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Article

Two-dimensional ordered cluster analysis of component groups in self-organization

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Abstract
An algorithm for two-dimensional cluster analysis of component groups, originally from Zhang et al., (2004), was introduced in this study. The algorithm composes of three procedures, i.e., calculation of distance measures, randomization statistic test, and ordered clustering of components.

Keywords two-dimensional cluster analysis; components; groups.

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1 Introduction

Ecological processes at the landscape level are self-organizing processes. Geographicaly, a landscape is composed of many mosaics (components, as called in self-organization) occupied by various organisms. For most organisms, mosaic structure determines their feeding, survival and prosperity (Bell et al., 1991; Zhang et al., 2004). As a membrane or barrier or channel, the boundary between two mosaics affects the movement and migration of organisms (Forman, 1995; Zhang and Schoenly, 1999; Qi, 2002; Qi and Zhang, 2002; Zhang, 2012, 2013; Zhang et al., 2013). Relationship between mosaic boundaries and biotic/abiotic factors has been confirmed in many studies (Gillison and Brewer, 1985; Hansen et al., 1988; Holland et al., 1991). It was found that homogeneous and continuous mosaics with less natural barriers were conducive to the spread of organisms. The number and shape of mosaics determines ecosystems at the landscape level. In this study, an algorithm for two-dimensional cluster analysis of component groups, originally from Zhang et al., (2004), was introduced to address ordered classification of mosaics.

2 Method

Assume there are m mosaic indices and n sampling sites (mosaics, or components). Now we have the $n \times m$ matrix (y_{ij}), and the algorithm is as follows:

2.1 Choose distance measures

Distance measures are used to measure the similarity between mosaics (components). A larger distance value means a lower similarity between two mosaics. We chose four categories, a total of 14 types of distance measures here (Qi, 2002; Zhang, 2007; Zhang et al., 2004; Zhang, 2012; Zhang and Fang, 1982; Krebs, 1989).

(1) Minkowski distance measures. They include Euclidean distance, Manhattan distance, and Chebyshov distance:

$$z_{ij}=(\sum^{m}_{k=1}(y_{ik} - y_{jk})^2/m)^{1/2}$$
$$z_{ij}= \sum^{m}_{k=1}|y_{ik} - y_{jk}|/m$$
$$z_{ij}= max_{k} |y_{ik} - y_{jk}| \qquad i,j=1,2,\ldots,n$$

(2) Correlation based measures. They include Pearson correlation and angular cosine:

$$z_{ij}= 1-\sum^{m}_{k=1} ((y_{ik} - y_{ib})(y_{jk}- y_{jb}))/(\sum^{m}_{k=1} (y_{ik} - y_{ib})^2 \sum^{m}_{k=1} (y_{jk} - y_{jb})^2)^{1/2}$$
$$z_{ij}= 1-\sum^{m}_{k=1} (y_{ik}\, y_{jk}) /(\sum^{m}_{k=1} y_{ik}^2 \sum^{m}_{k=1} y_{jk}^2)^{1/2} \qquad i,j=1,2,\ldots,n$$

The two categories of indices are used to the indices with real values.

(3) Nominal distance measures. They include linkage coefficient, and three co-linkage coefficients based distance measures:

$$z_{ij}=1-(x^2/(x^2+n_{..}))^{1/2}$$
$$z_{ij}=1-(x^2/(n_{..} \max(p-1,q-1)))^{1/2}$$
$$z_{ij}=1-(x^2/(n_{..} \min(p-1,q-1)))^{1/2}$$
$$z_{ij}=1-(x^2/(n_{..} ((p-1)(q-1))^{1/2}))^{1/2}$$

where

$$x^2= n_{..}(\sum^{p}_{i=1}\sum^{q}_{j=1}n_{ij}^2/(n_{i.}\, n_{.j})-1)$$
$$n_{..} =\sum^{p}_{i=1} n_{i.}\,, \quad n_{i.} =\sum^{q}_{j=1} n_{ij}\quad , \quad n_{.j} =\sum^{p}_{i=1} n_{ij}$$

where there are p nominal values, i.e., t_1, t_2,…, t_p, for sampling site i and q nominal values, i.e., r_1, r_2,…, r_q, for sampling site j. Assume that n_{kl} is the number of sampling site i takes value t_k and sampling site j takes value r_l, $k = 1, 2, . . . , p$; $l = 1, 2, . . . ,q$.

(4) Boolean distance measures, including point correlation, quadratic correlation, two angular cosine functions, and Jaccard coefficient based distance measures:

$$z_{ij}=1-(ad-bc)/((a+b)(c+d)(a+c)(b+d))^{1/2}$$
$$z_{ij}=1-\sin((a+d-(b+c))/(a+b+c+d)*3.1415926/2)$$
$$z_{ij}=1-(a*a/((a+b)(a+c)))^{1/2}$$
$$z_{ij}=1-(a*a*d*d/((a+b)(a+c)(b+d)(c+d)))^{1/2}$$
$$z_{ij}=(b+c)/(b+c+d) \qquad i,j=1,2,\ldots,n$$

where both sampling site i and sampling site j take values 0 or 1. a is the number of both sampling site i and sampling site j take value 0, b is the number of sampling site i takes 0 and sampling site j takes 1, c is the number of sampling site i takes 1 and sampling site j takes 0, and d is the number of both sampling site i and sampling site j take value 1.

2.2 Randomization test

If $min\ y_{ij} <0$, let $y_{ij} = y_{ij} - min\ y_{ij}$, i=1,2,…,n; j=1,2,…,m. z_{ij} is the decimal number of y_{ij}, and $d_{ij}=10^{Zij}$. Let

$$y_{ij}= y_{ij}\ max_j\ d_{ij} \qquad i=1,2,\ldots,n$$

Through these transformations all of the values in sampling data become integers which are equivalent to numbers of individuals. The randomization test used in present study is based on the idea that, if no difference exists, then the distribution of individuals in sampling sites i and j will be a result of allocating the mixed sampling site values at random into two sampling site of size equal to those of the original sampling site (Solow, 1993; Manly, 1997; Zhang and Schoenly, 2001; Zhang et al., 2004; Zhang, 2007). The randomization test procedure is described as the follows. Assume the two sampling sites to be tested are i and j, i=1, 2, …, $n-1$; $j>i$. The $s_{ij}=\sum^{m}_{k=1} y_{ik}+\sum^{m}_{k=1} y_{jk}$ individuals of the combined sampling site are randomly reallocated into two randomized sampling sites with $\sum^{m}_{k=1} y_{ik}$ and $\sum^{m}_{k=1} y_{jk}$ labeled individuals. Calculate the expected absolute distance (similarity) between the two randomized sampling sites and compare whether it is not less than the absolute distance (similarity) between the true sampling sites i and j. Repeat the simulation many times, calculate the number of the expected are not less than the absolute distance (similarity) between the sampling site i and j, take the percentage as the p value. The p value is used to make statistical test. The threshold p value for test may be defined as 0.05, 0.01, etc. If the calculated p value is less than (in the case of similarity, larger than) p threshold, then the difference between sampling sites i and j is statistically significant.

2.3 Ordered regionalization of mosaics (components)

This procedure aims to conduct ordered regionalization of mosaics according to their similarity (Fang, 1979; Zhang, 1993). Mosaics with significant difference belong to different groups (clusters). In the ordered cluster analysis, the mosaics in the same group are geographically adjacent, and the lines between any two mosaics that belong to different groups are not intersected.

Assume the two-dimensional coordinate of each sampling site (mosaic) is (y_{i11}, y_{i12}), i=1,2,…,n. And for sampling sites i and j, i=1,2,...,n-1; $j>i$, calculate

$$g_1(i,j)=\{k, i \mid y_{k12}>(y_{j12}- y_{i12})(y_{k11}- y_{i11})/(y_{j11}- y_{i11})+ y_{i12}\}$$
$$g_2(i,j)=\{k, j \mid y_{k12}<(y_{j12}- y_{i12})(y_{k11}- y_{i11})/(y_{j11}- y_{i11})+ y_{i12}\}$$
$$G_1(i,j)=\{k, j \mid y_{k12}>(y_{j12}- y_{i12})(y_{k11}- y_{i11})/(y_{j11}- y_{i11})+ y_{i12}\}$$
$$G_2(i,j)=\{k, i \mid y_{k12}<(y_{j12}- y_{i12})(y_{k11}- y_{i11})/(y_{j11}- y_{i11})+ y_{i12}\}$$

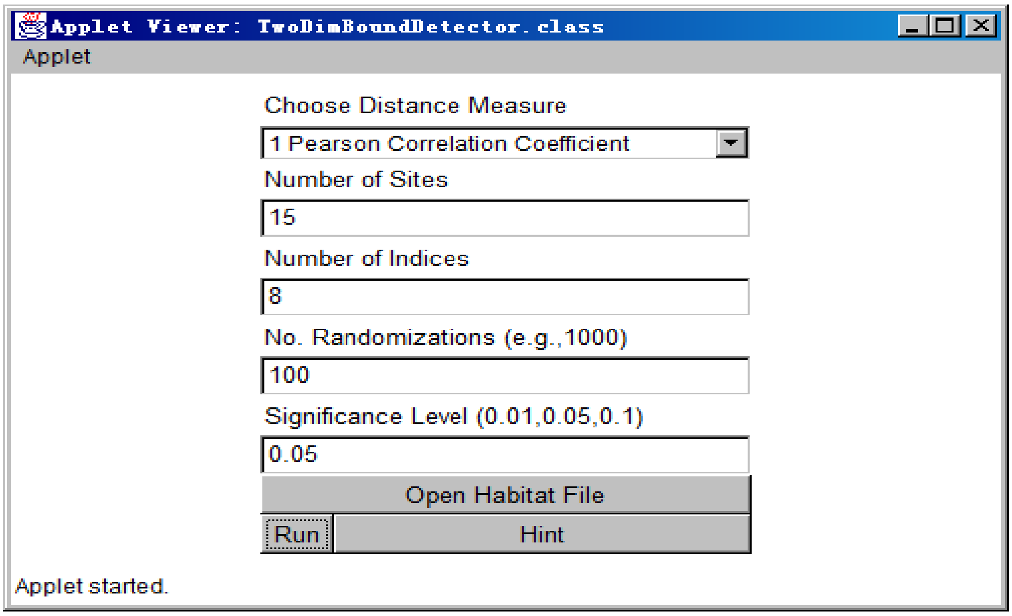
Thus there will be $n(n$-1) possible classifications. In each classification, for the sampling site i ($i_1\leq i\leq i_2$-1) in sub-group 1 and the sampling site j ($i_2\leq j\leq i_3$-1) in sub-group 2, calculate the p value, p_{ij}, in the randomization test, and choose the classification that meets the condition:

$$min\ pbar=(\sum^{i2-1}_{i=i1}\sum^{i3-1}_{j=i2} p_{ij})/((i_2- i_1)(i_3- i_2))$$

Suppose there have been k groups, obtain two sub-groups for each group, and choose a group to make sub-classification. If $k=n$, then stop the procedure. Therefore a cluster graph with different statistical significance levels can be achieved.

If all values of *max min pbar* are larger than the given threshold *p* value, then the landscape is continuous and homogeneous. Or else there are several mosaics with significant differences.

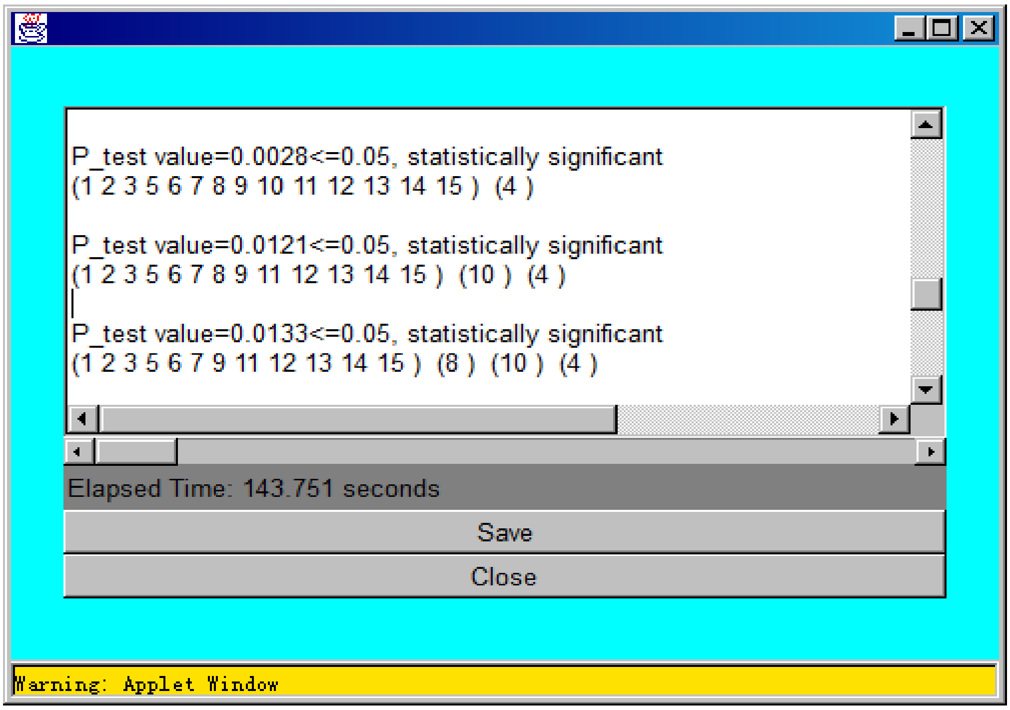
The algorithm is implemented as a Java program, TwoDimBoundDetector, based on JDK 1.1.8, in which several classes and an HTML file is included (http://www.iaees.org/publications/software/index.asp) (Fig. 1 and 2). In data file, the first two columns are 2-dimensional coordinates of sampling sites and the remaining columns are for every index.



Choose Distance Measure
1 Pearson Correlation Coefficient
Number of Sites
15
Number of Indices
8
No. Randomizations (e.g.,1000)
100
Significance Level (0.01,0.05,0.1)
0.05

Applet started.

Fig. 1 Applet window of the algorithm-Input.



```
P_test value=0.0028<=0.05, statistically significant
(1 2 3 5 6 7 8 9 10 11 12 13 14 15 )  (4 )

P_test value=0.0121<=0.05, statistically significant
(1 2 3 5 6 7 8 9 11 12 13 14 15 )  (10 )  (4 )

P_test value=0.0133<=0.05, statistically significant
(1 2 3 5 6 7 9 11 12 13 14 15 )  (8 )  (10 )  (4 )
```

Elapsed Time: 143.751 seconds

Fig. 2 Applet window of the algorithm-Output.

3 Applications

3.1 Two-dimensional distribution of grass families in Zhuhai

Sampling survey was conducted on May 22, 2008 in a grass community of Zhuhai, China (Fig. 3). In total of 100 samples were taken along a linear transect. Each sample had a size of 1m × 1m. Grass families and cover (%) in each sample were recorded. Totally 16 grass families were found and treated as the indices for cluster analysis.

1	11	21	31	41	51	61	71	81	91
2	12	22	32	42	52	62	72	82	92
3	13	23	33	43	53	63	73	83	93
4	14	24	34	44	54	64	74	84	94
5	15	25	35	45	55	65	75	85	95
6	16	26	36	46	56	66	76	86	96
7	17	27	37	47	57	67	77	87	97
8	18	28	38	48	58	68	78	88	98
9	19	29	39	49	59	69	79	89	99
10	20	30	40	50	60	70	80	90	100

Fig. 3 Geographical distribution of sampling sites in a meadow of Zhuhai.

We chose Euclidean distance, and randomize 100 times; the threshold *p* value is 0.05. The classification results of 100 samples were as follows:

P_test value=0.0017<=0.05, statistically significant

(1) (2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100)

P_test value=0.0039<=0.05, statistically significant

(1) (2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100) (20)

P_test value=0.0045<=0.05, statistically significant

(1) (2) (3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100) (20)

P_test value=0.0227<=0.05, statistically significant

(1) (2) (3) (4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100) (20)

P_test value=0.0237<=0.05, statistically significant

(1) (2) (3) (4 5 6 7 9 10 11 12 13 14 15 16 17 18 19 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100) (8) (20)

P_test value=0.0298<=0.05, statistically significant

(1) (2) (3) (4 5 6 7 9 10 11 12 13 14 15 16 17 18 19 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100) (60) (8) (20)

P_test value=0.0308<=0.05, statistically significant

(1) (2) (3) (4 5 6 7 9 10 13 14 15 16 17 18 19 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100) (11 12) (60) (8) (20)

P_test value=0.0308<=0.05, statistically significant

(1) (2) (3) (4 5 6 7 9 10 13 14 15 16 17 18 19 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100) (41) (11 12) (60) (8) (20)

P_test value=0.0311<=0.05, statistically significant

(1) (2) (3) (4 5 6 7 9 10 13 14 15 16 17 18 19 21 22 23 24 25 26 27 28 29 30 31 33 34 35 36 37 38 39 40 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100) (32) (41) (11 12) (60) (8) (20)

P_test value=0.0315<=0.05, statistically significant

(1) (2) (3) (4 5 6 7 9 10 13 14 15 16 17 18 19 21 22 23 24 25 26 27 28 29 30 31 33 34 35 36 37 38 39 40 42 43 44 45 46 47 48 49 50 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.0319<=0.05, statistically significant

(1) (2) (3) (4 13 21 22 31) (5 6 7 9 10 14 15 16 17 18 19 23 24 25 26 27 28 29 30 33 34 35 36 37 38 39 40 42 43 44 45 46 47 48 49 50 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.0332<=0.05, statistically significant

(1) (2) (3) (4 13 21 22 31) (5 6 9 10 14 15 16 17 18 19 23 24 25 26 27 28 29 30 33 34 35 36 37 38 39 40 42 43 44 45 46 47 48 49 50 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.0482<=0.05, statistically significant

(1) (2) (3) (4 13 21 22 31) (5 6 9 10 14 15 16 17 18 19 23 24 25 26 27 28 29 30 33 34 35 36 37 38 39 40 42 43 44 45 46 47 48 49 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.0593>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 14 15 16 17 18 19 23 24 25 26 27 28 29 30 33 34 35 36 37 38 39

40 42 43 44 45 46 47 48 49 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.0733>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 14 15 16 17 18 19 23 24 25 26 27 28 29 30 33 34 35 36 37 38 39 40 42 43 44 45 46 47 48 49 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 95 96 97 98 99 100) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.0755>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 14 15 16 17 18 19 24 25 26 27 28 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 49 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 95 96 97 98 99 100) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.0744>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 14 15 16 17 18 19 24 25 26 27 28 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 49 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 96 97 98 99 100) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.0778>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14 24 25 26 27 28 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 49 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 96 97 98 99 100) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.08>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14 24 25 26 28 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 49 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 96 97 98 99 100) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.0818>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14 24 25 28 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 49 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 96 97 98 99 100) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.083>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14 24 25 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 49 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 96 97 98 99 100) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.0877>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14 24 25 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 49 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 97 98 99 100) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.1072>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14 24 25 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 49 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 98 99 100) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.1093>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14 24 25 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 49 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 99 100) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.1106>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14 24 25 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 49 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 100) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.1133>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14 24 25 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 49 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 90 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.117>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14 24 25 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 49 52 53 54 55 56 57 58 59 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 87 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.1444>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14 24 25 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 49 52 53 54 55 56 57 58 61 62 63 64 65 66 67 68 71 72 73 74 75 76 77 87) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.1428>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14 24 25 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 49 52 53 54 55 56 57 58 61 62 63 64 65 66 67 68 71 72 73 75 76 77 87) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.158>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14 24 25 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 49 52 53 54 55 56 57 58 61 62 63 64 65 67 68 71 72 73 75 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.1658>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14 24 25 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 52 53 54 55 56 57 61 62 63 64 65 71 72 73 75) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.2045>0.05, not statistically significant

(1)   (2)   (3)   (4 13 21 22 31)   (5 9 10 15 16 17 18 19)   (14 24 25 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 52 53 54 55 56 57 61 62 63 64 71 72 73 75)   (65)   (49 58 67 68 76 77 87)   (66)   (74)   (59 69 70 78 79 80 88 90)   (81 82 83 84 85 86 91 92 93 100)   (89)   (99)   (98)   (97)   (96)   (28)   (26)   (27)   (95)   (23 42)   (94)   (6)   (50)   (7)   (51)   (32)   (41)   (11 12)   (60)   (8)   (20)

P_test value=0.2168>0.05, not statistically significant

(1)   (2)   (3)   (4 13 21 22 31)   (5 9 10 15 16 17 18 19)   (14 24 25 29 30 33 34 35 36 37 38 39 40 43 44 45 46 47 48 52 53 54 55 56 57 61 62 63 64 71 72 73)   (75)   (65)   (49 58 67 68 76 77 87)   (66)   (74)   (59 69 70 78 79 80 88 90)   (81 82 83 84 85 86 91 92 93 100)   (89)   (99)   (98)   (97)   (96)   (28)   (26)   (27)   (95)   (23 42)   (94)   (6)   (50)   (7)   (51)   (32)   (41)   (11 12)   (60)   (8)   (20)

P_test value=0.2653>0.05, not statistically significant

(1)   (2)   (3)   (4 13 21 22 31)   (5 9 10 15 16 17 18 19)   (14 24 25 29 30 33 34 35 36 37 38 39 40 43 44 45 47 48 52 53 54 55 56 57 61 62 63 64 71 72 73)   (46)   (75)   (65)   (49 58 67 68 76 77 87)   (66)   (74)   (59 69 70 78 79 80 88 90)   (81 82 83 84 85 86 91 92 93 100)   (89)   (99)   (98)   (97)   (96)   (28)   (26)   (27)   (95)   (23 42)   (94)   (6)   (50)   (7)   (51)   (32)   (41)   (11 12)   (60)   (8)   (20)

P_test value=0.2898>0.05, not statistically significant

(1)   (2)   (3)   (4 13 21 22 31)   (5 9 10 15 16 17 18 19)   (14 24 25 29 30 33 34 35 36 37 38 39 40 43 44 45 47 48 53 54 55 56 57 63 64 72 73)   (52 61 62 71)   (46)   (75)   (65)   (49 58 67 68 76 77 87)   (66)   (74)   (59 69 70 78 79 80 88 90)   (81 82 83 84 85 86 91 92 93 100)   (89)   (99)   (98)   (97)   (96)   (28)   (26)   (27)   (95)   (23 42)   (94)   (6)   (50)   (7)   (51)   (32)   (41)   (11 12)   (60)   (8)   (20)

P_test value=0.2992>0.05, not statistically significant

(1)   (2)   (3)   (4 13 21 22 31)   (5 9 10 15 16 17 18 19)   (14 24 25 29 30 33 34 35 36 37 38 39 40 43 44 45 47 48 53 54 55 56 57 63 64 72)   (73)   (52 61 62 71)   (46)   (75)   (65)   (49 58 67 68 76 77 87)   (66)   (74)   (59 69 70 78 79 80 88 90)   (81 82 83 84 85 86 91 92 93 100)   (89)   (99)   (98)   (97)   (96)   (28)   (26)   (27)   (95)   (23 42)   (94)   (6)   (50)   (7)   (51)   (32)   (41)   (11 12)   (60)   (8)   (20)

P_test value=0.2875>0.05, not statistically significant

(1)   (2)   (3)   (4 13 21 22 31)   (5 9 10 15 16 17 18 19)   (14)   (24 25 29 30 33 34 35 36 37 38 39 40 43 44 45 47 48 53 54 55 56 57 63 64 72)   (73)   (52 61 62 71)   (46)   (75)   (65)   (49 58 67 68 76 77 87)   (66)   (74)   (59 69 70 78 79 80 88 90)   (81 82 83 84 85 86 91 92 93 100)   (89)   (99)   (98)   (97)   (96)   (28)   (26)   (27)   (95)   (23 42)   (94)   (6)   (50)   (7)   (51)   (32)   (41)   (11 12)   (60)   (8)   (20)

P_test value=0.3004>0.05, not statistically significant

(1)   (2)   (3)   (4 13 21 22 31)   (5 9 10 15 16 17 18 19)   (14)   (24 25 29 33 34 35 36 37 38 39 40 43 44 45 47 48 53 54 55 56 57 63 64 72)   (30)   (73)   (52 61 62 71)   (46)   (75)   (65)   (49 58 67 68 76 77 87)   (66)   (74)   (59 69 70 78 79 80 88 90)   (81 82 83 84 85 86 91 92 93 100)   (89)   (99)   (98)   (97)   (96)   (28)   (26)   (27)   (95)   (23 42)   (94)   (6)   (50)   (7)   (51)   (32)   (41)   (11 12)   (60)   (8)   (20)

P_test value=0.3207>0.05, not statistically significant

(1)   (2)   (3)   (4 13 21 22 31)   (5 9 10 15 16 17 18 19)   (14)   (24 25 29 33 34 35 36 37 38 39 40 43 44 45 47 48 53 54 55 56 63 64 72)   (57)   (30)   (73)   (52 61 62 71)   (46)   (75)   (65)   (49 58 67 68 76 77 87)   (66)   (74)   (59 69 70 78 79 80 88 90)   (81 82 83 84 85 86 91 92 93 100)   (89)   (99)

(98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.3224>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 29 33 34 35 36 37 38 39 40 43 44 45 48 53 54 55 56 63 64 72) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.3424>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 29 33 34 35 36 38 39 40 43 44 45 48 53 54 55 56 63 64 72) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.3769>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 33 34 35 36 38 39 40 43 44 45 48 53 54 55 56 63 64 72) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.3631>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 33 34 35 36 38 39 40 43 44 45 48 53 54 55 56 63 72) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.4022>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 33 34 43 44 53 54 63 72) (35 36 38 39 40 45 48 55 56) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.375>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 33 34 43 44 53 54 63 72) (35 36 38 40 45 48 55 56) (39) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.412>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 33 34 43 44 53 54 63 72) (35 36 38 40 45 48 55) (56) (39) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.3349>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 33 34 43 44 53 54 63 72) (35 36 38 45 48 55) (40) (56) (39) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.548>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 33 34 43 44 53 54 63 72) (35 36 38 45 55) (48) (40) (56) (39) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.8099>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 33 34 43 44 53 54 63 72) (35 36 45 55) (38) (48) (40) (56) (39) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.9333>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 33 34 43 44 53 54 63 72) (35 36 45) (55) (38) (48) (40) (56) (39) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.965>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 33 34 43 44 53 54 63 72) (35) (36 45) (55) (38) (48) (40) (56) (39) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.99>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 33 34 43 44 53 54 63 72) (35) (36) (45) (55) (38) (48) (40) (56) (39) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.2388>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 33 34 43 44 53 54 72) (63) (35) (36) (45) (55) (38) (48) (40) (56) (39) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.4835>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 34 44 53 54 72) (33 43) (63)

(35) (36) (45) (55) (38) (48) (40) (56) (39) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.614>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 34 53 54 72) (44) (33 43) (63) (35) (36) (45) (55) (38) (48) (40) (56) (39) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.71>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 34 53 72) (54) (44) (33 43) (63) (35) (36) (45) (55) (38) (48) (40) (56) (39) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.7383>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 25 34 72) (53) (54) (44) (33 43) (63) (35) (36) (45) (55) (38) (48) (40) (56) (39) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.8133>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24 34 72) (25) (53) (54) (44) (33 43) (63) (35) (36) (45) (55) (38) (48) (40) (56) (39) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.89>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24) (34 72) (25) (53) (54) (44) (33 43) (63) (35) (36) (45) (55) (38) (48) (40) (56) (39) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=1.0>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24) (34) (72) (25) (53) (54) (44) (33 43) (63) (35) (36) (45) (55) (38) (48) (40) (56) (39) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66) (74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

P_test value=0.33>0.05, not statistically significant

(1) (2) (3) (4 13 21 22 31) (5 9 10 15 16 17 18 19) (14) (24) (34) (72) (25) (53) (54) (44) (33) (43) (63) (35) (36) (45) (55) (38) (48) (40) (56) (39) (64) (29) (37) (47) (57) (30) (73) (52 61 62 71) (46) (75) (65) (49 58 67 68 76 77 87) (66)

(74) (59 69 70 78 79 80 88 90) (81 82 83 84 85 86 91 92 93 100) (89) (99) (98) (97) (96) (28) (26) (27) (95) (23 42) (94) (6) (50) (7) (51) (32) (41) (11 12) (60) (8) (20)

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Fig. 4 indicates 2-dimensional classification for *p*=0.0482 (<=0.05, statistically significant).

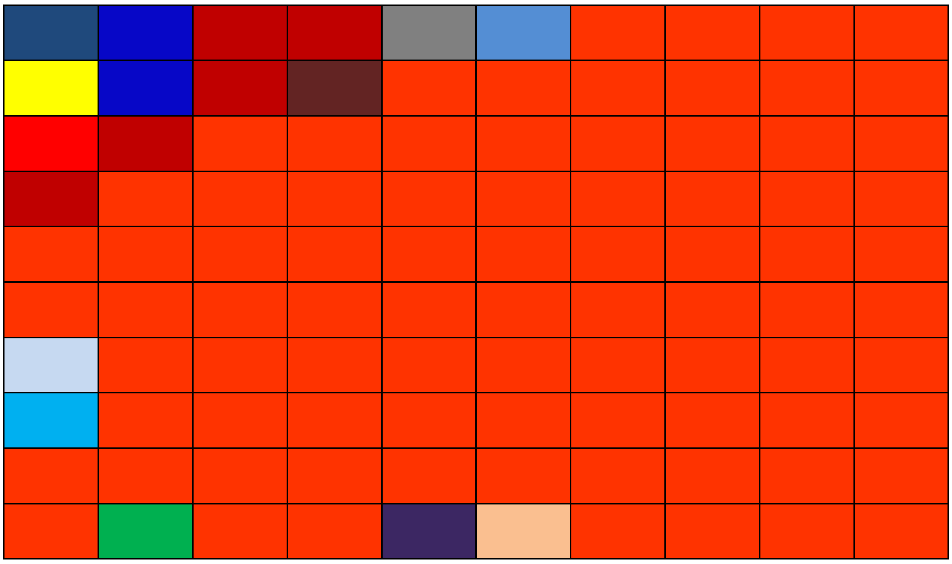

Fig. 4 Classification for *p*=0.0482 (<=0.05, statistically significant).

3.2 Two-dimensional vegetation distribution in Ngari

Data on vegetation types and environmental indicators for Ngari, Tibet, was chosen for the case application (Chang, 1991). A total of 15 sampling sites (they were sampled based on vegetation types as low mountain desert, low mountain steppe desert, low mountain desert steppe, middle mountain desert, middle mountain grassland desert, middle mountain desert grassland, upper-middle mountain desert grassland, upper-middle mountain grassland, sub-alpine grasslands, sub-alpine meadow grassland, alpine grassland desert, alpine desert grassland, alpine grasslands, alpine meadow grassland and alpine meadow, with numbers 1-15), and 8 indices of mosaic characteristics (mean annual temperature, temperature of the hottest month, the coldest temperature, annual precipitation, biological temperature, transpiration rate, surface soil organic matter content and pH value) were used. Latitude and longitude, i.e., geographical coordinates, were used as the two-dimensional coordinates (Fig. 5; Table 1).

We chose Euclidean distance, and randomize 100 times; the threshold *p* value is 0.05. The classification results were as follows:

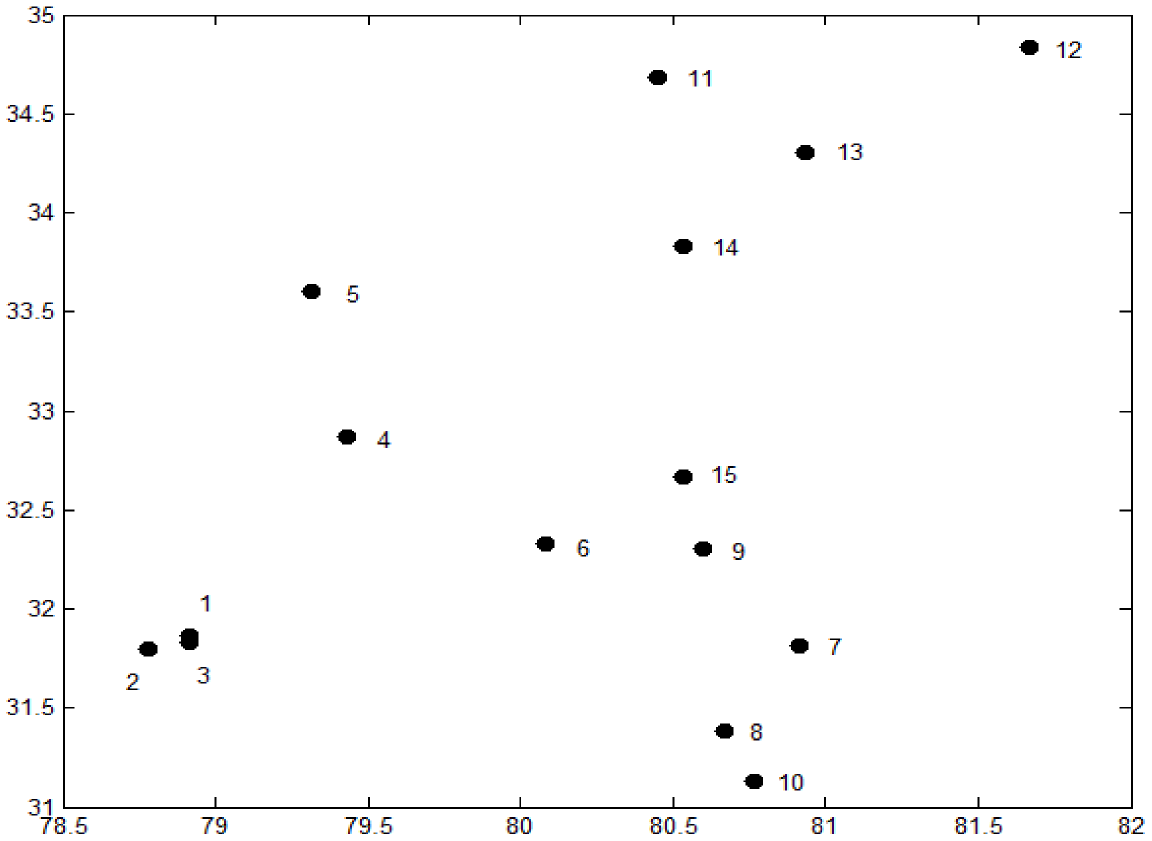

Fig. 5 Geographical distribution of sampling sites in Ngari.

Table 1 Data on vegetation types and environmental indicators for Ngari, Tibet (Zhang et al., 1991).

Latitude (°)	Longitude (°)	Mean annual temper.	Temper. of the hottest month	The coldest temper.	Annual precipi.	Biological temper.	Transpiration rate	Surface soil organic matter content	PH
78.917	31.867	5.3	18.3	-5	123.6	7.7	2.2	0.9	8
78.783	31.8	7.3	20.6	-1	161.3	9.9	1.3	1.1	7.9
78.917	31.833	3.4	16	-8.2	97.8	6	2.8	1.9	7.8
79.317	33.6	-2.5	11	-14.8	48.3	3	2.9	0.5	8.3
79.433	32.867	-3	10.7	-14.1	68.7	3	2.5	0.7	8
80.083	32.333	-1.2	11.1	-13.3	92	3.2	2.3	1	7.9
80.917	31.817	-1.4	10.3	-13.4	120.6	2.9	1.6	1.5	7.8
80.667	31.383	-1.9	9.2	-13.6	123.2	2.5	1.3	2.4	7.5
80.6	32.3	-3	8.8	-14.6	112.3	2.3	1.2	2.6	7.5
80.767	31.133	-2.7	8	-13.8	142.2	2.2	0.6	4.1	6.9
80.45	34.683	-9	4.5	-18.8	81.2	0.8	0.4	0.4	8.4
81.667	34.833	-8.1	5.7	-19.1	84.1	0.9	1.1	0.9	8.1
80.933	34.3	-7.7	5.6	-18.3	87	1	0.8	2.4	7.6
80.533	33.833	-7.6	5.2	-17.5	101.3	1.1	0	3.2	7.2
80.533	32.667	-6.5	5.2	-16.1	129.5	1.3	-0.5	6.5	6.4

We chose Pearson correlation coefficient, and randomize 100 times; the threshold *p* value is 0.05. The results were as follows:

P_test value=0.0028<=0.05, statistically significant
(1 2 3 5 6 7 8 9 10 11 12 13 14 15) (4)
P_test value=0.0121<=0.05, statistically significant
(1 2 3 5 6 7 8 9 11 12 13 14 15) (10) (4)
P_test value=0.0133<=0.05, statistically significant
(1 2 3 5 6 7 9 11 12 13 14 15) (8) (10) (4)
P_test value=0.0129<=0.05, statistically significant
(1 2 3 5 6 9 11 12 13 14 15) (7) (8) (10) (4)
P_test value=0.0108<=0.05, statistically significant
(1 2 3 5 6 11 12 13 14 15) (9) (7) (8) (10) (4)
P_test value=0.0077<=0.05, statistically significant
(1 2 3 5 6 11 12 13 14) (15) (9) (7) (8) (10) (4)
P_test value=0.0133<=0.05, statistically significant
(1 2 3 5 11 12 13 14) (6) (15) (9) (7) (8) (10) (4)

Between-sampling site *p* values matrix is listed as the following:

1	0.23	0.38	0	0	0	0	0	0	0	0	0	0	0	0
0.23	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0.38	0	1	0	0	0.24	0.09	0.05	0.02	0	0	0	0	0	0
0	0	0	1	0.04	0	0	0	0	0	0	0	0	0	0
0	0	0	0.04	1	0.22	0	0	0	0	0.13	0.26	0.13	0	0
0	0	0.24	0	0.22	1	0.24	0.1	0.42	0	0.02	0.04	0.07	0.05	0
0	0	0.09	0	0	0.24	1	1	0.9	0.34	0	0	0	0.02	0.01
0	0	0.05	0	0	0.1	1	1	0.93	0.78	0	0	0	0.04	0.1
0	0	0.02	0	0	0.42	0.9	0.93	1	0.23	0	0	0.01	0.23	0.11
0	0	0	0	0	0	0.34	0.78	0.23	1	0	0	0	0	0.2
0	0	0	0	0.13	0.02	0	0	0	0	1	1	0.95	0.08	0
0	0	0	0	0.26	0.04	0	0	0	0	1	1	0.97	0.14	0
0	0	0	0	0.13	0.07	0	0	0.01	0	0.95	0.97	1	0.56	0
0	0	0	0	0	0.05	0.02	0.04	0.23	0	0.08	0.14	0.56	1	0.07
0	0	0	0	0	0	0.01	0.1	0.11	0.2	0	0	0	0.07	1

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