Short Communication

A program for statistic test of community evenness

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Abstract

A Java program to statistically test community evenness was developed in this study. In the algorithm the community diversity was represented by Shaanon-Wiener index, and Ewens-Caswell neutrality model was used to test community evenness. The algorithm was used to test the evenness of four arthropod communities in Pearl River Delta, China. The results showed that all communities were not even.

Keywords Ewens-Caswell neutrality model; community; evenness; statistic test; Java program.

1 Introduction

Community evenness refers to the relative number of every species in a community. A community with equal individual number for every species is the most even and no dominant species exists in the community (Krebs, 1989; Zhang, 2007). In this article a Java program was developed to statistically test community evenness.

2 Ewens-Caswell Test of Community Evenness

Suppose there are m species (taxa, etc.) in the community, and the number of individuals of species i is x_i, $i=1,2,...,m$. The total number of individuals is:

$$s=\sum_{i=1}^{m} x_i$$

Calculate the Shaanon-Wiener index:

$$D=-\sum_{i=1}^{m}(x_i/s*\ln(x_i/s)),$$

and the corresponding evenness is $D/\ln(m)$.

Assume evenness is β distributed, then we can use Ewens-Caswell test. In Ewens-Caswell test, first calculate initial values (Zhang and Qi, 2002):

$$w_1(1)=1, w_2(1)= 1, w_2(i)=1/i, \qquad i=2,3,…,s-m+1.$$

Then calculate recursive formulae:

$$w_1(j)= w_2(j), \quad w_2(j)=((j+i-2)*w_2(j-1)+i* w_1(j))/(j+i-1), \quad j=2,3,\ldots,s-m+1,$$

and,

$$w=1, \quad w=((i+m-2)*w +m*w_2(i))/(i+m-1), \quad i=2,3,\ldots,s-m+1.$$

In addition, calculate:

$$s_a=\sum_{i=1}^{s-m+1}w_2(i)\ln(s-m-i+2), \quad s_b=\sum_{i=1}^{s-m+1}w_2(i)(s-m-i+2)(\ln(s-m-i+2))^2,$$

$$s_a=\sum_{i=1}^{s-m+1} \sum_{j=1}^{s-m-i+2}(\ln(i) \ln(j) w_1(s-m-i-j+3)),$$

and,

$$c_a= s_a m/w, \quad c_b= s_b m/w, \quad c_c= s_c m(m-1)/w.$$

Thus, the expected diversity (e_p), standard deviation (s_d), standard deviation of actual index deviated from expected index (n_s), and F test value (f) are:

$$e_p=\ln(s)-c_a/s, \quad s_d=(c_b+c_c-c_a^2)^{0.5}/s, \quad n_s=(D-e_p)/s_d, \quad f=(\ln(m)-e_p)D/((\ln(m)-D)e_p)$$

where the degree of freedom of F test is:

$$df_1=2*e_p/\ln(m)(e_p(1-e_p/\ln(m))-1), \quad df_2= df_1*(\ln(m)-e_p)/e_p$$

If the confidence degree is greater than 95%, then the evenness is accordant with Ewens-Caswell neutral model. The community is thus even. There is not significant dominant species in the community.

As used in the previous studies (Liu and Zhang, 2011; Zhang, 2011), the algorithm is also implemented as a Java program, CommDivEvenTest, based on JDK 1.1.8, in which several classes and an HTML file is included (http://www.iaees.org/publications/software/index.asp). In community data file, there is only a row in which abundance (number of individuals, etc.) of all taxa are listed.

3 Application

We obtained a set of arthropod data investigated in rice fields of four cities of Pearl River Delta, Guangzhou (average of 23 samples; 41 families), Zhongshan (average of 17 samples; 42 families), Zhuhai (average of 23 samples; 39 families), and Dongguan (average of 17 samples; 47 families) in September 2008 (Wei, 2010; Table 1).

The results from the algorithm showed that four arthropod communities are all not even and dominant families existed for the four communities (Table 2).

Table 1 Averaged individual numbers of families for four cities

Zhongshan	2.471	28.24	1.588	0.941	0.235	1.647	0.588	0.412	1.235	0.176	0.765	103.2	0.941	0.176
	0.059	0.059	0.059	1.059	0.353	3.765	0.118	1.176	0.294	1.294	0.118	0.471	6.412	0.059
	0.235	0.059	0.647	0.235	0.824	0.706	0.059	0.471	0.588	0.176	0.118	0.412	0.176	
Zhuhai	0.435	29.26	0.13	2.783	0.217	0.783	0.391	0.826	0.739	0.174	2.435	8.696	0.087	0.522
	5.913	0.174	0.043	0.043	0.739	0.522	1.217	0.304	0.87	0.174	1.826	0.043	0.043	0.043
	0.217	7.087	0.13	0.13	0.435	0.261	0.304	0.696	0.13	0.13	1.087	0.043	0.043	0.043
Dongguan	63.65	0.235	3.353	0.059	1.294	1.294	1.176	4.529	0.882	0.176	2	6.588	0.176	0.176
	2.529	0.118	0.059	0.059	1.059	0.588	2.529	0.176	1.235	0.235	2.118	0.353	18.35	0.059
	0.118	0.588	0.941	0.529	0.529	1.294	0.353	0.353	0.118	0.294	0.118			
Guzngzhou	0.13	26.7	1	1.739	0.217	0.826	0.522	0.435	2.652	0.217	0.13	0.043	0.043	1.391
	4.304	0.478	0.174	0.478	1.13	0.217	0.348	0.043	0.043	1.478	2.826	2.783	0.261	1.478
	0.174	1.261	0.261	0.043	0.304	7.522	0.043	0.043	0.043	0.304	0.522	0.522	0.217	0.913
	0.261	0.304	0.304	0.217	0.087									

Table 2 Results of diversity and evenness test

	Zhongshan	Zhuhai	Dongguan	Guangzhou
Shaanon-Wiener index (SW)	1.5273	2.5398	2.0321	2.8943
Expected Shaanon-Wiener index (ESW)	3.261	3.6313	3.2992	3.8271
Standard deviation of ESW	0.0967	0.0234	0.0809	0.0041
Upper limit of ESW (95% confidence degree)	3.4507	3.6773	3.4578	3.8352
Lower limit of ESW (95% confidence degree)	3.0713	3.5854	3.1407	3.8189
Standard deviation of SW from ESW	-17.919	-46.558	-15.662	-224.278
F-value	0.0969	0.062	0.1375	0.0182
Confidence degree(%)	0	0	0	0
Pass Ewens-Caswell test at 95% confidence degree?	No	No	No	No
Is community even and no dominant taxa exist?	No	No	No	No

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