UDC 575.17 (582.542.11)

N. Miryuta [1], K. Wojciechowski [2], I. Parnikoza [1, 3, 4, *]

[1] State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, 16 Taras Shevchenko Blvd., Kyiv, 01601, Ukraine

[2] Administration of Lublin Voevodship Regional Landscape Parks, 4 Mieczysława Karłowicza Str., 20-027, Lublin, Poland

[3] Institute of Molecular Biology and Genetics, National Academy of Sciences of Ukraine, 150 Acad. Zabolotny Str., Kyiv, 03143, Ukraine

[4] National Historical-Architectural museum "Kyiv Fortress", 24a Gospitalna Str., Kyiv, 01133, Ukraine

* Corresponding author: ivan.parnikoza@uac.gov.ua

Calculation of the external factors influence indices on plants and its application to *Deschampsia antarctica* Ė. Desv. populations

Abstract. **The main objective** of the research is developing and describing in detail the calculation algorithm of the United Temperature Influence Index (UTII) and United Macroelements content in Soil Influence Index (UMCSII) on basic plant characteristics in sample populations. Additionaly, we present an example of its application in *Deschampsia antarctica* È Desv. research at Galindez Island, Argentine Islands, maritime Antarctic under natural condition based on experimental data sets. The final goal of the research was to evaluate the UTII and UMCSII, based on the sample plant populations contribution to the United Quality Latent Index of adaptability (UQLI). **Methods**. The surface temperature data set was obtained by temperature loggers at each individual plant population during April 2017 — April 2018. To determine the individual *D. antarctica* cover and measure the morphometric parameters of eleven *D. antarctica* populations, we evaluated leaf length, inflorescence length, flower length (by lower flower glume), and the number of flowers in inflorescence. Protein densitometry profiles of seeds for eleven *D. antarctica* populations were analyzed. To obtain the United Temperature Influence Index (UTII) and United Macroelements Content in Soil Influence Index (UMCSII) on basic plant characteristics, the extreme grouping method was applied. This method is described in current work in detail. The estimation of UTII and UMCSII were calculated by pairwise comparisons of spatial pair differences indices sets. **Results**. The calculation algorithms of the United Temperature Influence Index (UTII) and United Macroelements Content in Soil Influence Index (UMCSII), based on the example of eleven populations of *D. antarctica,* were developed and described in detail for Galindez Island in the 2017/18 season. Determining the total contribution of UTII and UMCSII to the UQLI is an example of comparing the value of temperature and soil macroelements to environmental parameters. **Conclusions**. UTII was shown to have a significant contribution to the UQLI in December and January, when the largest spatial temperature variations were observed. UMCSII did not have a statistical confidence of contribution to the UQLI, but sum with the UTII increased UTII contribution value to the UQLI. The index UTII is proposed to describe an influence of source temperature data to a large number of plant populations sample different characteristics by reducing the dimension to one number. The index UMCSII is proposed to describe an influence of a large number of source macroelements content in soil data to sample populations covers by reducing the dimension to one number. The UTII and UMCSII sets can be used to compare them with sets of the UQLI of adaptability populations sample of the same species growing under different conditions to construct correlation models for different populations.

Keywords: *Deschampsia antarctica* È Desv., United Quality Latent Index of adaptability (UQLI), United Temperature Influence Index (UTII), United Macroelements Content in Soil Influence Index (UMCSII), Argentine Islands, maritime Antarctic.

Cite: Miryuta N., Wojciechowski K., Parnikoza I. Calculation of the external factors influence indices on plants and its application to *Deschampsia antarctica* Ė. Desv. populations. *Ukrainian Antarctic Journal*, 2019. № 2 (19), 94—116.

INTRODUCTION

Today it is extremely important task to develop methods that allow to quantitatively study of adaptation of organisms to extreme environmental conditions. Particularly relevant is the task for the polar regions, in particular Antarctic, for which it is important to study how Antarctic life evolved and survived (Kennicutt et al., 2014). One of the good objects to study is polar vascular plants, characterized by a wide range of adaptations (Callaghan, Cllins, 1981; Alberdi et al., 2002; Convey, 2003). In Antarctica, where there are only two species of vascular plants, they may be indicators of climate change (Fowbert, Lewis Smith, 1994; Gerighausen et al., 2003; Cannone et al., 2016; Sáez et al., 2018). Monitoring of populations of one of the native Antarctic vascular plants — *Deschampsia antarctica* È. Desv., 1837 on the model of Galindez Island, the Argentine Islands was started. As a result of this effort we have proposed a method of calculation United Quality Latent Index of Adaptability (UQLI) for a comprehensive assessment of the response of different adaptation mechanisms (Ayvasyan et al., 1989; Bauman et al., 2008; Miryuta et al., 2019). This integral index has described the adaptability of *D. antarctica* populations to stressful environmental conditions. The maritime Antarctic natural conditions were quite heterogeneous (Komarkova et al., 1985, 1990; Barcikowski et al., 2003; Parnikoza et al., 2018). That's why the UQLI integral index has different value for plant populations localized at different parts of Galindez Island. The spatial distribution of soil temperatures during the season and spatial distribution of macroelements content in the soil are known to exist in Antarctica, particulary on Galindez Island (Casanova-Katny et al., 2010; Parnikoza et al., 2016, 2018; Sáez et al., 2018). It means that the soil temperature is very different at different population's locations at the beginning of the season, what determines different initial conditions for the development of different plant populations. The temperature equalization at distinct sites is observed during the season, and the end result of the development of plants having different initial conditions is diverse at the end of the season. The same thing happens with the initial concentrations of macroelements in soils of different sites, only the relaxation time to the equilibrium state is much longer (Bockheim, 2015).

To understand which external factors play the largest role in the formation of end-of-season plant populations, which are described by the UQLI value, based on plant population characteristics only (Ayvasyan et al., 1989; Bauman et al., 2008), we decided to research the influence of spatial soil temperature differences and differences in spatial soil macroelements content on the spatial differences in the individual plant adaptation indices values for ten populations from Galindez Island. To compare UQLI data set with data sets of temperature and macroelements content, it was needed to lead the latter to the same abstraction level as UQLI. To achieve this goal, we developed algorithms of a statistical methods set application to construct the United Influence Indices of two external factor sets on determining the influence of different environmental conditions on *D. antarctica* populations. The construction of United Influence Indices of different environmental factors on different indices of the plant populations adaptability will allow a better determination of which of the measured indices makes the greatest contribution to the United Quality Latent Index of plant population adaptability. We remind you that UQLI takes into account the maximum possible number of external influences. Intermediate data under applying the algorithm of calculation United Indices of specific external conditions influence on each plant population adaptability indices also allows to design correlation models of the individual influence indices interaction with the individual adaptability indices in the probability relationships form for each studied population.

MATERIALS AND METHODS

Localization of studed *D. antarctica* populations is presented in Table 1.

The temperature data sets from experimental sites as external factor were obtained by loggers HOBO UA-002-64 for 11 *D. antarctica* populations (Parnikoza et al., 2018). The macroelement content in the soil data sets for 10

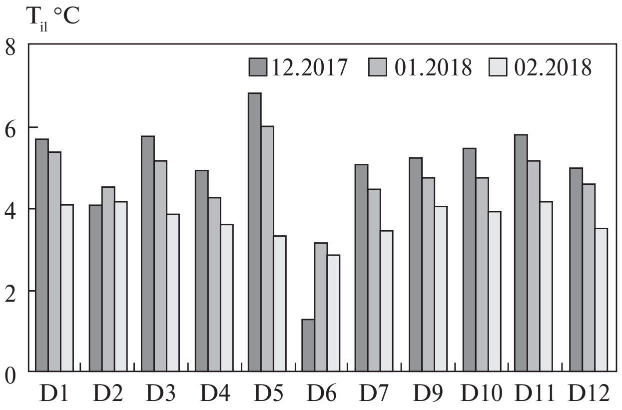

Fig. 1. Distribution of average soil surface temperatures by month (T_{il} °C) for studied *D. antarctica* populations of Galindez Island, Argentine Islands, season 2017/2018 (Parnikoza et al., 2018)

D. antarctica populations from Galindez Island have been taken from the article (Parnikoza et al., 2016).

T_{il} is the average monthly soil surface temperature, where i = 1, 2, ... 11 and runs around the values corresponding to the number of the studied site of the populations D_1 (D1), D_2 (D2), ... D_7 (D7), D_8 (D9), ... D_{11} (D12), l = 1, 2, 3 corresponds to the month summer season number (T_{i1} — average temperature in December 2017, T_{i2} — in January 2018, T_{i3} — in February 2018). The temperature data during this season are shown in the following Table 2 and Fig. 1.

Or_{im} is the macroelement content in the soil, where i = 1, 2, ... 10 and runs around the values corresponding to the number of the studied site of the populations D_1 (D1), D_2 (D2), ... D_6 (D6), D_7 (D9), ... D_{10} (D12): (D(7) is absent because soil sample have not sampled, D8 is absent because this population had less than five plants while we used for analizes ten plants), m = 1, 2, 3, 4, 5 corresponds to number of the corresponding parameter: relative content C_{org} (organic carbon) (Or_{i1}), content N (nitrogen) (Or_{i2}), content P_2O_5 (phosphorus) (Or_{i3}), content K_2O (potassium) (Or_{i4}), pH_{KCl} (exchange acidity) (Or_{i5})). The

Table 1. **Localization and plant population cover (S_i) of studied *D. antarctica* populations, Galindez Island, Argentine Islands, season 2017/2018 (Miryuta et al., 2019)**

i	D_i*	Localization of the population	S_i, %
1	D_1(D1)	Meteo Point, coastal rocks of Marina Point near the meteorological station, S 65.244780°, W 64.255800°	1
2	D_2(D2)	near main station building (Coronation House), Marina Point, S 65.245700°, W 64.256400°	30
3	D_3(D3)	Leopard Tower, Penguin Point, S 65.247500°, W 64.241200°	3
4	D_4(D4)	Ship Rock, Penguin Point, S 65.248600°, W64.238230°	3
5	D_5(D5)	the upper terrace of the Govorukha dome under the Anna Hill, S 65.248260°, W 64.245240°	1
6	D_6(D6)	near the Antarctic pearlwort (*Colobanthus quitensis* (Kunth) Bartl.) point on the Roztochia Ridge, S 65.247990°, W 64.242720°	3
7	D_7(D7)	on the Krapla Rock, S 65.247017°, W 64.243167°	5
8	D_8(D9)	on the rocky shore of the Neck Ridge behind the large magnetic pavilion, S 65.245467°, W 64.249867°	15
9	D_9(D10)	on Magnit Cape, S 65.245008°, W 64.253205°	5
10	D_{10}(D11)	on the Cemetry Ridge near the pavilion of Very Low Frequencies (VLF), S 65.246170°, W 64.248250°	1
11	D_{11}(D12)	on the Gull Tower slopes on Stella Point, S 65.247450°, W 64.252740°	10

Notes: * The absence of a D8 population in this column is due to the fact that in the last five years this plants population has decreased to several plants and sampling has become impossible without definitive destruction of this population.

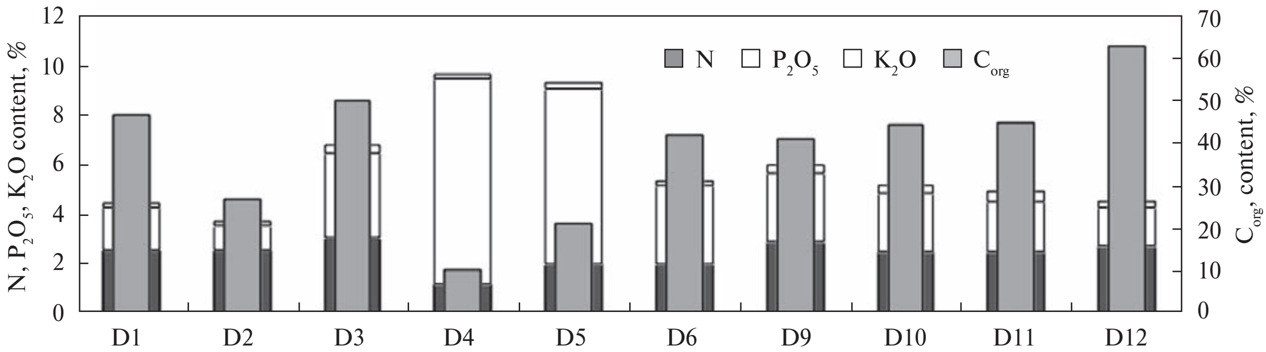

Fig. 2. The macroelements content in the soil of studied *D. antarctica* populations of Galindez Island, Argentine Islands (Parnikoza et al., 2018)

macroelements content is shown in the following Table 3 and Fig. 2.

General characteristics and examples of *D. antarctica* plant source data sets under nature conditions used in our work have been presented below (Miryuta et al., 2019).

The plant population cover (S_i) was estimated visually as the percentage cover of the vertically projected area of the above-ground plant parts for n = 11 populations, whereas the *i*-th value corresponds to the number of studied population: D_1 (D1), D_2 (D2), ... D_7 (D7), D_8 (D9), ... D_{n-1} (Dn), D_n (D (n + 1). In this data series due to the absence of population data with a fixed number on the map (D8 population had less than five plants while we used for analizes ten plants, the next population was assigned a regular number with the constant number in brackets, for example, D_8 (D9)). S_i sets data used in our work have been obtained by methods described in article (Parnikoza et al., 2015).

Ph_{ij} were morphometric parameters, where j = 1, 2, 3, 4 corresponded to the parameters, respectively: leaf length (dl), inflorescence length (dm), flower length (lower flower glume length, dk), number of flowers in the inflorescence (dn). Ph_{ij} sets data used in our work

Table 2. **The average soil surface temperature indices in December 2017, January 2018, February 2018 for *D. antarctica* populations and control site of *Polytrichum –Chorisodontium* moss bank, Galindez Island, Argentine Islands. Data in table cells: mean ± standard deviation / variance (Parnikoza et al., 2018)**

D_i	T_{i1} °C	T_{i1} range °C	T_{i2} °C	T_{i2} range °C	T_{i3} °C	T_{i3} range °C
D_1(D1)	5.7 ± 2.7/7.5	0.3—10.5	5.4 ± 2.1/4.6	1.3—9.0	4.1 ± 1.6/2.7	1.7—7.4
D_2(D2)	4.1 ± 2.5/6.1	0.2—8.5	4.5 ± 2.0/4.1	0.1—8.2	4.2 ± 1.8/3.4	1.2—7.8
D_3(D3)	5.8 ± 2.6/7.0	0.3—10.4	5.2 ± 2.2/5.0	0.1—8.4	3.9 ± 1.4/2.0	1.6—6.6
D_4(D4)	4.9 ± 2.7/7.5	–0.2—9.7	4.3 ± 2.1/4.3	0.1—8.2	3.6 ± 1.8/3.1	0.9—9.1
D_5(D5)	6.8 ± 3.4/11.6	0.7—14.0	6.0 ± 3.1/10.1	0.1—12.5	3.3 ± 1.4/2.1	0—5.9
D_6(D6)	1.3 ± 2.0/4.0	–0.1—7.0	3.2 ± 1.7/2.8	0—6.2	2.9 ± 1.1/1.3	1.0—5.7
D_7(D7)	5.1 ± 2.8/8.0	0.3—11.5	4.5 ± 2.0/4.1	0.1—8.1	3.5 ± 1.5/2.2	1.4—7.5
D_8(D9)	5.3 ± 2.7/7.1	0.1—9.6	4.8 ± 2.2/4.8	0.1—9.0	4.0 ± 1.5/2.3	1.7—6.8
D_9(D10)	5.5 ± 2.9/8.4	0.1—11.0	4.8 ± 2.3/5.4	0.1—9.6	4.0 ± 1.6/2.7	1.4—7.4
D_{10}(D11)	5.8 ± 2.9/8.3	0.1—11.0	5.2 ± 2.3/5.3	0.1—9.0	4.2 ± 1.6/2.7	1.7—7.2
D_{11}(D12)	5.0 ± 2.5/6.4	0.2—9.1	4.6 ± 2.1/4.6	0.1—8.7	3.9 ± 1.5/2.7	1.7—7.2
Control	2.9 ± 1.8/3.4	–0.1—6.7	3.1 ± 1.6/2.6	0.1—5.8	2.9 ± 1.3/1.6	0.7—5.6

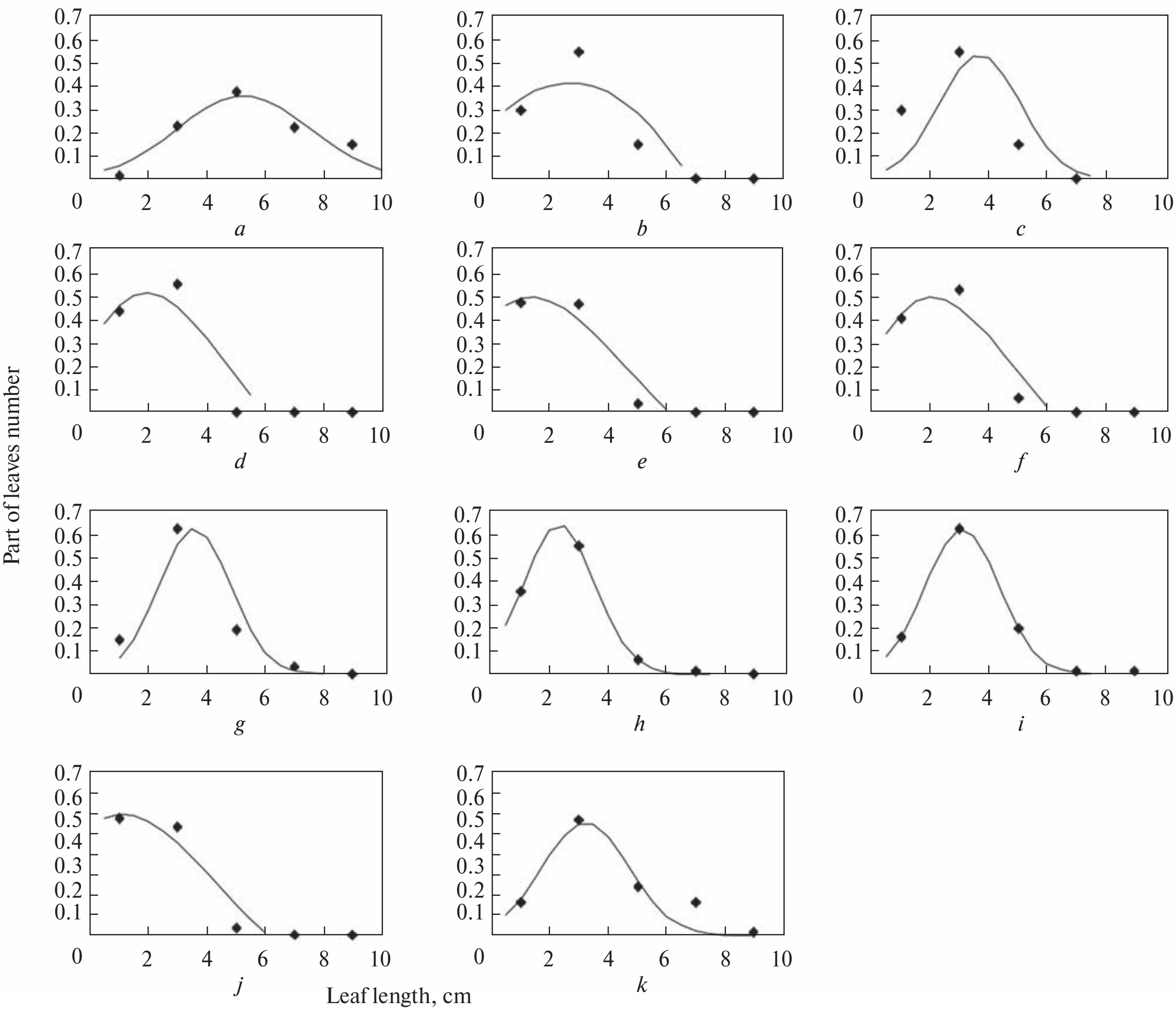

Fig. 3. Density functions of a leaf length of *D. antarctica* plants from populations: *a* — D1, *c* — D3, *g* — D7, *h* — D9, *i* — D10, *k* — D12 (Gaussian model) and *b* — D2, *d* — D4, *e* — D5, *f* — D6, *j* — D11 (Polinomial Fit), Galindez Island, Argentine Islands, season 2017/2018 (Miryuta et al., 2019)

have been obtained by methods described in articles (Parnikoza et al., 2015; Miryuta et al., 2015, 2017).

Pr_{ik} were the relative content of protective and reserve proteins in the seeds, where k = 1, 2, ... 5 (6) (number of the fraction that correspond to: globulins with molecular mass more than 150, glutenins with MM from 94 to 145, sulfur-poor prolamins — from 45 to 80; sulfur-rich prolamins — from 20 to 40; part of sulfur-rich prolamins and probably IRIP protein — 27—31; not full formed prolamins and low molecular weight dehydrins — less than 20 kDa). Pr_{ik} sets data used in our work have been obtained by methods set described in articles (Miryuta et al., 2015, 2017).

An example for the season 2017/2018 is shown in Table 2 and Fig. 3—5.

RESULTS AND DISCUSSION

The described UQLI (I^q_i) in article (Miryuta et al., 2019) characterized the multi-level population re-

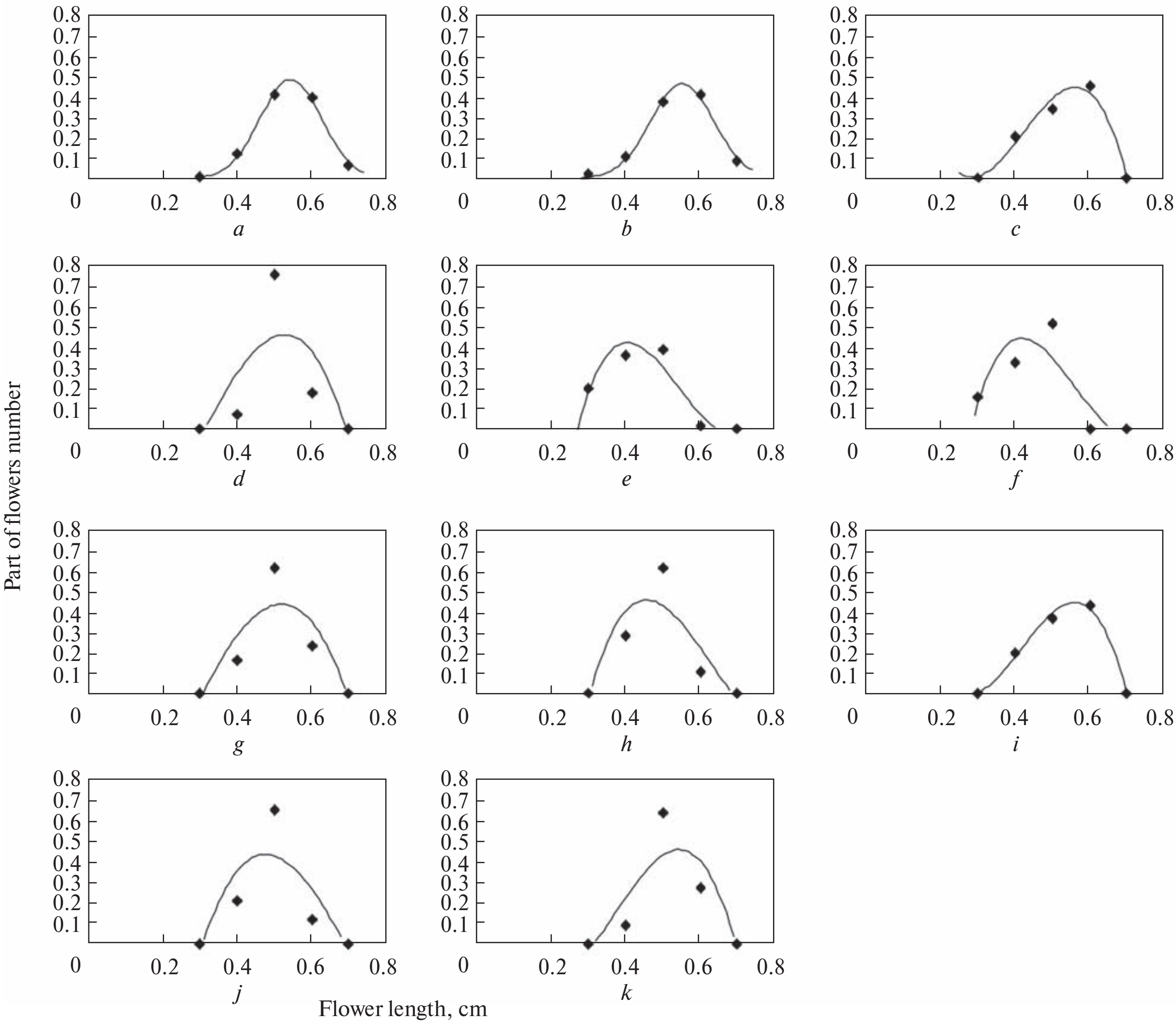

Fig. 4. Density functions of flower length (lower glume length) of *D. antarctica* plants from populations: *a* — D1, *b* — D2 (Gaussian model) and *c* — D3, *d* — D4, *e* — D5, *f* — D6, *g* — D7, *h* — D9, *i* — D10, *j* — D11, *k* — D12 (Polinomial Fit), Galindez Island, Argentine Islands, season 2017/2018 (Miryuta et al., 2019)

sponse to the all types of environmental conditions variation in the their growth in nature microenvironment on the basis of data characterizing the plants populations by method (Ayvasyan et al., 1989; Bauman et al., 2008), but did not allow to estimate contributions of the influence of individual environmental factors to it (Table 4).

Loggers have been used to evaluate specific environmental factors. The loggers measured the temperature on the soil surface in populations located on Galindez Island, in which the plants adaptability was monitored over five years. After obtaining data from the temperature in specific plants populations, the question arose as to how to take into account the temperature influence on the plant population's ability to adapt to a changing environment. The Mantel test is used in such cases in ecology. This test is based on the comparison of spatial differences matrices of the index to be affected, and the parameter that is likely to exert this influence. But this test has

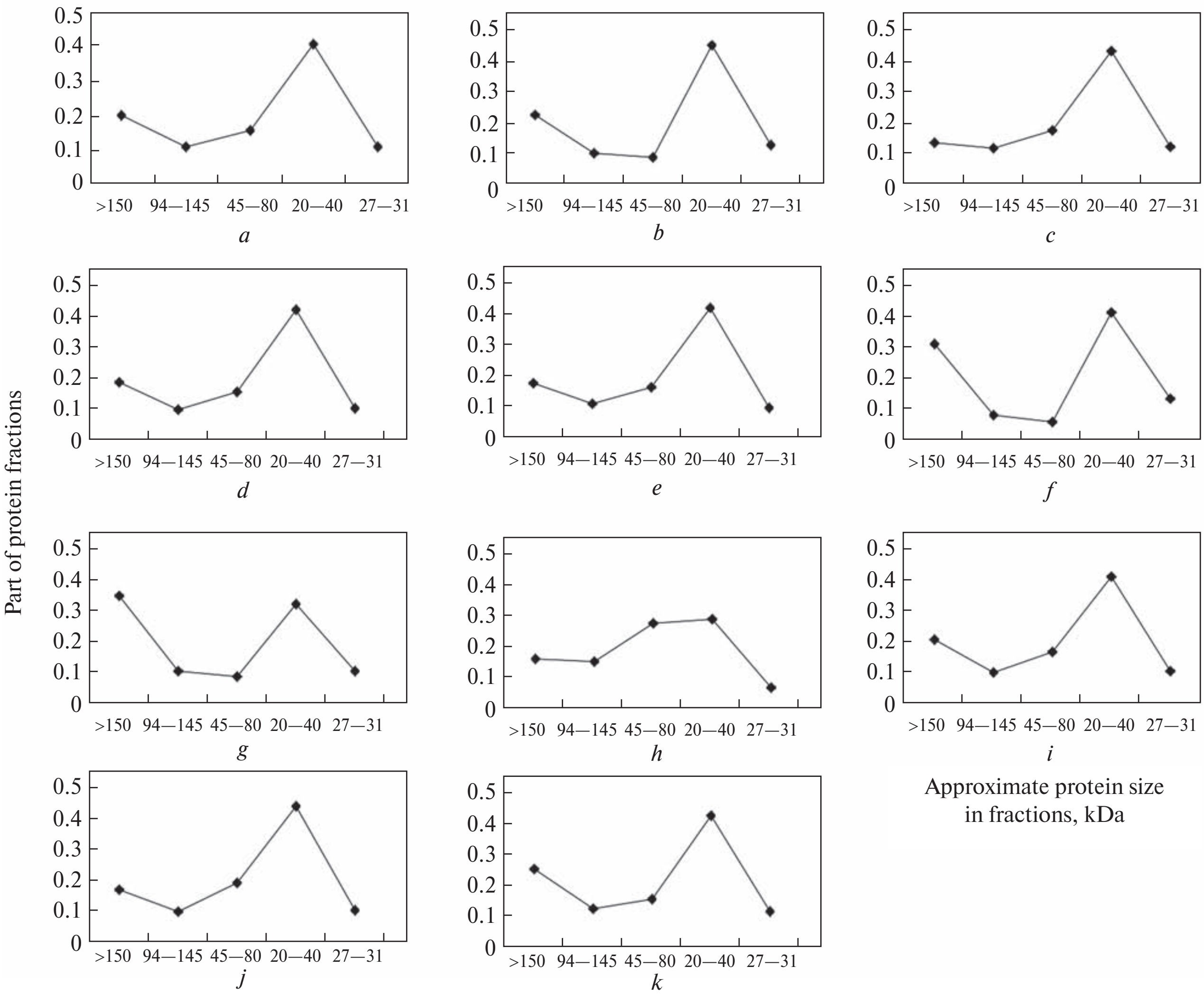

Fig. 5. The values of the different protein fractions parts in *D. antarctica* seeds from populations: *a* — D1, *b* — D2, *c* — D3, *d* — D4, *e* — D5, *f* — D6, *g* — D7, *h* — D9, *i* — D10, *j* — D11, *k* — D12, Galindez Island, Argentine Islands, season 2017/2018. Fractions of protective and reserve proteins that corespond to: globulins with molecular mass more than 150, glutenins with molecular mass from 94 to 145, sulfur-poor prolamins — from 45 to 80; sulfur-rich prolamins — from 20 to 40; part of sulfur-rich prolamins and probably IRIP protein — 27—31; not full formed prolamins and low molecular weight dehydrins — less than 20 kDa (Miryuta et al., 2019)

several disadvantages (Legendre et al., 2015). In addition, the studied system is quite complex. This means that the impact factor has to have the same level of abstraction as the impacted index in order to determine the contribution of the former to the latter. In addition the system may have intermediate components that provide this effect. These can be both external and internal factors. Therefore, we have developed a system of algorithms for the calculation of United Influence Indices of various factors, which can be called external (or internal) in relation to the United Quality Latent Index of adaptability. These United Influence Indicators of different factors have the same level of abstraction as the UQLI (I^q_i), so they can be used to determine the contribution of relevant factors to it.

Here are examples of the developed algorithms of United Temperature Influence Index (UTII, I^t_i) and United Macroelements Content in Soil Influence Index (UMCSII, I^s_i) content on studied plant populations. These UTII (I^t_i) and UMCSII (I^s_i) are values of the same abstraction level as UQLI (I^q_i). So, the correlation coefficient between it sets values and the corresponding UQLI (I^q_i) value set by regression technique perhaps would show the contribution of the relevant influencer index to the integral index of population adaptability under all kinds of conditions for the studied populations.

The algorithm for the United Temperature Influence Index on the adaptability plants indices determining is given in Fig. 6.

The algorithm for the United Macroelements in the Soil Content Influence Index on the adaptability plants indices determining is given in Fig. 7.

We will explain the scheme shown in Fig. 6, 7 step by step.

1. Source data sets. The source data sets of the average monthly temperatures (T_{il}) were used to characterize the weather conditions at the populations growth places (Table 2, Fig. 1) (Parnikoza et al., 2018). The content of macroelements in the soil (Or_{im}) was determined to characterize the substrate, where the selected populations grew (Table 3, Fig. 2) (Parnikoza et al., 2016). The source data sets that characterize the plants populations partly shown in Table 1 (S_i) and in Fig. 3—5 (Ph_{ij} and Pr_{ik}) (Miryuta et al., 2019) were used also.

2. Spatial pairwise comparison of each source data set which characterized the plant populations environment (by i). The comparison was carried out as follows. We have found pairwise spatial differences in modulus for data sets T_{il} and Or_{im}. The resulting sets of pairwise spatial comparisons were denoted by ΔT_{il}, and ΔOr_{im}. Examples of such comparisons are given in Tables 5, 6. We have found pairwise spatial differences for S_i, Ph_{ij} and Pr_{ik} data sets, which presented in Tables 2, 3 in our previous article (Miryuta et al., 2019).

We have found pairwise spatial differences in the modulus for S_i and Pr_{ik} data sets. The test value for pairwise comparison of distributions for the data set Ph_{ij} has been found by the Mood median test. This non-parametric test is a variation of the χ^2 test, which allows estimating intra-group differences for two populations without assessing the normal distribution of population indices. The Table 2 included the non-zero values of criterion statistics (which are proportional to the distance between the medians), which exceeded the table value of 5% limit $\chi_{n-1}{}^2$ =

Table 3. **Basic biogeochemical parameters of soils under populations of *D. antarctica* (Galindez Island, Argentine Islands) (Parnikoza et al., 2016)**

i	D_i	C_{org} (%)	pH_{KCl}	General content (%)		
				N	P_2O_5	K_2O
1	D_1(D1)	47.0	4.1	2.60	1.67	0.21
2	D_2(D2)	27.0	5.5	2.57	0.98	0.14
3	D_3(D3)	49.9	6.1	3.07	3.38	0.35
4	D_4(D4)	10.6	7.5	1.19	8.33	0.16
5	D_5(D5)	21.3	7.4	2.02	7.10	0.20
6	D_6(D6)	41.9	6.6	1.99	3.18	0.16
7	D_7(D9)	41.2	4.8	2.94	2.77	0.32
8	D_8(D10)	44.6	6.7	2.50	2.38	0.32
9	D_9(D11)	45.1	6.0	2.50	2.01	0.46
10	D_{10}(D12)	63.0	5.0	2.76	1.56	0.21

Table 4. **Results of the United Latent Quality Index determination for *i*-th *D. antarctica* populations, Galindez Island, Argentine Islands, season 2017/2018 (Miryuta et al., 2019)**

i	D_i	I_{i1}	I_{i2}	I_{i3}	I^q_i
1	D_1(D1)	0.16	0.56	0.15	0.87
2	D_2(D2)	0.05	–0.56	–0.4	–0.55
3	D_3(D3)	0.22	0.64	0.4	1.26
4	D_4(D4)	0.43	0.44	0.35	1.22
5	D_5(D5)	0.03	0.48	0.1	0.61
6	D_6(D6)	–0.29	0	0	–0.29
7	D_7(D7)	–0.2	–0.08	0.05	–0.23
8	D_8(D9)	–0.36	0.44	0	0.08
9	D_8(D10)	0.26	0.52	0.3	1.08
10	D_9(D11)	0.05	0.48	0	0.53
11	D_{10}(D12)	0.34	0.36	0.2	0.9

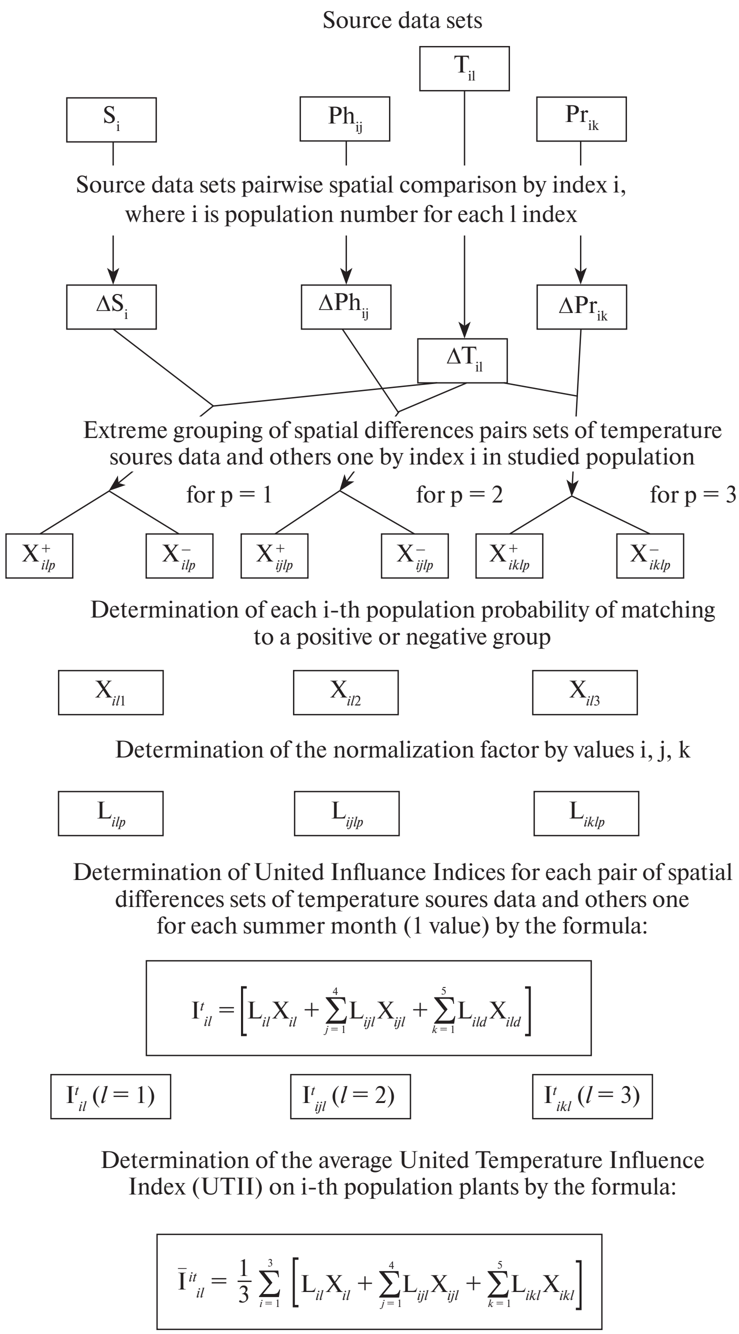

Fig. 6. An example of an algorithm for UTII determination for vascular plant populations

= 3.84 (n = 2) and zero if test value didn't exceed 3.84 by χ^2 test (Pollard, 1982; Corder, Foreman, 2014). The resulting sets of pairwise spatial comparisons were denoted by ΔS_i, ΔPh_{ij}, ΔPr_{ik}. Examples of such comparisons are presented in Tables 2, 3 in article (Miryuta et al., 2019).

3. Extreme grouping of points in coordinates pairs: pairwise spatial differences sets of plant population charac-

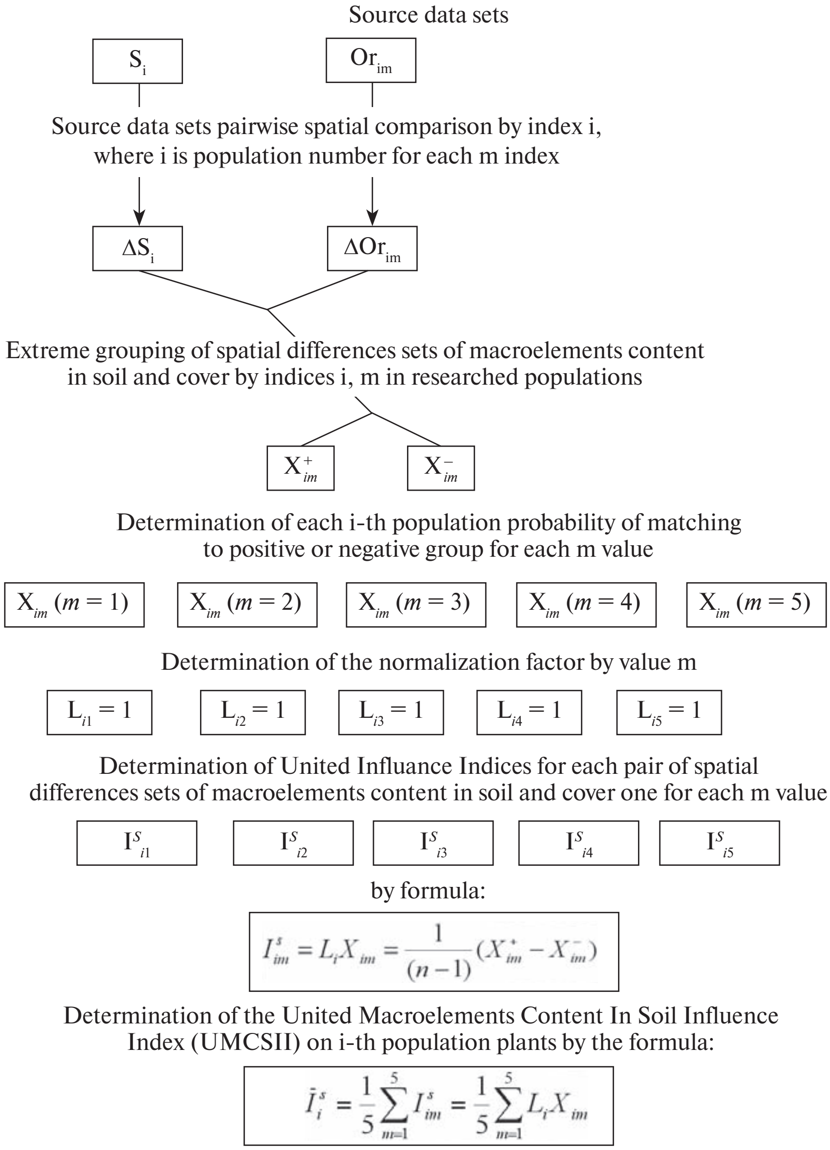

Fig. 7. An example of an algorithm for UMCSII determination for vascular plant populations

teristics against pairwise spatial differences sets of temperatures on soil average value and (or) the macroelements in the soil content in population growth places.

We have calculated the UQLI (I^q_i) of plants adaptability for each population of the sample based on the results analysis of the extreme grouping of points in indices pairs that characterize plant populations (Table 3). These indices I^q_i characterized adaptability of each population to all conditions of population growth in general. But the obtained adaptability indices have reflected the ability to adapt in the studied populations by indirect way. Measuring the temperature on the soil by loggers, as well as chemical analysis of soils in growth population location, allowed to specify the measured external indices influence on the populations total UQLI.

Changes in temperature and soil composition are known to influence on the various plant populations parameters by a different method. That's why we have introduced the United Temperature Influence Indices (UTII) and United Macroelement in the Soil Content Influence Indices (UMSCII) on each plant population. UTII and UMSCII were calculated by analyzing the spatial pairwise differences in the different plant parameters characteristics with spatial pair their environment characteristics differences in the pairs: $|\Delta S_i|$ versus $|\Delta T_i|$, ΔPh_{ij} versus $|\Delta T_i|$, $|\Delta Pr_{ik}|$ versus $|\Delta T_i|$, $|\Delta S_i|$ versus $|\Delta Or_{im}|$. This way of taking into account the external factors influence on the plants changing parameters, would reflect the researched populations adaptability by more direct way.

This assertion could be justified by comparing the series of United Temperature Influence Indices (UTII) and United Macroelements in the Soil Content Influence Indices (UMSCII) with a series of UQLI for population sampling. So, the following method was used to determine the UTII and UMSCII.

Table 5. **Spatial differences (by value *i*) of average monthly temperatures (ΔT_{il}) during the summer months (by value *l*) of *D. antarctica* populations of Galindez Island, Argentine Islands, season 2017/18**

Δi	ΔT_{il} ($l = 1$)	ΔT_{il} ($l = 2$)	ΔT_{il} ($l = 3$)
D1—D2	1.658	0.853	0.094
D1—D3	0.067	0.227	0.231
D1—D4	0.794	1.109	0.472
D1—D5	1.107	0.615	0.766
D1—D6	4.471	2.23	1.224
D1—D7	0.622	0.936	0.633
D1—D9	0.484	0.613	0.056
D1—D10	0.253	0.64	0.149
D1—D11	0.077	0.23	0.091
D1—D12	0.725	0.805	0.574
D2—D3	1.725	0.626	0.325
D2—D4	0.864	0.256	0.566
D2—D5	2.765	1.468	0.86
D2—D6	2.813	1.377	1.318
D2—D7	1.036	0.083	0.727
D2—D9	1.174	0.24	0.15
D2—D10	1.405	0.213	0.243
D2—D11	1.735	0.623	0.003
D2—D12	0.933	0.048	0.668
D3—D4	0.861	0.882	0.241
D3—D5	1.04	0.842	0.535
D3—D6	4.538	2.003	0.993
D3—D7	0.689	0.709	0.402
D3—D9	0.551	0.386	0.175
D3—D10	0.32	0.413	0.082
D3—D11	0.01	0.003	0.322
D3—D12	0.792	0.578	0.343
D4—D5	1.901	1.724	0.294
D4—D6	3.677	1.121	0.752
D4—D7	0.172	0.173	0.161
D4—D9	0.31	0.496	0.416
D4—D10	0.541	0.469	0.323
D4—D11	0.871	0.879	0.563
D4—D12	0.069	0.304	0.102
D5—D6	5.578	2.845	0.458
D5—D7	1.729	1.551	0.133
D5—D9	1.591	1.228	0.71
D5—D10	1.36	1.255	0.617
D5—D11	1.03	0.845	0.857
D5—D12	1.832	1.42	0.192
D6—D7	3.849	1.294	0.591
D6—D9	3.987	1.617	1.168
D6—D10	4.218	1.59	1.075
D6—D11	4.548	2	1.315
D6—D12	3.746	1.425	0.65
D7—D9	0.138	0.323	0.577
D7—D10	0.369	0.296	0.484
D7—D11	0.699	0.706	0.724
D7—D12	0.103	0.131	0.059
D9—D10	0.231	0.027	0.093
D9—D11	0.561	0.383	0.147
D9—D12	0.241	0.192	0.518
D10—D11	0.33	0.41	0.24
D10—D12	0.472	0.165	0.425
D11—D12	0.802	0.575	0.665

End of Table 5

ISSN 1727-7485. Ukrainian Antarctic Journal. 2019, № 2(19)

Extreme grouping was carried out by pairwise linear regression technique. The choice of this technique is based on the fact that it is probably the only possible way to interpret these results. The closest Mantel test only finds cases when the analyzed parameters are in synchrony (with positive correlations). In this context, we compared the differences between populations in the measured indices sample series by quantitative changes phase or antiphase (that from biological point of view correspond to synchrony or asynchrony of following adaptation mechanisms, Parnikoza et al., 2015).

Example of extremal grouping of pairwise spatial variables for pairs of indices $|\Delta S_i|$ versus $|\Delta T_{il}|$, ΔPh_{ij} versus $|\Delta T_{il}|$, $|\Delta Pr_{ik}|$ versus $|\Delta T_{il}|$ for $l = 2$ (for determining the influence of average temperatures in January 2018 on the plant populations characteristic at the season end), $j = 1$, $k = 2$ is shown in Fig. 8.

An example of the extremal grouping of pairwise spatial differences for the pairs of values $|\Delta S_i|$ versus $|\Delta Or_{im}|$, m=1, 2, 5 (for determining the influence of C_{org}, N, pH_{KCl} content on the cover at the season end) is shown in Fig. 9.

Extreme grouping refers to heuristic methods of statistical analysis, those cannot be performed according to a given machine algorithm, but needs to solve special problems with researcher participation. Extreme grouping is as follows: one spatial differences set are applied on the x-axis and another one on the y-axis for all pairs of experimental populations. The regression line and the coefficient R^2 indicate that there is no correlation. Next, the researcher, based on points location, determines the possible configuration of the passage of the regression lines, which are likely to have positive and negative correlations. Separate point manipulations allow you to divide the points of the spatial differences values into two groups for optimal R^2 of regression values. Note that, after isolation of groups with significant correlations, the manipulation of each individual doubtful orientated difference only slightly changes the overall picture of the grouping (Miryuta et al., 2019).

4. Determination of the matching probability into positive or negative group for each population (by number i) depending on the spatial changes in the temperature and in the content of macroelements.

Table 6. **Spatial differences (by value *i*) of macroelements content (ΔOr_{im}) of *D. antarctica* populations, Galindez Island, Argentine Islands for value *m* = 1...5, season 2017/2018**

Δi	ΔOr_{im} (m = 1, C_{org})	ΔOr_{im} (m = 2, N)	ΔOr_{im} (m = 3, P_2O_5)	ΔOr_{im} (m = 4, K_2O)	ΔOr_{im} (m = 5, pH_{KCl})
D1—D2	20	0.03	0.69	0.07	1.4
D1—D3	2.9	0.47	1.71	0.14	2
D1—D4	36.4	1.41	6.66	0.05	3.4
D1—D5	25.7	0.58	5.43	0.01	3.3
D1—D6	5.1	0.61	1.51	0.05	2.5
D1—D9	5.8	0.34	1.1	0.11	0.7
D1—D10	2.4	0.1	0.71	0.11	2.6
D1—D11	1.9	0.1	0.34	0.25	1.9
D1—D12	16	0.16	0.11	0.0	0.9
D2—D3	22.9	0.5	2.4	0.21	0.6
D2—D4	16.4	1.38	7.35	0.02	2
D2—D5	5.7	0.55	6.12	0.06	1.9
D2—D6	14.9	0.58	2.2	0.02	1.1
D2—D9	14.2	0.37	1.79	0.18	0.7
D2—D10	17.6	0.07	1.4	0.18	1.2
D2—D11	18.1	0.07	1.03	0.32	0.5
D2—D12	36	0.19	0.58	0.07	0.5
D3—D4	39.3	1.88	4.95	0.19	1.4
D3—D5	28.6	1.05	3.72	0.15	1.3
D3—D6	8	1.08	0.2	0.19	0.5
D3—D9	8.7	0.13	0.61	0.03	1.3
D3—D10	5.3	0.57	1	0.03	0.6
D3—D11	4.8	0.57	1.37	0.11	0.1
D3—D12	13.1	0.31	1.82	0.14	1.1
D4—D5	10.7	0.83	1.23	0.04	0.1
D4—D6	31.3	0.8	5.15	0.0	0.9
D4—D9	30.6	1.75	5.56	0.16	2.7
D4—D10	34	1.31	5.95	0.16	0.8
D4—D11	34.5	1.31	6.32	0.3	1.5
D4—D12	52.4	1.57	6.77	0.05	2.5
D5—D6	20.6	0.03	3.92	0.04	0.8
D5—D9	19.9	0.92	4.33	0.12	2.6
D5—D10	23.3	0.48	4.72	0.12	0.7
D5—D11	23.8	0.48	5.09	0.26	1.4
D5—D12	41.7	0.74	5.54	0.01	2.4
D6—D9	0.7	0.95	0.41	0.16	1.8
D6- D10	2.7	0.51	0.8	0.16	0.1
D6- D11	3.2	0.51	1.17	0.3	0.6
D6- D12	21.1	0.77	1.62	0.05	1.6
D9—D10	3.4	0.44	0.39	0.0	1.9
D9—D11	3.9	0.44	0.76	0.14	1.2
D9—D12	21.8	0.18	1.21	0.11	0.2
D10—D11	0.5	0.0	0.37	0.14	0.7
D10—D12	18.4	0.26	0.82	0.11	1.7
D11—D12	17.9	0.26	0.45	0.25	1

The distribution probability in groups for each population for $|\Delta S_i|$, ΔPh_{ij}, $|\Delta Pr_{ik}|$ sets depending on spatial changes in temperature. The measured pairs number was indicated by the lower index *p* in the algorithm shown in Fig. 11. The value $p = 1, 2, 3$ was assigned to the indices pairs $|\Delta S_i|$ versus $|\Delta T_{ilp}|$, ΔPh_{ij} versus $|\Delta T_{ilp}|$, $|\Delta Pr_{ik}|$ versus $|\Delta T_{ilp}|$, respectively. In the same algorithm, the value of $l = 1, 2, 3$ was assigned to the average soil surface temperature in the population growth places for the each season months, respectively.

To determine the matching probability into positive or negative group for each population (by number *i*) the table obtained for each indices pair in MsGraph was presented in the form was given in example presented in Table 7.

The distribution probability by each population groups for $|\Delta S_i|$ set depended on spatial temperature changes. The measured pairs number was indicated by the lower index *m* in the algorithm shown in Fig. 6. The value $m = 1, 2, 3, 4, 5$ was assigned to the indices pair $|\Delta S_i|$ versus $|\Delta Or_{im}|$. The example presented in Table 8.

The probability of matching number into the positive and negative groups was indicated as X^{+}_{ilp} and

Table 7. **The result of extreme grouping for indices pairs $|\Delta S_i|$ versus $|\Delta T_{ilp}|$, ΔPh_{ij} versus $|\Delta T_{ilp}|$, $|\Delta Pr_{ik}|$ versus $|\Delta T_{ilp}|$ for the case of comparison (by value *i*) of the spatial differences sets $|\Delta S_i|$, ΔPh_{ij} ($j = 1$), $|\Delta Pr_{ik}|$ ($k = 2$) with spatial average soil temperature differences set $|\Delta T_{ij}|$ for ($l = 2$) of *D. antarctica* populations of Galindez Island, Argentine Islands, season 2017/2018**

Δi	ΔT_{ilp} ($l = 2$)	$\lvert\Delta S_i\rvert$ ($p = 1$)		ΔPh_{ij} ($j = 1$), ($p = 2$)		ΔPr_{ik} ($k = 2$), ($p = 3$)	
		+	–	+	–	+	–
D1—D2	0.853	0	1	0	1	1	0
D1—D3	0.227	1	0	1	0	1	0
D1—D4	1.109	0	1	0	1	0	1
D1—D5	0.615	0	0	0	1	1	0
D1—D6	2.23	0	1	1	0	0	1
D1—D7	0.936	1	0	0	1	0	1
D1—D9	0.613	0	1	0	1	0	1
D1—D10	0.64	1	0	0	1	1	0
D1—D11	0.23	1	0	0	1	0	1
D1—D12	0.805	1	0	1	0	1	0
D2—D3	0.626	0	1	1	0	1	0
D2—D4	0.256	0	1	1	0	0	1
D2—D5	1.468	1	0	0	1	0	1
D2—D6	1.377	1	0	0	1	0	1
D2—D7	0.083	0	1	1	0	0	1
D2—D9	0.24	0	1	1	0	0	1
D2—D10	0.213	0	1	1	0	1	0
D2—D11	0.623	0	1	1	0	0	1
D2—D12	0.048	0	1	1	0	1	0
D3—D4	0.882	1	0	0	1	0	1
D3—D5	0.842	1	0	1	0	1	0
D3—D6	2.003	0	1	1	0	0	1
D3—D7	0.709	1	0	1	0	1	0
D3—D9	0.386	0	1	1	0	0	1
D3—D10	0.413	1	0	1	0	0	1
D3—D11	0.003	1	0	0	1	0	1
D3—D12	0.578	1	0	1	0	1	0
D4—D5	1.724	0	1	0	1	1	0
D4—D6	1.121	0	1	0	1	0	1
D4—D7	0.173	1	0	0	1	0	1
D4—D9	0.496	0	1	1	0	0	1
D4—D10	0.469	1	0	1	0	1	0
D4—D11	0.879	1	0	1	0	1	0
D4—D12	0.304	1	0	1	0	0	1
D5—D6	2.845	0	1	0	1	0	1
D5—D7	1.551	0	1	0	1	0	1
D5—D9	1.228	1	0	0	1	0	1
D5—D10	1.255	0	1	0	1	1	0
D5—D11	0.845	1	0	1	0	1	0
D5—D12	1.42	0	1	0	1	0	1
D6—D7	1.294	0	1	1	0	1	0
D6—D9	1.617	0	1	0	1	1	0
D6—D10	1.59	0	1	0	1	0	1
D6—D11	2	0	1	0	1	0	1
D6—D12	1.425	0	1	0	1	0	1
D7—D9	0.323	0	1	1	0	0	1
D7—D10	0.296	1	0	1	0	0	1
D7—D11	0.706	1	0	1	0	0	1
D7—D12	0.131	1	0	1	0	1	0
D9—D10	0.027	0	1	1	0	0	1
D9—D11	0.383	0	1	1	0	0	1
D9—D12	0.192	1	0	1	0	0	1
D10—D11	0.41	1	0	1	0	1	0
D10—D12	0.165	1	0	1	0	0	1
D11—D12	0.575	1	0	1	0	0	1

End of Table 7

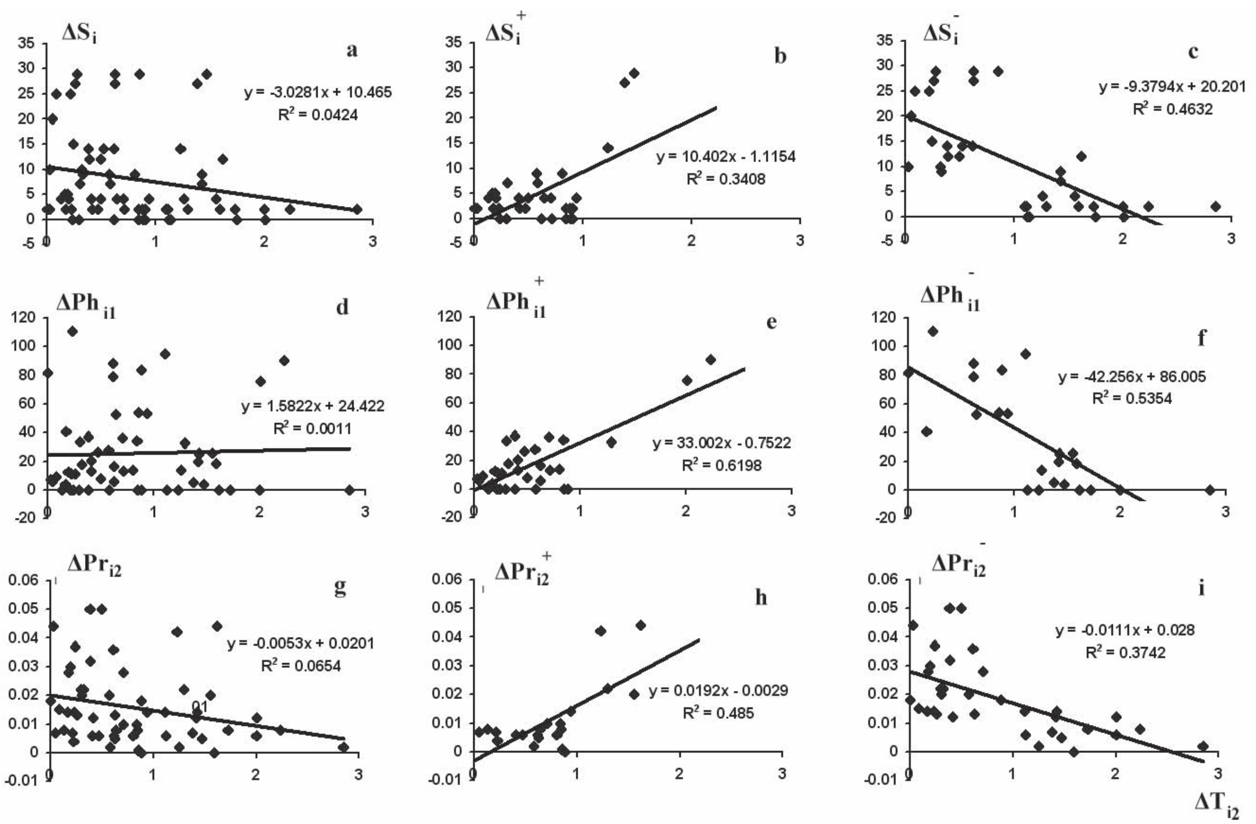

Fig. 8. Dependence of spatial differences sets cover ($|\Delta S_i|$), leaf length (ΔPh_{i1}) and protein content of 95—145 KDa fraction ($|\Delta Pr_{i2}|$) of *D. antarctica* populations of Galindez Island, Argentine Islands, season 2017/2018, on spatial average temperature differences sets in the 01.2018: *a, d, g* – for all points located on the plot between population indices sets pairs $|\Delta S_i|$ versus $|\Delta T_{i2}|$, ΔPh_{i1} versus $|\Delta T_{i2}|$, $|\Delta Pr_{i2}|$ versus $|\Delta T_{i2}|$; *b, e, h* – for points located on plane of the plot which belong to positive group, $|\Delta S^+_i|$ versus $|\Delta T_{i2}|$, ΔPh^+_{i1} versus $|\Delta T_{i2}|$, $|\Delta Pr^+_{i2}|$ versus $|\Delta T_{i2}|$, *c, f, i* – for points located on plane of the plot which belong to negative group, $|\Delta S^-_i|$ versus $|\Delta T_{i2}|$, ΔPh^-_{i1} versus $|\Delta T_{i2}|$, $|\Delta Pr^-_{i2}|$ versus $|\Delta T_{i2}|$. There are regression equations by the least squares technique and squares of the corresponding correlation coefficients between the above indices values on the charts. The test value of R^2, on the charts: *a* – $F_{1,64} = 2.816$, *d* – $F_{1,53} = 0.053$, *g* — $F_{1,53} = 3.710$ (do not exceed the value of the upper 5% F-distribution limit for N=66 ($F_{1,64} = 4.00$), N = 55 ($F_{1,53} = 4.08$)), *b* – $F_{1,30} = 15.510$, *e* – $F_{1,30} = 48.900$, *h* – $F_{1,19} = 17.898$ (exceed the value of the upper 5% F-distribution limit for N = 32 ($F_{1,30} = 4.17$), N = 32 ($F_{1,30} = 4.17$), N = 21 ($F_{1,19} = 4.35$)); *c* – $F_{1,32} = 27.616$, *f* – $F_{1,21} = 24.192$, **i** – $F_{1,32}=19.136$ (exceed the value of the upper 5% F-distribution limit for N = 34 ($F_{1,32} = 4.17$), N = 34 ($F_{1,32} = 4.17$), N = 23 ($F_{1,21} = 4.32$)). These facts mean the absence of linear dependence in the cases *a, d, g* and the presence of linear dependence in the cases *b, e, h, c, f, i*

X^-_{ilp} for $p = 1$, $l = 1, 2, 3$, X^+_{ijlp} and X^-_{ijlp} ($j = 1, 2, 3, 4$) for $p = 2$, $l = 1, 2, 3$, X^+_{iklp} and X^-_{iklp} ($k = 1, 2 \ldots 5$) for $p = 3$, $l = 1, 2, 3$ for each value *i* in the example presented in Table 7. The populations sample size was $i_{max} = n$ (in the considered case n = 11). The scores number maximum was n-1 = 10. To determine the total probability of matching into one of two groups (X^+_{ilp} or X^-_{ilp}) for the indices pairs $|\Delta S_i|$ versus $|\Delta T_{ilp}|$ ($p = 1$), $|\Delta Ph_{ij}|$ versus $|\Delta T_{ilp}|$ ($p = 2$), $|\Delta Pr_{ik}|$ versus $|\Delta T_{ilp}|$ ($p = 3$) we applied formulas for each value $p = 1, 2, 3$:

$$X_{il1} = \frac{1}{n-1}(X^+_{il1} - X^-_{il1}) \quad \text{for } p = 1,\ l = 1, 2, 3 \qquad (1)$$

$$X_{il2} = \frac{1}{n-1}\sum_j (X^+_{ijl2} - X^-_{ijl2}) \quad \text{for } p = 2,\ l = 1, 2, 3 \qquad (2)$$

$$X_{il3} = \frac{1}{n-1}\sum_k (X^+_{ikl3} - X^-_{ikl3}) \quad \text{for } p = 3,\ l = 1, 2, 3 \qquad (3).$$

We have three values sets $l = 1, 2, 3$ for each season month separately in formulas (1), (2), (3).

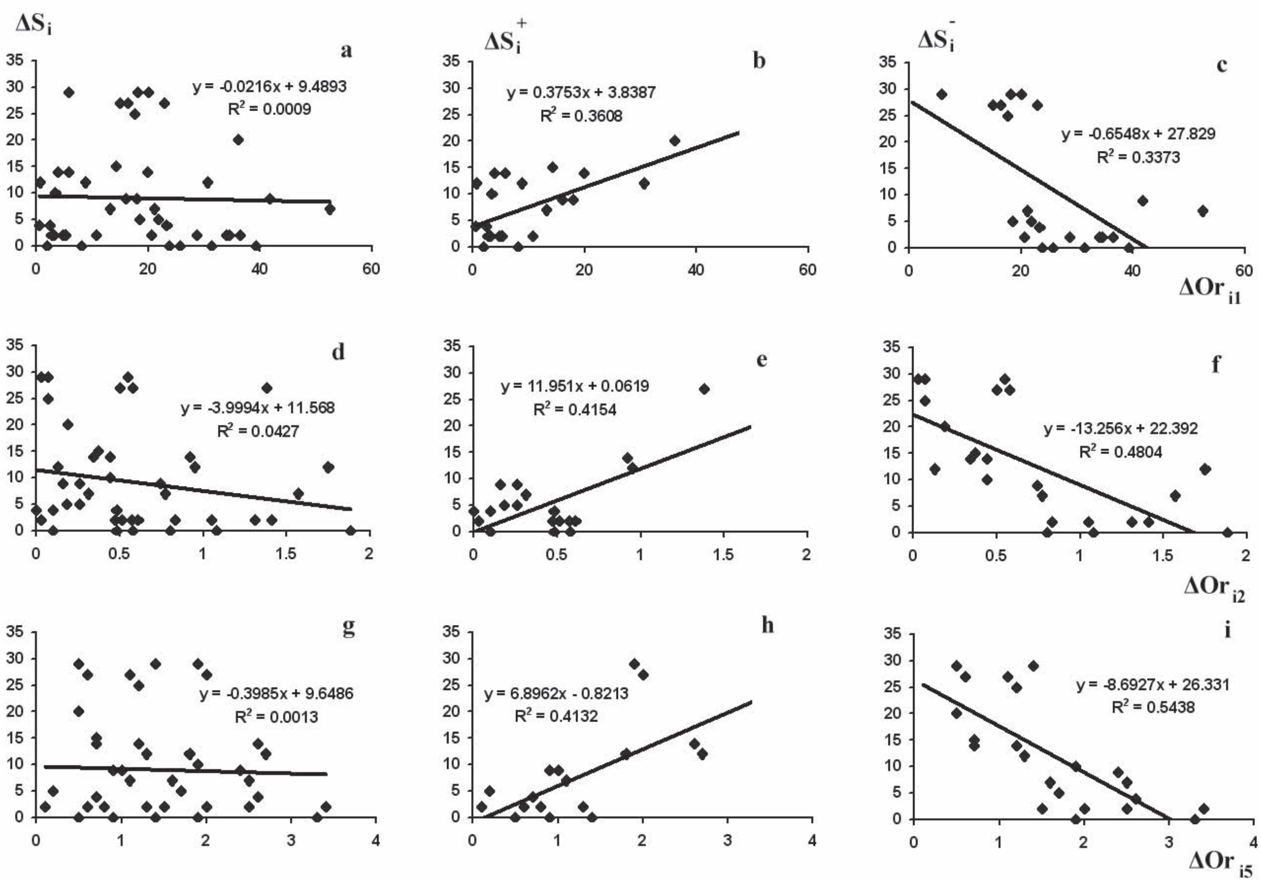

Fig. 9. Dependence of spatial differences sets cover $|\Delta S_i|$ of *D. antarctica* plants populations of Galindez Island, Argentine Islands, season 2017/2018, on spatial macroelements content differences sets: **a**, **d**, **g** – for all points located on the plot between population indices sets paires $|\Delta S_i|$ versus $|\Delta Or_{i1}|$, $|\Delta S_i|$ versus $|\Delta Or_{i2}|$, $|\Delta S_i|$ versus $|\Delta Or_{i5}|$; **b**, **e**, **h** – for points located on plane of the plot which belong to positive group, $|\Delta S^+_i|$ versus $|\Delta Or_{i1}|$, $|\Delta S^+_i|$ versus $|\Delta Or_{i2}|$, $|\Delta S^+_i|$ versus $|\Delta Or_{i5}|$, **c**, **f**, **i** – for points located on plane of the plot which belong to negative group, $|\Delta S^-_i|$ versus $|\Delta Or_{i1}|$, $|\Delta S^-_i|$ versus $|\Delta Or_{i2}|$, $|\Delta S^-_i|$ versus $|\Delta Or_{i5}|$. There are regression equations by the least squares technique and squares of the corresponding correlation coefficients between the above indices values on the charts. The test value of R^2, on the charts: **a** – $F_{1,43} = 0.043$, **d** – $F_{1,43} = 1.935$, **g** — $F_{1,43}=0.045$ (do not exceed the value of the upper 5% F-distribution limit for N = 45 ($F_{1,43} = 4.08$)), **b** – $F_{1,21} = 11.847$, **e** – $F_{1,19} = 13.509$, **h** – $F_{1,21}=14.784$ (exceed the value of the upper 5% F-distribution limit for N = 23 ($F_{1,21}=4.32$), N = 21 ($F_{1,19}=4.38$), N = 23 ($F_{1,21} = 4.32$)); **c** – $F_{1,20} = 10.180$, **f** – $F_{1,22}=20.35$, **i** – $F_{1,20}=23.840$ (exceed the value of the upper 5% F-distribution limit for N = 22 ($F_{1,20} = 4.35$), N=24 ($F_{1,22} = 4.30$), N=22 ($F_{1,20}=4.35$)). These facts mean the absence of linear dependence in the cases **a**, **d**, **g** and the presence of linear dependence in the cases **b**, **e**, **h**, **c**, **f**, **i**

The matching number in the positive and negative groups X^+_{im} and X^-_{im} for $m = 1,2,3,4,5$ was determined for each value i in the example presented in Table 8. The populations sample size was i_{max} = n (in the case under consideration n = 10). The scores number maximum was n-1 = 9. To determine the total probability of matching into one of two groups (X^+_{im} or X^-_{im}) for indices pairs $|\Delta S_i|$ versus $|\Delta Or_{im}|$ (m = 1, 2, 3, 4, 5) we applied the formula (4):

$$X_{im} = \frac{1}{n-1}(X^+_{im} - X^-_{im}) \quad \text{for } m = 1, 2, 3, 4, 5 \qquad (4).$$

5. Determination of the coefficient normalization for each data set.

Each pair of indices $|\Delta S_i|$ versus $|\Delta T_{ilp}|$, ΔPh_{ij} versus $|\Delta T_{ilp}|$, $|\Delta Pr_{ik}|$ versus $|\Delta T_{ilp}|$ had a different total points number on all charts subject to extreme grouping in the example presented in Table 7, therefore the normalization was performed for each pair of indices separately. The coefficient normalization was determined as follows.

The coefficient normalization for the first indices pair $|\Delta S_i|$ versus $|\Delta T_{ilp}|$ was $L_{ilp} = 1$ ($l = 1, 2, 3, p = 1$).

The normalization coefficient for the second pair of indices ΔPh_{ij} versus $|\Delta T_{ilp}|$ ($l = 1, 2, 3, p = 2, j = m$) (in this case, m = 4) was $L_{ijlp} = 1/m$, $L_{i4l2} = 0.25$.

The normalization coefficient for the third pair of indices $|\Delta Pr_{ik}|$ versus $|\Delta T_{ilp}|$ ($l = 1,2,3$, $p=3$, $k=r$) (in this case $r = 5$) was $L_{iklp} = 1/r$ ($k = r$), $L_{i5l3} = 0.2$.

Each pair of indices $|\Delta S_i|$ versus $|\Delta Or_{im}|$ $m = 1, 2, 3, 4, 5$ had the same total points number on all charts for the example presented in Table 8, therefore the normalization coefficient was $L_{im} = 1$.

6. Determination of United Temperature on soil Influence Indices (I^t_i) and United Macroelements Content in Soil Influence Index (I^s_i) to adaptability indices for the i-th population.

The United Temperature Influence Index (UTII) for each indices pair was indicated I^t_{il1}, I^t_{il2}, I^t_{il3} for the indices pairs $|\Delta S_i|$ — $|\Delta T_{ilp}|$ (p=1), $|\Delta Ph_{ij}|$ — $|\Delta T_{ilp}|$ (p=2), $|\Delta Pr_{ik}|$ - $|\Delta T_{ilp}|$ (p=3) respectively. The formulas for the intermediate indices derived from the formulas (1—3) was written as:

$$I^t_{il1} = L_{l1} \times X_{l1} = \frac{1}{(n-1)}(X^+_{l1} - X^-_{l1})$$

$$I^t_{l2} = L_{ijl2} \times X_{l2} = \frac{1}{m(n-1)}\sum_j (X^+_{ijl2} - X^-_{ijl2}) \qquad (5),$$

$$I^t_{l3} = L_{ikl3} \times X_{l3} = \frac{1}{r(n-1)}\sum_k (X^+_{ikl3} - X^-_{ikl3})$$

where X^+_{il1}, X^+_{ijl2}, X^+_{ikl3}, — the matching number to the positive group, X^-_{il1}, X^-_{ijl2}, X^-_{ikl3} — the matching number to the negative group, X_{il1}, X_{il2}, X_{il3} — the i-th population matching probability to corresponding group for each indices pair $|\Delta S_i|$ versus $|\Delta T_{ilp}|$ ($p = 1$), $|\Delta Ph_{ij}|$ versus $|\Delta T_{ilp}|$ ($p = 2$), $|\Delta Pr_{ik}|$ versus $|\Delta T_{ilp}|$ ($p = 3$), respectively, L_{il1}, L_{ijl2}, L_{ikl3} — normalization coefficients for each pair of indices $|\Delta S_i|$ versus $|\Delta T_{ilp}|$ ($p = 1$), $|\Delta Ph_{ij}|$ versus $|\Delta T_{ilp}|$ ($p = 2$), $|\Delta Pr_{ik}|$ versus $|\Delta T_{ilp}|$ ($p = 3$), respectively.

The United Macroelements Content in the Soil Influence Index (UMCSII) was indicated I^s_{im} for the

Table 8. **The result of extreme grouping for indices pairs sets $|\Delta S_i|$ versus $|\Delta Or_{im}|$ (by value *i*) where the spatial differences set $|\Delta S_i|$ depended from spatial soil macroelements content differences sets $|\Delta Or_{im}|$ for (m=1, 2, 5) of *D. antarctica* populations of Galindez Island, Argentine Islands, season 2017/2018**

Δi	$\lvert\Delta S_i\rvert$	ΔOr_{im} ($m = 1$, C_{org})		ΔOr_{im} ($m = 2$, N)		ΔOr_{im} ($m = 5$, pH_{KCl})	
		+	–	+	–	+	–
D1—D2	29	0	1	0	1	0	1
D1—D3	2	1	0	1	0	0	1
D1—D4	2	0	1	0	1	0	1
D1—D5	0	0	1	1	0	0	1
D1—D6	2	1	0	1	0	0	1
D1—D9	14	1	0	0	1	0	1
D1—D10	4	1	0	1	0	0	1
D1—D11	0	1	0	1	0	0	1
D1—D12	9	1	0	1	0	1	0
D2—D3	27	0	1	0	1	0	1
D2—D4	27	0	1	1	0	1	0
D2—D5	29	0	1	0	1	1	0
D2—D6	27	0	1	0	1	0	1
D2—D9	15	1	0	0	1	0	1
D2—D10	25	0	1	0	1	0	1
D2—D11	29	0	1	0	1	0	1
D2—D12	20	1	0	0	1	0	1
D3—D4	0	0	1	0	1	1	0
D3—D5	2	0	1	0	1	1	0
D3—D6	0	1	0	0	1	1	0
D3—D9	12	1	0	0	1	0	1
D3—D10	2	1	0	1	0	1	0
D3—D11	2	1	0	1	0	1	0
D3—D12	7	1	0	1	0	1	0
D4—D5	2	1	0	0	1	1	0
D4—D6	0	0	1	0	1	1	0
D4—D9	12	1	0	0	1	1	0
D4—D10	2	0	1	0	1	1	0
D4—D11	2	0	1	0	1	0	1
D4—D12	7	0	1	0	1	0	1
D5—D6	2	0	1	1	0	1	0
D5—D9	14	1	0	1	0	1	0
D5—D10	4	0	1	1	0	1	0
D5—D11	0	0	1	1	0	1	0
D5—D12	9	0	1	0	1	0	1
D6—D9	12	1	0	1	0	1	0
D6—D10	2	1	0	1	0	1	0
D6—D11	2	1	0	1	0	1	0
D6—D12	7	0	1	0	1	0	1
D9—D10	10	1	0	0	1	0	1
D9—D11	14	1	0	0	1	0	1
D9—D12	5	0	1	1	0	1	0
D10—D11	4	1	0	1	0	1	0
D10—D12	5	0	1	1	0	0	1
D11—D12	9	1	0	1	0	1	0

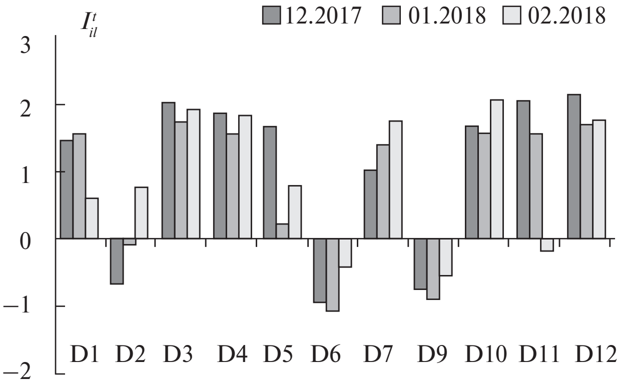

Fig. 10. The United soil surface Temperature Influence Index (UTII) to *D. antarctica* populations plants during each studied month of season 2017/2018

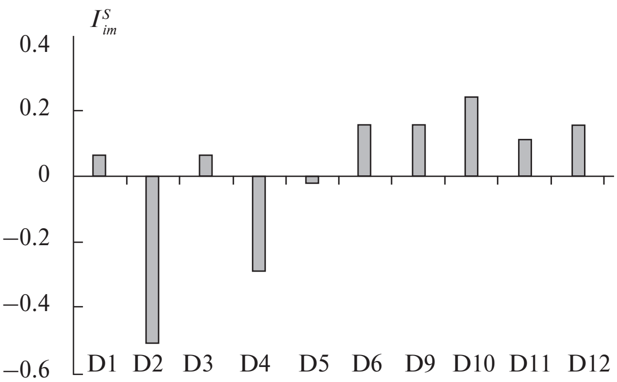

Fig. 11. The United Macroelements Content In Soil Influence Index (UMCSII) of *D. antarctica* populations of Galindez Island, Argentine Islands, season 2017/2018

indices pairs $|\Delta S_i|$ versus $|\Delta Or_{im}|$ (m=1,2,3,4,5). The formula for intermediate indices sets derived from formula (4) was written as:

$$I^s_{im} = L_i \times X_{im} = \frac{1}{(n-1)}(X^+_{im} - X^-_{im}) \ (m = 1, 2, 3, 4, 5) \ (6).$$

7. Determination of the United Influence Indices on adaptability indices of the n populations samples for each i-th population.

The final formulas for the United Temperature Influence Indices (UTII- I^t_i) and the United Macroelements Content in the Soil Influence Indices (UMCSII- I^s_i) on the i-th plant population adaptation determination were (7, 8):

$$\bar{I}^t_i = \frac{1}{3}\sum_{l=1}^{3} I^t_{il} = \frac{1}{3}\sum_{l=1}^{3}\left[L_{il}X_{il} + \sum_{j=1}^{4} L_{ijl}X_{ijl} + \sum_{k=1}^{5} L_{ikl}X_{ikl}\right] \quad (7)$$

$$I^s_i = \frac{1}{5}\sum_{m=1}^{5} I^s_{im} = \frac{1}{5}\sum_{m=1}^{5} L_i X_{im} \quad (8).$$

The I^t_i calculation result for the above example of the 10 *D. antarctica* plants populations sample in the season 2017/2018 by the formula (7) is presented in Table 9 and in Fig. 10.

The I^s_i calculation result for the above example of the 10 *D. antarctica* plants populations sample in the season 2017/2018 by the formula (8) is presented in Table 10 and in Fig. 11.

Table 9. **Results of the United Soil Surface Temperature Influence Index (UTII) to different adaptation indices determination for *i*-th population of *D. antarctica* of Galindez Island, Argentine Islands, season 2017/2018**

D_i	t_{i11}	I^t_{i21}	I^t_{i31}	I^t_{i12}	I^t_{i22}	I^t_{i32}	I^t_{i31}	I^t_{i32}	I^t_{i33}	I^t_i
D_1(D1)	0.7	0.6	–0.6	0.025	0.225	0.575	0.72	0.72	0.62	1.195
D_2(D2)	–0.8	–0.8	0.5	0.05	0.35	–0.05	0.1	0.36	0.3	0.003
D_3(D3)	0.7	0.7	0.6	0.65	0.325	0.65	0.66	0.7	0.68	1.888
D_4(D4)	0.6	0.6	0.7	0.875	0.6	0.725	0.4	0.36	0.42	1.76
D_5(D5)	0.6	0.5	0.6	0.7	–0.8	0.35	0.36	0.52	–0.18	0.88
D_6(D6)	–0.8	–0.9	–0.8	–0.05	–0.35	0.225	–0.1	0.16	0.16	–0.818
D_8(D9)	–0.9	–0.8	–0.7	0.7	0.35	0.275	–0.56	–0.46	–0.12	–0.738
D_9(D10)	0.7	0.6	0.7	0.45	0.475	0.7	0.52	0.48	0.68	1.768
D_{10}(D11)	0.7	0.8	–0.7	0.6	0.25	–0.05	0.76	0.5	0.58	1.15
D_{11}(D12)	0.8	0.7	0.6	0.9	0.8	0.775	0.46	0.2	0.38	1.872

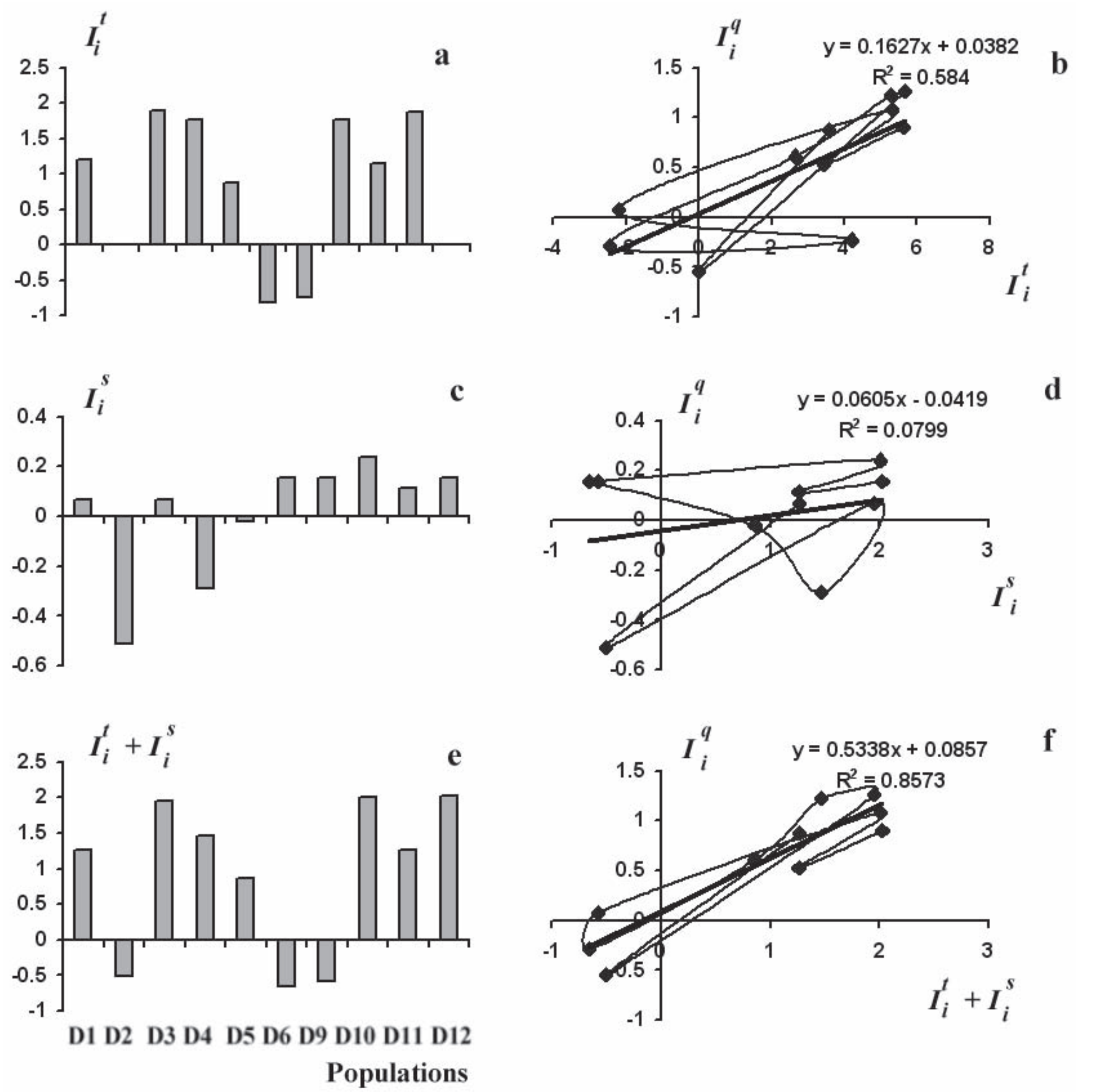

Fig. 12. United Temperature Influence Index during the three summer months I^t_i of the season 2017/2018 to morphometric parameters, content of different seed proteins and cover of *D. antarctica* populations of Galindez Island, Argentine Islands (**a**), United Macroelements Content In Soil Influence Index I^s_i to the cover (**c**); total UTII and UMCSII $I^t_i+I^s_i$ to individual adaptability indices (**e**). Dependence of the United Qualilty Latent Index of Adaptability (I^q_i) on I^t_i (**b**), I^s_i (**d**), $I^t_i+I^s_i$ (**f**) (Parnikoza et al., 2018)

The result of the I^s_i calculation for the above example for sample of 10 *D. antarctica* plants populations Galindez Island in 2017/2018 season according to the formula (8) are presented in Table 10 and in Fig. 11.

A comparison of the data series of UQLI — I^q_i versus UTII — I^t_i and UMCSII — I^s_i was made and presented in Fig. 12 and in Table 11.

The biological meaning of both calculated United Influence Indices could be described by following way. The population plants, that had small/large spatial changes in surface temperature/macroelements content in the soil (for the corresponding populations pair) accompanied by small/large spatial changes in the all studied adaptation indices (for UTII)/ in cover (for UMCSII), had positive values of United Influence Indices on population plants. The population plants, that had small/large spatial changes in

Table 10. **Results of the United Macroelements Content In Soil Influence Index (UMCSII) to cover determination for *i*-th population of *D. antarctica* plants populations of Galindez Island, Argentine Islands in 2017/2018 season**

D_i	I^s_{i1}	I^s_{i2}	I^s_{i3}	I^s_{i4}	I^s_{i5}	I^s_i
D_1(D1)	0.333	0.333	0.111	0.333	–0.778	0.067
D_2(D2)	–0.556	–0.778	–0.556	–0.111	–0.556	–0.51
D_3(D3)	0.333	–0.111	0.111	–0.333	0.333	0.067
D_4(D4)	–0.556	–0.778	–0.556	0.111	0.333	–0.29
D_5(D5)	–0.556	0.111	–0.333	0.111	0.556	–0.022
D_6(D6)	0.111	0.111	0.111	0.111	0.333	0.156
D_8(D9)	0.778	–0.333	–0.333	0.778	–0.111	0.156
D_9(D10)	–0.111	0.333	0.333	0.333	0.333	0.24
D_{10}(D11)	0.333	0.333	0.111	–0.333	0.111	0.111
D_{11}(D12)	–0.111	0.111	0.333	0.333	0.111	0.156

Table 11. **Contributions of United soil surface Temperature Influence Index (UTII—I^t_i), United Macroelements Content In Soil Influence Index (UMCSII — I^s_i) and $I^t_i + I^s_i$ to the United Qualilty Latent Index of Adaptability (UQLI—I^q_i) of *D. antarctica* populations of Galindez Island, Argentine Islands, season 2017/2018 (Parnikoza et al., 2018)**

Pairs of integral indices sets	n	R^2	$F_{1, n-2}$	$F_{1, n-2}$ ($\alpha = 0.05$)	R
I^q_i versus I^t_{i1}	11	0.6778	18.94	5.12	0.823
I^q_i versus I^t_{i2}	11	0.4989	8.96	5.12	0.708
I^q_i versus I^t_{i3}	11	0.2978	3.81	5.12	0.55
I^q_i versus I^t_i	11	0.585	12.636	5.12	0.764
I^q_i versus I^s_i	10	0.0799	0.696	5.32	0.282
I^q_i versus (I^t_i+I^s_i)	10	0.8573	48.104	5.32	0.926

Notes: I^t_{i1} is the United soil surface Temperature Influence Index in December 2017, I^t_{i2} is the same in January 2018, and I^t_{i3} is the same in February 2018; I^s_i is the United Macroelements Content In Soil Influence Index, n is the number of researched populations, R^2 is the square of the correlation coefficient, $F_{1,n-2}$ is the test value, $F_{1, n-2}$ ($\alpha = 0.05$) is the upper 5% F distribution limit, R is the correlation coefficient that is equivalent to the corresponding influence index contribution to UQLI (I^q_i).

surface temperature/macroelements content in the soil (for the corresponding populations pair) accompanied by large/small spatial in the all studied adaptation indices (for UTII)/ in cover (for UMCSII), had negative values of United Influence Indices on population plants.

The data comparison analysis of UQLI (I^q_i) with UTII (I^t_{i1}, I^t_{i2}, I^t_{i3}, I^t_i), UMCSII (I^s_i) and its sum (I^t_i+I^s_i) were presented in Table 11. These analysis results allow to make a conclusion that the largest soil surface temperature factor contribution (about 80%) to *D. antarctica* populations I^q_i (UQLI) on Galindez Islands took place in December 2017 (I^t_{i1}). Its contribution has been 70% in January 2018 (I^t_{i2}), the contribution value was not reliable in February 2018 (I^t_{i3}). The average contribution value of the UTII (I^t_i) was approximately 76% during the summer months of the Antarctic season. The I^s_i contribution to I^q_i was not significant (about 20%). However, the total (I^t_i + I^s_i) contribution to I^q_i has increased compared to the I^t_i contribution (76%) to about 90%. It should be noted that the analysis did not take into account the effects of humidity, salinity and other factors (its remained latent), which may either increase or decrease the contribution of (I^t_i + I^s_i) to I^q_i.

The reliable UTII contribution to UQLI is shown in December and January, at the time of the greatest temperature variation. UMCSII is shown to influence to UQLI only the UMCSII summarized with UTII, and this sum had significantly more increase contribution to UQLI (Table 11).

Additional information can be obtained by creating correlation models for each population. These correlation models show probabilistic relationships that reflect the relationships between individual adaptability indices for different plant populations. An example of such correlation model is presented in Fig. 13.

Information about the probability of matching number into the positive and negative groups, obtained from the Tables 7, 8, was used to create correlation models. The values of X^+_{ilp} or X^-_{ilp}, X^+_{ijlp} or X^-_{ijlp}, X^+_{iklp} or X^-_{iklp} (in formulas (1)—(3)) were used to creat the correlation model, depending of that value X^+ or X^- was larger by module.

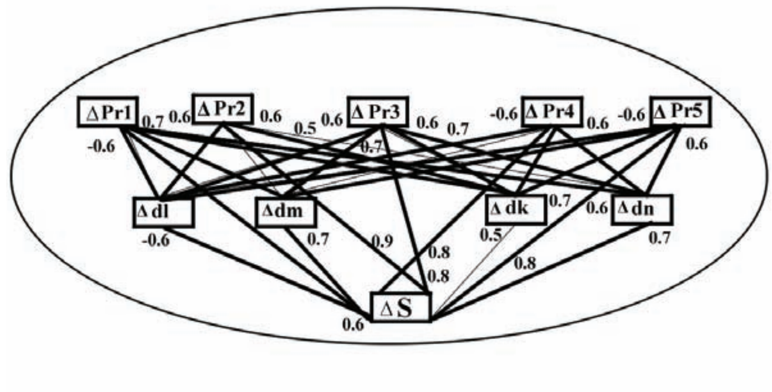

Fig. 13. Correlation model for D1 *D. antarctica* populations of Galindez Island, Argentine Islands, season 2017/2018 demonstrating probabilistic relationships between plant population characteristics. The numbers indicate the likelihood of relationships between indices in phase (+) or antiphase (–). The markings are spatial differences: leaf length (Δdl), inflorescence length (Δdm), flower length (lower flower glume length, Δdk), number of flowers in the inflorescence (dn); fractions that correspond to: globulins with molecular mass more than 150 (ΔPr1), glutenins with MM from 94 to 145 (ΔPr2), sulfur-poor prolamins — from 45 to 80 (ΔPr3); sulfur-rich prolamins — from 20 to 40 (ΔPr4); part of sulfur-rich prolamins and probably IRIP protein — 27—31 (ΔPr5); not full formed prolamins and low molecular weight dehydrins — less than 20 kDa (ΔPr6)

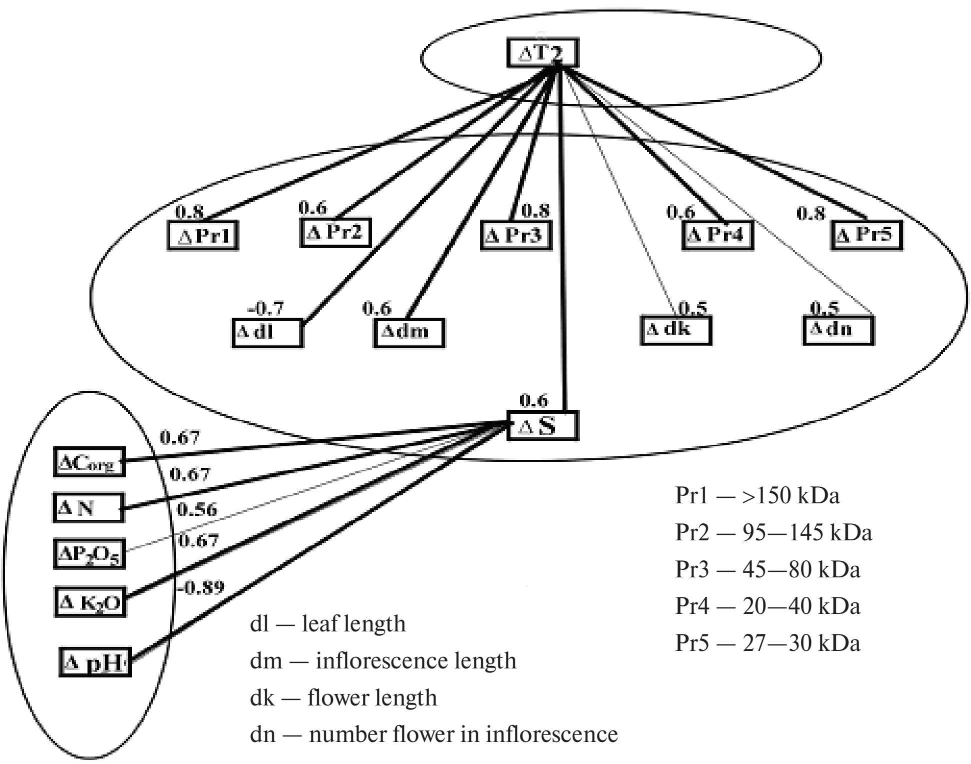

Fig. 14. Correlation model of the influence of spatial changes in temperature and macroelements composition on spatial distances of individual adaptability indices in the D1 *D. antarctica* populations of Galindez Island in January 2018 (T_2). Pr1-5 — seed protein fractions of the respective groups by weight. The numbers indicate the likelihood of relationships between indices in phase (+) or antiphase (–). The marking are spatial differences: leaf length (Δdl), inflorescence length (Δdm), flower length (lower flower glume length, Δdk), number of flowers in the inflorescence (dn); fractions that correspond to: globulins with molecular mass more than 150 (ΔPr1), glutenins with MM from 94 to 145 (ΔPr2), sulfur-poor prolamins — from 45 to 80 (ΔPr3); sulfur-rich prolamins — from 20 to 40 (ΔPr4); part of sulfur-rich prolamins and probably IRIP protein — 27—31 (ΔPr5); not full formed prolamins and low molecular weight dehydrins — less than 20 kDa (ΔPr6)

This correlation models (Fig. 14) demonstrate the probabilistic relationships between spatial temperature differences and spatial macroelements content differences and the plant adaptability population characteristics for the D1 plant population in January 2018 (T_2).

Such correlation models for 11 sampling populations in dynamics will allow to trace changes in the probabilistic relationships of the spatial changes in the plant population characteristics depending from spatial distances in temperature and other indices of environmental influance during annual monitoring studies.

CONCLUSIONS

The algorithms for the United Temperature Influence Index (UTII, I^t) and United Macroelements Content in Soil Influence Index (UMCSII, I^s) on the base of population characteristics set were described in detail for ten *D. antarctica* populations from Galindez Island studied in season 2017/18.

The UQLI (I^q) was evaluated for eleven experimental populations of *D. antarctica* from Galindez Island by algorithm described in work (Miryuta et al., 2019).

UTII (I^t) was shown to have a significant contribution to the UQLI (I^q) in December and January, when the largest spatial temperature variations were observed. Therefore, the most sensitive *D. antarctica* is in the begining of the growing season. UMCSII (I^s) did not have a statistical confidence of contribution to the UQLIA, but sum with the UTII increased UTII contribution value to the UQLIA.

The index UTII is proposed to describe an influence of source temperature data to a large number of different characteristics in sample populations by reducing the dimension to one number. The index UMCSII is proposed to describe an influence of a large number of source macroelements content in soil data to sample populations covers by reducing the dimension to one number. The UTII and UMCSII sets can be used to compare with a set of the UQLIA populations sample of the same species growing under different conditions to construct correlation models for different populations.

The intermediate data in the calculation UQLI, UTII, UMCSII can also be used to create correlation models. Such correlation models for eleven sampling plant populations in dynamics will allow to trace changes in the probabilistic relationships of the spatial changes in the plant population characteristics depending from spatial distances in temperature and other indices of environmental influence during annual monitoring studies.

REFERENCES

Alberdi, M., Bravo, L.A., Gutierrez, A., Gidekel, M., Corcuera, L.J. 2002. Ecophysiology of Antarctic vascular plants. *Physiol. Plant,* 115, 479—486.

Ayvazyan, S.A., Buchstaber, V.M., Yenyukov, I.S., Meshalkin, L.D. 1989. *Applied statistics Moscow*. (In Russian).

Barcikowski, A., Czaplewska, J., Loro, P., Łyskievich, A., Smykla, J. Wojciechowska A. 2003. Ecological variability of *Deschampsia antarctica* in the area of Admiralty Bay (King George island, Maritime Antarctic). *Problems of grass biology*. L. Frey (Ed.) Kraków, W. Szafer Institute of Botany, PAS, 383—396.

Bauman, E.V., Moskalenko, N.E. 2008. Methods of Extremal Grouping of the Fractional Parameters. *Automation and Remote Control,* 69, 1965—1972.

Bockheim, J.G. (ed) 2015. The Soils of Antartica. — World Soils Book Series. Springer. New York, Dordrecht, London, 1—322.

Cannone, N., Guglielmin, M., Convey, P., Worland, M.R., Longo, S.F. 2016. Vascular plant changes in extreme environments: effects of multiple drivers. *Climatic Change,* 134, 651—665.

Callaghan, T. V., Cllins, N. J. 1981. Life cycles, population dynamics and growth of the tundra plants. In Bliss. L. C., Heal, O.W. and Moore J.J. (eds.) Tundra ecosystems: Comparative Analysis. Cambridge: Cambridge University Press, 257—284.

Casanova-Katny, M.A., Zúñiga, G.E., Corcuera, L.J., Bravo, L., Alberdi, M. 2010. *Deschampsia antarctica* Desv. primary photochemistry performs differently in plants grown in the field and laboratory. *Polar Biology,* 33, 477—483.

Convey, P. 2003. Maritime Antarctic climate Change Signals from terrestrial biology. *Antarctis research series*, 79, 145—158.

Corder, G.W., Foreman, D.I. 2014. *Nonparametric Statistics: A Step-by-Step Approach*. 2014. Wiley.

Fowbert, J. A., Lewis Smith, R. I. 1994. Rapid population Increases in native vascular plants in the Argentine Islands Antarctic Peninsula. *Arctic and Alpine Research,* 26 (3), 290—296.

Gerighausen, U. Bräutigam, K., Mustafa, O., Peter, H.-U. 2003. Expansion of vascular plants on an Antarctic Islands a consequence of climate change? In: A. H. L. Huiskes, W.W.C. Gieskes, J. Rozema et al. (eds) Antarctic Biology in a Global context, Backhuys Publishers, Leiden, 79—83.

Kennicutt, M.C., Chown, S.L., Cassano, J.J., Liggett, D., Massom, R., Peck, L. S., Rintoul, S. R., Storey, J. W. V., Vaughan, D. G., Wilson, T.J., Sutherland, W.J. 2014. Polar research: Six priorities for Antarctic science. *Nature*, 512 (7512), 23–25. https://doi.org/10.1038/512023a.

Komárkova V., Poncet S., Poncet J., 1985. Two native vascular plants, *Deschampsia antarctica* Desv. and *Colobanthus quitensis* (Kunth.) Bartl: A new southernmost locality and other localities in the Antarctic Peninsula area. *Arct. Alp. Res.*, 17, 401—416.

Komárkova V., Poncet S., Poncet J., 1990. Additional and revisited localities of vascular plants, *Deschampsia antarctica* Desv. and *Colobanthus quitensis* (Kunth.) Bartl. in the Antarctic Peninsula area. *Arct. Alp. Res*, 22, 108—113.

Legendre, P., Fortin, M.J., Borcard, D. 2015. Should the Mantel test be used in spatial analysis? *Methods in Ecology and Evolution. British Ecologycal Society.* https://doi.org/10.1111/2041-210X.12425.

Miryuta, N.Yu., Parnikoza, I.Yu., Shvydun, P.P., Miryuta, G.Yu., Poronnik, O.O., Kozeretska, I.A., Kunakh, V.A. 2015. Comparative analysys of adaptability united latent quality indicator of *Deschampsia antarctica* population form Galindez island (Argentine Islands, maritime Antarctic) during three seasons. *Ukrainian Antarctic Journal,* 14, 143—157. (In Ukrainian).

Miryuta, N.Yu., Parnikoza, I.Yu., Oliinyk, M., Smetana, E., Myryuta, G.Yu., Poronnik, O.O., Kunakh, V.A. 2017. Five seasons dynamic of adaptability united latent quality indicator of *Deschampsia antarctica* population in Galindez Island (Argentine Islands, maritime Antarctic). *Ukrainian Antarctic Journal,* 16, 129—142. (In Ukrainian).

Miryuta, N.Yu., Smykla, J., Parnikoza, I.Yu. 2019. Algorithm for the United Quality Latent Index of the plant adaptability and its application field in monitoring of *Deschampsia antarctica* È. Desv. populations. *Ukrainian Antarctic Journal*, 1 (18), 152—168.

Parnikoza, I., Miryuta, N., Ozheredova, I., Kozeretska, I., Smykla, J., Kunakh, V., Convey, P. 2015. Comparative analysis of *Deschampsia antarctica* Desv. population adaptability in the natural environment of the Admiralty Bay region (King George Island, maritime Antarctic). *Polar Biology*, 38 (9), 1401—1411.

Parnikoza, I., Abakumov, E., Korsun, S., Klymenko, I., Netsyk, M., Kudinova, A., Kozeretska, I. 2016. Soils of the Argentine Islands, Antarctica: Diversity and Characteristics. *Polarforschung,* 86 (2), 83–96.

Parnikoza, I.Yu., Miryuta, N.Yu., Ivanets, V.Yu., Dikyi, Je.O. 2018. Determination of the United Quality Latent Index of Adaptability (UQLIA) and contribution of some environmental parameters to it for *Deschampsia antarctica* populations, Galindez Island (maritime Antarctic) season 2017/2018. *The Bulletin of Ukrainian Society of Geneticists and Breeders,* 16 (2), 190—202.

Pollard, J.H.P. 1982. *A handbook of numerical and statistical techniques*. Moscow. (In Russian).

Sáez, P. L., Cavieres, L. A., Galmés, J., Gil-Pelegrín, E., Peguero-Pina, J. J., Sancho-Knapik, D., Vivas, M., Sanhueza, C., Ramırez, C. F., Rivera, B. K., Corcuera, L. J., Bravo, L. A. 2018. *In situ* warming in the Antarctic: effects on growth and photosynthesis in Antarctic vascular plants. *New Phytologist,* 218 (4), 1406–1418. https://doi.org/10.1111/nph.15124.

Received 18 November 2019
Accepted 10 January 2020

Н. Мірюта[1], *К. Войцеховський*[2], *І. Парнікоза*[1,3,4,*]

[1] Державна установа Національний антарктичний науковий центр МОН України, бульв. Тараса Шевченка, 16, Київ, 01601, Україна

[2] Дирекція регіональних ландшафтних парків Люблінського воєводства, вул. Мечислава Карловича, 4, 20-027, Люблін, Польща

[3] Інститут молекулярної біології і генетики Національної академії наук України, вул. Акад. Заболотного, 150, Київ, 03143, Україна

[4] Національний історико-архітектурний музей «Київська фортеця», вул. Госпітальна, 24А, Київ, 01133, Україна

*Автор для кореспонденції: ivan.parnikoza@uac.gov.ua

Розрахунок індексів впливу зовнішніх факторів на рослини та його застосування до популяцій *Deschampsia antarctica* Ė. Desv.

Реферат. **Мета дослідження** — розробити і детально описати алгоритми розрахунку зведених показників впливу температури поверхні ґрунту та вмісту макроелементів у ґрунті на основні характеристики судинних рослин на прикладі *Deschampsia antarctica* È. Desv. з о. Галіндез, Аргентинські острови, Морська Антарктика. Кінцева мета роботи полягає в оцінці внеску у зведений латентний показник пристосовуваності рослин досліджуваних популяцій (ЗЛПП) зведених показників впливу таких факторів довкілля, як температура поверхні (ЗПВТ) та вміст макроелементів у ґрунті (ЗПВГ). **Методи**. Набір вихідних даних температур поверхні ґрунту отримано за допомогою логерів для кожної окремої популяції протягом квітня 2017 р. — квітня 2018 р. Для отримання наборів експериментальних даних для одинадцяти популяцій *D. antarctica* застосовано методи визначення індивідуального проективного покриття *D. antarctica* та вимірювання морфометричних показників: довжини листка, суцвіття, квітки (за нижньою квітковою лускою), кількості квіток у суцвітті. Спектри запасних і захисних білків насіння досліджено за допомогою електрофорезу в поліакриламідному гелі. Для отримання зведених показників впливу температури поверхні та вмісту макроелементів у ґрунті на рослини досліджуваних популяцій застосовано метод екстремального групування. Розрахунок ЗПВТ та ЗПВГ проводили на основі попарних просторових порівнянь рядів показників. **Результати.** Розроблено і детально описано алгоритм розрахунку зведених показників впливу температури та вмісту макроелементів у ґрунті на окремі параметри пристосовуваності рослин одинадцяти популяцій *D. antarctica* о. Галіндез в сезоні 2017/18 р. Визначення внеску ЗПВТ та ЗПВГ у ЗЛПП наведено як приклад оцінки значимості цих параметрів оточуючого середовища в адаптивності рослин. **Висновки**. Показано, що ЗПВТ має достовірний внесок у ЗЛПП в грудні і січні, в момент найбільшої просторової варіації температури. ЗПВГ має достовірний внесок у ЗЛПП лише у сумі із ЗПВТ, збільшуючи значення внеску останнього у ЗЛПП. Показник ЗПВТ запропоновано для того, щоб описати вплив набору вихідних даних з температури на різні характеристики рослин великої вибірки популяцій шляхом зменшення їх розмірності до одного числа. Показник ЗПВҐ запропоновано для того, щоб описати вплив великої кількості вихідних даних із вмісту макроелементів в ґрунті на проективне покриття вибірки популяцій шляхом зменшення їх розмірності до одного числа. ЗПВТ та ЗПВҐ можуть бути використані для порівняння їх із ЗЛПП вибірки популяцій одного виду, що зростають за різних умов, для створення кореляційних моделей для різних популяцій.

Ключові слова: *Deschampsia antarctica* È. Desv, зведений латентний показник пристосовуваності (ЗЛПП), зведений показник впливу температури (ЗПВТ), зведений показник впливу вміста макроелементів у ґрунті (ЗПВҐ), Аргентинські острови, Морська Антарктика.