in January and February of 2013–2015. These plots represent different microenvironments. For example, Ardley Island represents a habitat of birds (i.e., penguins and skuas) with abundant organic matter, and the foreland of Collins Glacier represents a locality in the initial stage of plant growth after glacier retreat. At each site, a 1 m×1.5 m plot was set up on level ground, within which a 1 m×1 m area was used for the long-term monitoring of vegetation and its response to climate change. The remaining part of the plot was used to study, for example, soil microbes and trace elements. Steel nails were used to fix the plot. For each plot, we used portable GPS to record the latitude, longitude, and elevation, count the number of grass tufts, and estimate the percent coverage of grass, moss, and lichen in the field.

3 Results

3.1 Site characteristics of permanent plots in the area of Fildes Peninsula

All the plots were mainly distributed along the west and east coasts of the Fildes Peninsula, with the exception of Q5 and Q8. Plot Q5 was located in a moraine about 2–3 km away from the coast and Q8 was on Nelson Island (Figure 2). The elevation of the plots ranged from 11 m to 58 m above sea level (a.s.l.) and the aspect was characterized by northwest and northeast directions (Table 1). Q1 and Q3 were established at Holatio Cove and Collins Harbour, respectively, where plants grew between rocks covered by moss carpets. Q2 was on Ardley Island, with a strong influence of penguins (*Pygoscelis* spp.) and skuas (*Catharacta* spp.). Plot Q3 was strongly impacted by ornithogenic soil, with nests of terns (*Sterna* sp.) and gulls (*Larus* sp.) nearby. Several plots were established on bare ground, such as Q11, Q12, and Q13.

3.2 Population of *D. antarctica* in each plot

A large population of *D. antarctica* was observed at Nebles Point, which was previously recorded as the largest stand on Fildes Peninsula (Gerighausen et al., 2003; Torres-Mellado et al., 2011). In the 1 m^2 plot, more than 100 tufts were recorded and it had the highest grass cover (50%), followed by Q3 (37.50%), Q10 (31%), Q8 (25.50%), Q1 (20.75%), and Q4 (20%; Table 1). The population size of *D. antarctica* associated with abundant moss was generally greater than that on bare ground without (or with a lower percent of) moss-associates (Table 1). For example, single or two tufts were found in Q11, Q12, and Q13, in which lichens dominated and mosses had a relatively low cover.

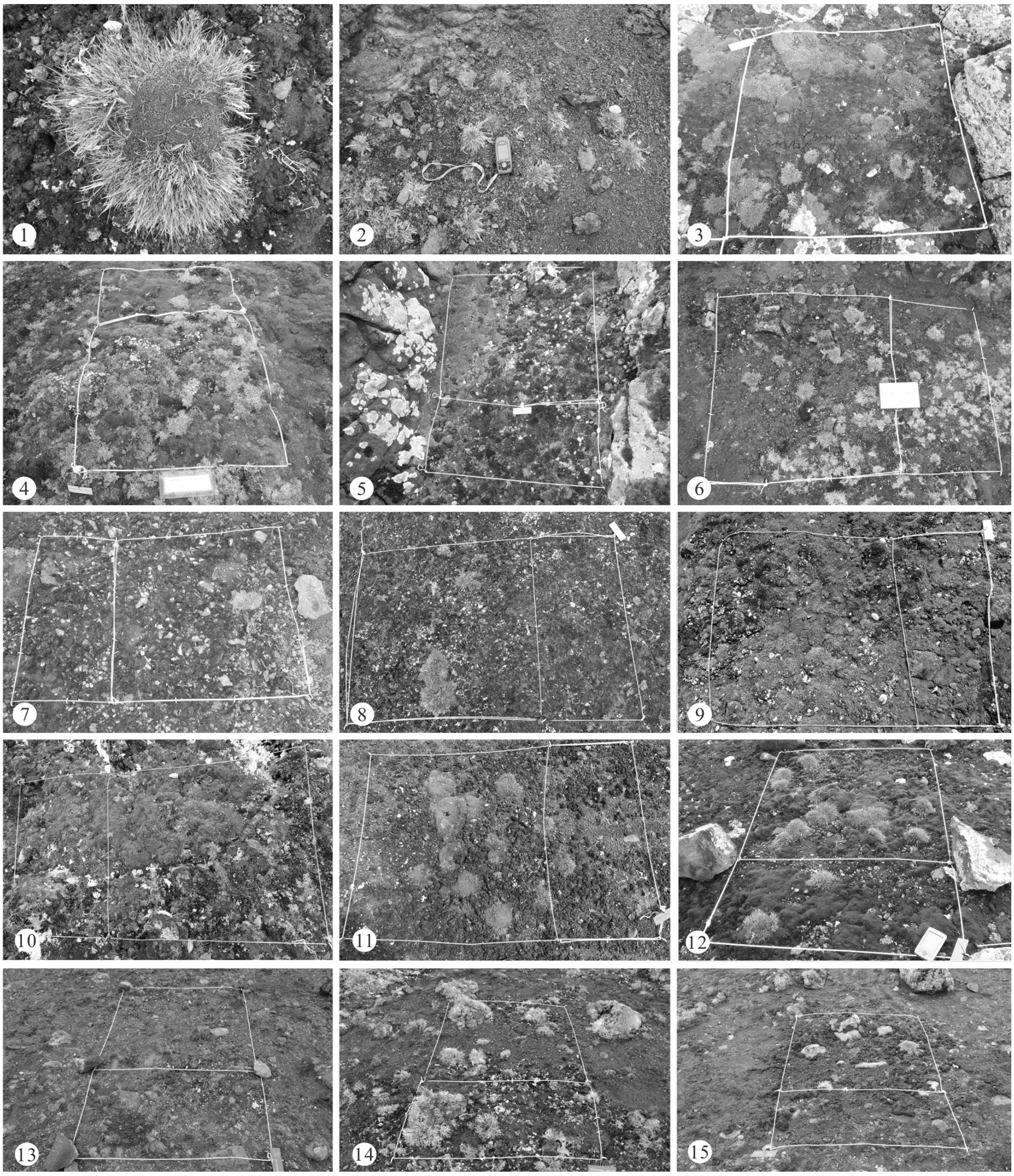

Figure 1 Habitats of Antarctic hairgrass (No.1: the grass is associated with moss, and No.2: the grass grows on bare ground) and permanent plots in the area of Fildes Peninsula (Nos. 3–15)

Although moss cover was high (35%) in Q5, the amount of grass tuft and cover was very low (1 and 1.75%, respectively). This may have been related to its location, the foreland of the Collins Glacier, which represents an initial vegetation stage after glacier retreat.

3.3 Associates of *D. antarctica* in plots

The terrestrial vegetation in Antarctica is mainly dominated by mosses, lichens, and two vascular plant species, viz. the Antarctic hairgrass *D. antarctica* and the pearlwort *C. quitensis* (Casanova-Katny and Cavieres, 2012). In the study plots, *D. antarctica* was usually found growing with moss- and lichen-dominated communities. From our personal observation, the dominant associates comprised eight taxa of mosses: *Brachythecium* sp., *Bryum* sp., *Cephaloziella* sp., *Chorisodontium aciphyllum* (Hook. f. et. Wils) Broth., *Polytrychum alpinum* (Hedw.) G. L. Sm., *Sanionia georgico-uncinata* (Müll. Hal.) Ochyra & Hedenäs, *Sanionia uncinata*, and *Syntrichia princeps* (De Not.) Mitt.; and 14 lichens: *Buellia augusta* Vain., *Buellia frigida* Darb., *Cladonia borealis* S. Stenroos, *Cladonia gracilis* (L.) Willd., *Lecidea spheniscidarum* Hertel, *Leptogium puberulum* Hue,

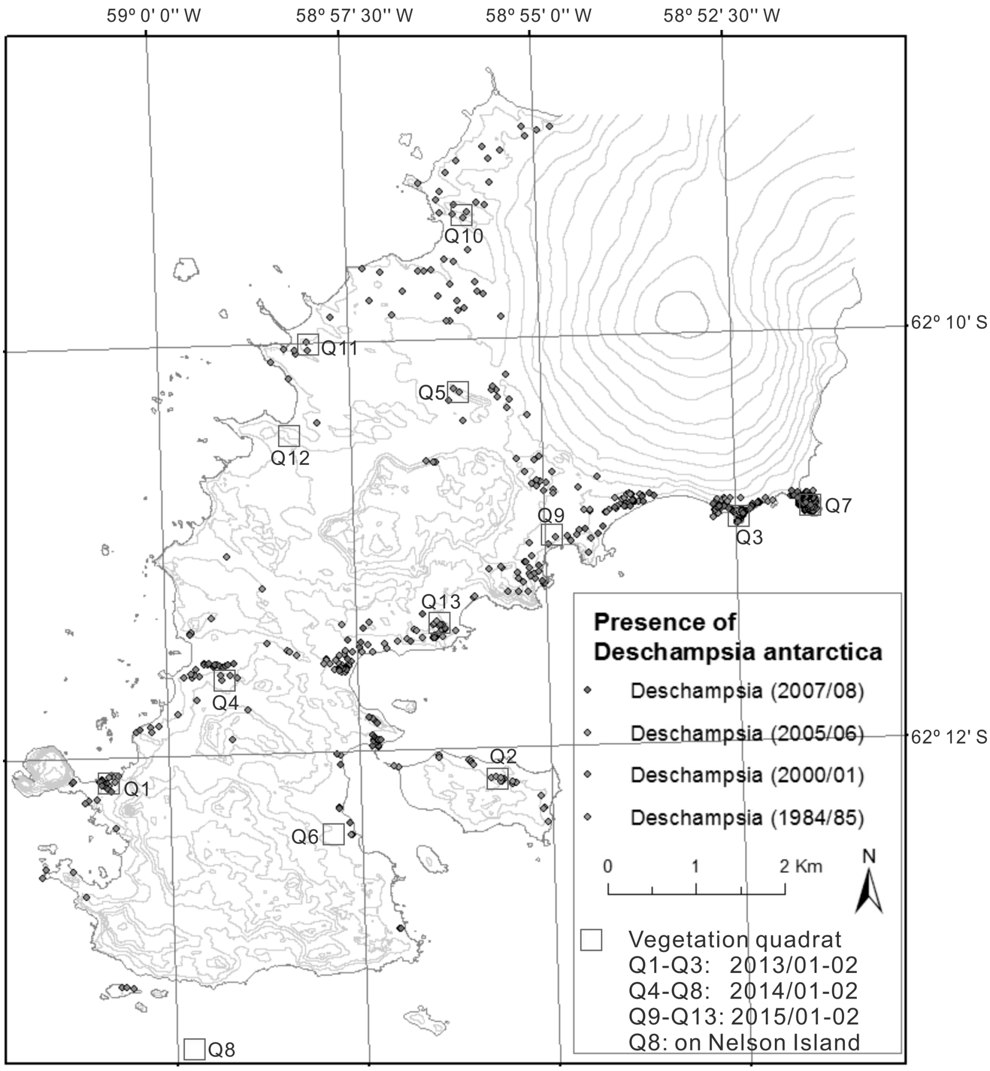

Figure 2 Geographical location of the permanent plots and rapid increase of *D. antarctica* over the past two decades in the area of Fildes Peninsula (personal communication with Peter Hans-Ulrich).

Ochrolechia frigida (Sw.) Lynge, *Pertusaria spegazzinii* Müll. Arg., *Placopsis* sp., *Psoroma cinnamomeum* Malme, *Sphaerophorus globosus* (Huds.) Vain., *Stereocaulon alpinum* Laurer, *Usnea antarctica* Du Rietz, and *Usnea aurantiacoatra* (Jacq.) Bory.

4 Discussion

Our field observations show that *D. antarctica* grows better in the plots close to the coast than those distant from the coast. This may be explained in two ways. First, the sites in close proximity to the coastal areas are often covered by waves during high winds or exposed to large amounts of sea spray (Edwards, 1972), which may bring more moisture into the plots and is beneficial to the growth of *D. antarctica*. Second, the ice-free coastal zone generally has high nutrient input from sea animal excrement (Tatur et al., 1997). Although *D. antarctica* is a pioneer colonist with a wide ecological range, occurring in habitats ranging from water-logged or highly nutrient-deficient to nutrient-enriched soil in the vicinity of nesting sites of flying birds, around penguin colonies, and seal rookeries (Tatur et al., 1997; Gerighausen et al., 2003; Smith, 2003; Smykla et al., 2007; Cannone et al., 2016), the latter is the most favorable condition for its growth. The present study found that *D. antarctica* grows most successfully in Q2, Q3, and Q7 with nutrient-enriched soil around penguin colonies and bird nests on Ardley Island, Collins Harbour, and Nebles Point; while single or two tufts were found in Q11, Q12, and Q13 with highly nutrient-deficient soil. Gerighausen et al. (2003) reported that most of the large grass colonies on Fildes Peninsula with high growth were observed at Nebles Point, Dart Island, and Ardley Island in the vicinity of bird colonies. Torres-Mellado et al. (2011) confirmed that major growth of *D. antarctica* on Fildes Peninsula occurred at Collins Harbour and Nebles Point due to the strong influence of ornithogenic soil with nests of skuas, terns, gulls, and abandoned giant petrel.

Table 1 Site characteristics of the 13 permanent plots

No.	Location	Coordinates	Elevation /(m a.s.l.)	Aspect	Number of grass tufts	Grass cover/%	Moss cover/%	Lichen cover/%
Q1	Holatio Cove	62º12'39"S, 59º00'49"W	11	NW	26	20.75	55	10
Q2	Ardley Island	62º12'4"S, 58º55'43"W	34	N	30	11	46	43
Q3	Collins Harbour	62º11'07"S, 58º52'44"W	16	NE	> 50	37.50	56	6
Q4	Shengwu Cove	62º12'00"S, 58º59'40"W	42	NW	46	20	15	7
Q5	Dajiao Lake	62º10'13"S, 58º55'26"W	50	NW	1	1.75	35	5
Q6	Great Wall Station	62º13'00"S, 58º57'52"W	42	NE	4	14	40	45
Q7	Nebles Point	62º11'02"S, 58º51'35"W	33	NE	> 100	50	40	10
Q8	Nelson Island	62º14'22"S, 58º59'07"W	38	NE	41	25.50	40	34.5
Q9	Norma Cove	62º11'20"S, 58º55'10"W	42	NW	24	10	20	10
Q10	Huashan Peninsula	62º09'11"S, 58º55'51"W	53	NW	17	31	60	1
Q11	Haiyan Cove	62º09'59"S, 58º58'06"W	35	NW	2	1.50	-	20
Q12	Xingfu Cove	62º10'33"S, 58º58'16"W	43	NW	1	1.50	10	30
Q13	Longmen Zui	62º11'47"S, 58º56'28"W	58	NE	1	2.50	5	25

In the Fildes Peninsula area, *D. antarctica* was mostly restricted to the coastal sites up to approximately 60 m a.s.l. Barcikowski et al. (2003) reported that *D. antarctica* was mainly found from the sea level up to about 70 m a.s.l. within the area of Admiralty Bay (King George Island). Cannone et al. (2016) concluded that *D. antarctica* and *C. quitensis* exhibited changes with elevation due to the interaction of climatic factors and animal disturbance on Signy Island (South Orkney Islands), and indicated that the maximum elevation of the sites occupied by both species was about 60 m a.s.l. However, the occurrence of *D. antarctica* above this elevation may be limited by physical disturbance due to the permafrost conditions and/or snow cover thickness and persistence.

Based on observations of the plots, we found that *D.antarctica* grew more frequently within moss-dominated communities than on bare ground, which reflects its preference of high moisture habitats. However, the interaction between *D. antarctica* and mosses is still debated. Several studies have indicated that tolerance and/or competition with moss is the principal plant interaction in Antarctic fellfields (Komárková et al., 1985; Wasley et al., 2006; Block et al., 2009; Krna et al., 2009). Hill et al. (2011) found that *D. antarctica* is a particularly effective competitor for available nitrogen in the soil, and its efficient acquisition of the nitrogen released in decomposition of soil organic matter may give it an advantage over competing mosses. Casanova-Katny and Cavieres (2012) demonstrated that Antarctic moss carpets facilitate the growth of *D. antarctica* and the positive interaction with mosses is thought to be important for the expansion of *D. antarctica*. This is because mosses substantially change the microclimatic conditions and influence temperature and water availability, which are two important abiotic factors limiting the distribution of plants in the Antarctic environment.

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References

Alberdi M, Bravo L A, Gutiérrez A, et al. 2002. Ecophysiology of Antarctic vascular plants. Physiol Plant, 115(4): 479–486

Barcikowski A, Czaplewska J, Loro P, et al. 2003. Ecological variability of *Deschampsia antarctica* in the area of Admiralty Bay (King George Island, Maritime Antarctic) // Frey L. Problems of grass biology. Kraków: W. Szafer Institute of Botany, Polish Academy of Sciences, 383–396

Block W, Smith R I L, Kennedy A D. 2009. Strategies of survival and resource exploitation in the Antarctic fellfield ecosystem. Biol Rev, 84(3): 449–484

Cannone N, Guglielmin M, Convey P, et al. 2016. Vascular plant changes in extreme environments: effects of multiple drivers. Clim Change, 134(4): 651–665

Casanova-Katny M A, Cavieres L A. 2012. Antarctic moss carpets facilitate growth of *Deschampsia antarctica* but not its survival. Polar Biol, 35(12): 1869–1878

Convey P, Hopkins D W, Roberts S J, et al. 2011. Global southern limit of flowering plants and moss peat accumulation. Polar Res, 30(1): 8929, doi: 10.3402/polar.v30i0.8929

Day T A, Ruhland C T, Xiong F S. 2008. Warming increases aboveground plant biomass and C stocks in vascular-plant-dominated Antarctic tundra. Glob Change Biol, 14(8): 1827–1843

Edwards J A. 1972. Studies in *Colobanthus quitensis* (Kunth) Bartl. and *Deschampsia antarctica* Desv.: V. Distribution, ecology and vegetative performance on Signy Island. Br Antarct Surv Bull, 28: 11–28

Fenton J H C, Smith R I L. 1982. Distribution, composition and general characteristics of the moss banks of the maritime Antarctic. Br Antarct Surv Bull, 51: 215–236

Fowbert J A, Smith R I L. 1994. Rapid population increases in native vascular plants in the Argentine Islands, Antarctic Peninsula. Arctic Alp Res, 26(3): 290–296

Gebauer A, Peter H U, Kaiser M. 1987. Floristisch-ökologische Untersuchungen in der Antarktis-dargestellt am Beispiel der Verbreitung von *Deschampsia antarctica* DESV. im Bereich von Fildes Peninsula/King George Island (South Shetland Islands). Wissenschaftliche Zeitschrift der Friedrich Schiller-Universitat Jena, Naturwissenschaftliche Reihe, 36(3): 505–515

Gerighausen U, Bräutigam K, Mustafa O, et al. 2003. Expansion of vascular plants on an Antarctic island—a consequence of climate change? // Huiskes A H L, Gieskes W W C, Rozema J, et al. Antarctic biology in a global context. Leiden: Backhuys, 79–83

Hill P W, Farrar J, Roberts P, et al. 2011. Vascular plant success in a warming Antarctic may be due to efficient nitrogen acquisition. Nat Clim Change, 1(1): 50–53

Komárková V, Poncet S, Poncet J. 1985. Two native Antarctic vascular plants, *Deschampsia antarctica* and *Colobanthus quitensis*: a new southernmost locality and other localities in the Antarctic Peninsula area. Arctic Alp Res, 17(4): 401–416

Kozeretska I A, Parnikoza I Y, Mustafa O, et al. 2010. Development of Antarctic herb tundra vegetation near Arctowski station, King George Island. Polar Sci, 3(4): 254–261

Krna M A, Day T A, Ruhland C T. 2009. Effects of neighboring plants on the growth and reproduction of *Deschampsia antarctica* in Antarctic tundra. Polar Biol, 32(10): 1487–1494

Li Y L, Zhou Y L, Zhang Z W. 1999. Determination and analysis of element composition and distribution of three kinds of lichen by EDS in King George Island, Antarctica. Chin J Polar Res, 11(1): 69–74 (in Chinese)

Parnikoza I, Convey P, Dykyy I, et al. 2009. Current status of the Antarctic herb tundra formation in the central Argentine Islands. Glob Change Biol, 15(7): 1685–1693

Peter H U, Buesser C, Mustafa O, et al. 2008. Risk assessment for the Fildes Peninsula and Ardley Island, and the development of management plans for their designation as Antarctic specially protected or specially managed areas. Dessau: German Federal Environment Agency

Quayle W C, Peck L S, Peat H, et al. 2002. Extreme responses to climate change in Antarctic lakes. Science, 295(5555): 645–645

Ruhland C T, Krna M A. 2010. Effects of salinity and temperature on *Deschampsia antarctica*. Polar Biol, 33(7): 1007–1012

Smith R I L. 1990. Signy Island as a paradigm of biological and environmental change in Antarctic terrestrial ecosystems // Kerry K R, Hempel G. Antarctic ecosystems: ecological change and conservation. Berlin: Springer, 32–50

Smith R I L. 1994. Vascular plants as bioindicators of regional warming in Antarctica. Oecologia, 99(3–4): 322–328

Smith R I L. 2003. The enigma of *Colobanthus quitensis* and *Deschampsia antarctica* in Antarctica // Huiskes A H L, Gieskes W W C, Rozema J, et al. Antarctic biology in a global context. Leiden: Backhuys Publishers, 234–239

Smykla J, Wołek J, Barcikowski A. 2007. Zonation of vegetation related to penguin rookeries on King George Island, maritime Antarctic. Arct Antarct Alp Res, 39(1): 143–151

Tatur A, Myrcha A, Niegodzisz J. 1997. Formation of abandoned penguin rookery ecosystems in the maritime Antarctic. Polar Biol, 17(5): 405–417

Torres-Mellado G A, Jaña R, Casanova-Katny M A. 2011. Antarctic hairgrass expansion in the South Shetland archipelago and Antarctic Peninsula revisited. Polar Biol, 34(11): 1679–1688

Vaughan D G, Marshall G J, Connolley W M, et al. 2003. Recent rapid regional climate warming on the Antarctic Peninsula. Clim Change, 60(3): 243–274

Wasley J, Robinson S A, Lovelock C E, et al. 2006. Some like it wet–biological characteristics underpinning tolerance of extreme water stress events in Antarctic bryophytes. Funct Plant Biol, 33(5): 443–455