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Short Note / Kısa Not

Quantum analysis for biological communities using presence data

Kursad Ozkan [1*]

[1] Suleyman Demirel University, Faculty of Forestry, Department of Soil Science and Ecology, 32200, Isparta, Turkey

[*] **Corresponding author e-mail (İletişim yazarı e-posta):** kursadozkan@sdu.edu.tr

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Abstract: The concepts, quantities and the explanations, found in books dealing with quantum ecology (Orlóci 2013-2015) have a profound potential to serve the assessments of biological community data from an ecological point of view. However, the data matrices subjected to quantum analysis are quantitative and vegetation related. Therefore, the answer to the following question has remained unresolved: Is it possible to calculate energy-based entropy nH, and the related H and instability %, based on presence data from biological communities at large? The present study was motivated to find a reasonable way for adaptation of presence community data to quantum analysis. To do this, the T and n terms, by which nH is parameterized, are changed to T*t* and n´t terms by making the Tt values a function of taxonomic distance T*t* and setting n´t equal to $(n^2 - n)/2$. Reasonable results were obtained on both the stand (complex) and the metacommunity levels. Since the results are based on the transformations of artificial data, confirmation of the approach is required in further studies using both presence and quantitative data sets from real communities.

Keywords: Emergent effect, complex, resonator, energy units, ecosystems, living communities

Sadece var verisi kullanılarak canlı toplumları için kuantum analizi

Özet: Orlóci'nin kuantum ekoloji ile ilgili yazdığı kitaplarda kuantum analizini uygulandığı tüm vejetasyon veri matrisleri sayılabilen verilerden oluştuğundan, canlı toplumların sadece var verilerinden nH, H ve esneklik % değerlerinin nasıl elde edileceği sorusu cevapsız kalmaktadır. Bu çalışma sadece var verilerinden oluşan canlı toplumlarına kuantum analizlerini uygulayabilecek mantıksal bir yol önererek cevapsız kalan bu soruya cevap bulmak amacıyla gerçekleştirilmiştir. Çalışmada öncelikle enerjinin esnek tanımından faydalanılarak kuantum analizinin ana girdileri olan T ve n, sırasıyla T*t* and n´*t* terimlerine dönüştürülmüştür. Bu bağlamda T*t* değerleri -üç kompleksten ve bir meta toplumdan oluşan yapay veri setine- taksonomik mesafe formülünün (Δ^*) üst bileşen eşitliliği uygulanarak hesaplanmış, n´*t* değerleri ise $(n^2 - n)/2$ formülü kullanılarak elde edilmiştir. Elde edilen T*t* ve n´*t* değerlerinden kompleks ve meta toplum seviyesinde uygulanan kuantum analizleri beklentiye uygun sonuçlar vermiştir. Bununla birlikte bu çalışma ile ilk defa önerilen bu yaklaşımın geçerliliği onun küçük veya büyük ölçekteki gerçek canlı toplum verilerine uygulanmasını gerektirmektedir.

Anahtar Kelimeler: Beliren etki, kompleks, resonatör, enerji üniteler, ekosistemler, canlı toplumlar

1. INTRODUCTION

Quantum ecology was firstly introduced by Orlóci (2013a) in the book *"Quantum Ecology. The energy structure and its analysis"*. We use the 2nd edition (Orlóci, 2015b) which explains the details of how he adapted the quantum theoretical principles and *modus operandi* in studies of vegetation energetics. According to his terminology, forest stands represent the *complexes*, equivalent to vegetation units, and species are the *resonators*. Orlóci uses the term "metacommunity" as a single or a number of pooled complexes.

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The principle energy scalar in quantum ecology is an adaptation of Max Planck's energy-based entropy function, nH = k ln W + constant. There are two constants in this, k and constant, and a W term for probability. Orlóci leaves out the constants by considering that proportionality is retained and it is sufficient in ecological studies. He uses symbol P for W, to avoid the symbols clashing with the usual symbols of statistical ecology. The short form of the energy-based entropy is nH = -ln P. Symbol P is equal to 1/C, and

$$\mathrm{C} = \frac{(\mathrm{n}+\mathrm{T}-1)!}{(\mathrm{n}-1)!\,\mathrm{T}!} \gg \frac{(\mathrm{n}+\mathrm{T})^{\mathrm{n}+\mathrm{T}}}{\mathrm{n}^{\mathrm{n}}\mathrm{T}^{\mathrm{T}}}$$

Therefore, the working equation is $\mathrm{nH} = \ln \mathrm{C} = (\mathrm{T}+\mathrm{n})\ln(\mathrm{T}+\mathrm{n}) - \mathrm{T}\ln\mathrm{T} - \mathrm{n}\ln\mathrm{n}$. In this equation n is the number of resonators and T is total energy unit count, which is the total performance of n species. Clearly, energy-based entropy is entirely dependent on the T and n.

After obtaining nH, the average value or "one resonator" H and instability % can be calculated by using Orlóci's other relevant equations. The first objective is to determine nH values for the terms in the energy equation: $E_j = E_{Phy} + E_{Env} + E_{Em}$. The individual terms represent the joint energy-based entropy (E_j), and nH footprints (PEF) specific to phylogeny (E_{Phy}), environmental mediation (E_{Env}) and emergent effects (E_{Em}). The nH, H and instability % can be calculated for different levels of a taxonomic tree (dendrogram), i.e. species, genera, families, and so forth.

Since the vegetation data matrices used by Orlóci (2013a, 2013b, 2014, 2015a; 2015b) include count data, or substitutes for such, we now present our answer to the question of how to use presence data in ecological quantum analysis.

2. MATERIAL AND METHODS

The aim of the present study is to show how to calculate energy-based entropy, a proxy measure of the potential energy level in a metacommunity, based on presence data, we use the simple artificial data sets presented in Figure 1.

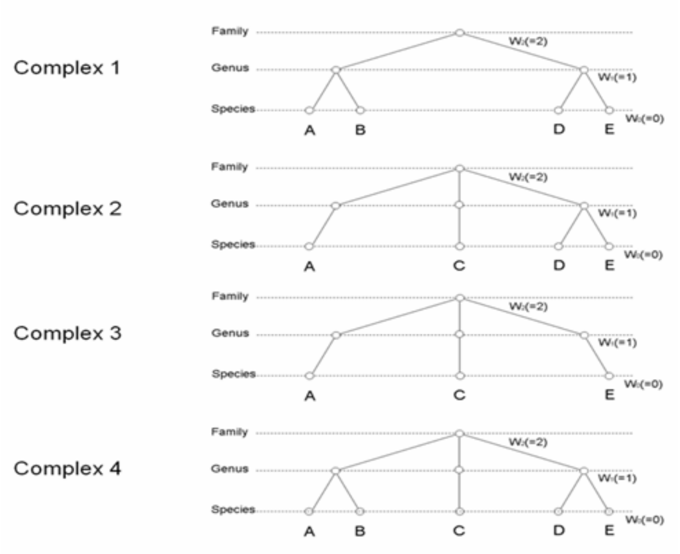

Figure 1. Dendrograms showing species, genus and family levels in four complexes
Şekil 1. Komplekslerin tür, cins ve familya seviyelerini gösteren dendrogramlar

2.1 Further definitions

What is energy? Since "we have no knowledge what energy is", as stated by Nobel Laureate physicist Richard Feynman, we cannot measure energy directly. We have to measure its manifestations. Orlóci (2015b) explains this in detail.

How can we obtain a presence based T**?** We do use Orlóci's equations, but we obtain T indirectly as a function of species presence. We call this a presence based T and designate it by T*t*, which is obtained from a phylogenetic tree (Figure 1).

Our T*t* value is $\sum\sum_{i<j} w_{ij} x_i x_j = \sum w_k f_k$ the numerator in the taxonomic distinctness equation defined according to Warwick and Clarke (1995):

$$\Delta^* = \frac{\sum\sum_{i<j} w_{ij} x_i x_j}{\sum\sum_{i<j} x_i x_j} = \frac{\sum w_k f_k}{\sum f_k}$$

In the Δ^* equation $x_i$denotes 0 or 1 for the *i*th resonator (*i*=1,…S) and w_{ij} is the distinctness weight given to the path length linking resonator *i* and *j* in the hierarchical classification. In the equation of T*t*, the sums are over *k*=1,…*K*, in which *K* is the number of hierarchical taxonomic levels, the (f_x) are the sum of cross-products of counts from all pairs of species connected at the same hierarchical level, and (W_k) the corresponding path weights. We already defined n′t [1].

The energy-based entropy nH is calculated by the following formula:

nHT*t*= (T*t*+n′*t*) ln (T*t*+n′*t*) – T*t* ln T*t* – n′*t* ln n′*t*

When an nHT*t* value is obtained, H is calculated from nHT*t* / n′*t* as HT*t* term. To calculate instabilityT*t* % from HT*t*, I used the following formulates given by Orlaci (2013b, 2014, 2015a).

$$\mathrm{P} = \mathrm{e}^{-\mathrm{H}}$$
$$\mathrm{W_{AB}} = 1 - \mathrm{P_A^2} - \mathrm{P_B^2}$$
$$\text{Instability} = 0{,}5 - \mathrm{W_{AB}}$$
$$\text{Instability}\ \% = 200\mathrm{W_{AB}}$$

In the equations, P is a probability value associated with H. This is a dimensionless quantity. Further, $\mathrm{P_A} = \frac{1}{\mathrm{C}}$ and $\mathrm{P_B} = 1 - \mathrm{P_A}$ and $\mathrm{W_{AB}}$ is structural instability level in a complex. The values of $\mathrm{W_{AB}}$ range from 0 (complete stability) to 0,5 (complete instability).

3. RESULTS AND DISCUSSION

There are four complexes and resonator identities A, B, C, D and E. Complex 1 includes 4 resonators (n=4). Resonator A and B belong to the same genus and D and E belong to another genus. In complex 2, the resonators (n=4), A, B, D and E, are shared by three genera. Each one of three resonators (n=3) is assigned to a different genus in Complex 3. Complex 4 composed of 5 resonators (n=5) are represented by three genera. All of the resonators found in complexes are collected into one family (Figure).

The T*t* values of complex 1, 2, 3 and 4 are respectively 10, 11, 6 and 18. As for the n′*t* values of the complexes, the values are 6, 6, 3, 10 from complex 1 to complex 4. The results are given in Table 1.

Table 1. Energy parameter values of the complexes based on T*t*. All nH and H values are in natural units (nats)

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[1] Instead of (n^2-n)/2, the denominator of $\sum\sum_{i<j} x_i x_j = \sum f_k$ of Δ^* can also be used to find n*t*, considering that resonators have 1 or 0 value.

Tablo 1. Komplekslerin T*t* tabanlı enerji parametre değerleri. nH ve H değerleri doğal birimler (dobi) olarak ifadelendirilir

Complexes	**C**	**P=1/C**	**nHT*t***	**HT*t***	**P**	**Wab**	**StabilityT*t* %**	**InstabilityT*t* %**
1	39537.77	2.53E-05	10.58501	1.764169	0.171329	0.283951	43.2098	56.7902
2	62144.78	1.61E-05	11.03722	1.839537	0.158891	0.267289	46.5421	53.4579
3	307.5469	0.003252	5.728628	1.909543	0.148148	0.252401	49.5199	50.4801
4	84240277	1.19E-08	18.24918	1.824918	0.161231	0.270471	45.9058	54.0942

The highest nHT*t* value is found in Complex 4 whereas Complex 3 includes the lowest instabilityT*t* % (Table 1). In comparing the complexes, the complicated complexes generally have higher nHT*t* and instabilityT*t* % values (Ozkan, 2016). As expected, Complex 2 having the simplest structure has the lowest nHT*t* and instabilityT*t* % values. Complex 4, the most complicated one, includes the highest nHT*t* value. It's instabilityT*t* % value is lower than complex 1 but higher than the others (Table 1). Based on the nHT*t* and instabilityT*t* % values, the optimality of complex 4 is readily seen.

To calculate energy parameters based on the T*t* term at the metacommunity level, first of all, the phylogenetic tree of the metacommunity should be numerically defined. Since the complexes are composed of 5 resonators, the phylogenetic tree of the metacommunity is arranged by those resonators as given in Figure l 2.

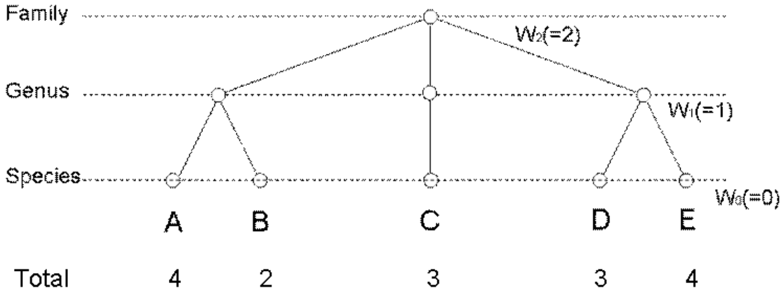

Figure 2. The phylogenetic tree of the resonators at the pooled complex (metacommunity) level. The base numbers and total recurrence numbers of the resonators obtained from the complexes

Şekil 2. Kompleksleri oluşturan resonatörlerin filogenetik ağacı ve onların toplam rastlanma değerleri (meta toplum seviyesindeki filogenetik ağaç). Komplekslerden elde edilen resonatörlerin taban sayıları ve rastlanma değerleri

By using the upper component, T*t* value is equal to 182. The n´*t* value of the joint (E_j) is equal to 25. There are 4 sites. Therefore the n´t value for environmental mediation (E_{Env}) is 6. The n´t value for phylogeny (E_{Phy}) is 10 due to fact that phylogenetic tree of metacommunity is composed of 5 resonators. Based on the T*t* and n´t values, the results for the metacommunity are given in Table 2.

Table 2. Potential energy footprints of the basic processes. All nH and H are in natural units (nats).
Tablo 2. T*t* terimi ile ana süreçlerin potansiyel enerji ayak izi değerleri

Components	P=exp(-nHT*t*)	nHT*t*	n´t	%	HT*t*	P=exp(- HT*t*)
E_{Phy}	8.69E-18	39.28404	5	51.50541	3.928404	0.019675
E_{Env}	2.89E-12	26.57132	4	34.83772	4.428553	0.011932
E_j	7.51E-34	76.27168	16	100	3.050867	0.047318
E_{Em}	2.99E-05	10.41632	*7	13.65686	1.488046	0.225813

*Emergent effect (E_{Em}) is calculated as a difference.

As can be seen in Table / Tablo 2, the nHT*t* values of E_{Phy}, E_{Env} and E_j are 39.28, 26.57, 76.27 respectively. Since $E_j = E_{Phy} + E_{Env} + E_{Em}$, the nHT*t* value of E_{Em} is equal to 10.41. The nHT*t* values of all components are significant at the level of 0.01. It means that all nHT*t* values are unique. The potential energy footprint of E_{Phy} overwhelms the effect of E_{Env}. This is telling us in concrete numbers that E_{Env} comes with an energy footprint less than 2/3 as large as the energy footprint of E_{Phy}. But we arrive at a different conclusion, namely E_{Env} 39/5 to 27/4 when the HT*t* footprints are compared.

4. CONCLUSIONS

More recently, the probability based holistic approaches are becoming increasingly popular in ecological studies. One is the holistic approach to community energetics. Even though the concepts, quantities and the explanations found in Orlóci's books have a profound potential to serve in assessments of biological community data from ecological point of view, it is likely that the need for revisions and adjustments will come to light as applications progress. One of these is dealing with presence data for the phylogenetic trees of biological communities. Our focus is on this particular problem.

In the present study, we calculated T*t* the total of units obtained from the linkages in the dendrograms. Based on parameters n´t and T*t*, PEF values were calculated. When presence vegetation data is used, as can be seen in Table 1 and Table 2, the results of the analysis reflect the complexities in the resonator or species richness at the metacommunity levels. The results suggest that presence data can provide meaningful results in nH-based community studies.

Since holistic information is essential for preparing ecosystem based management plans, presence data should be minimally sufficient. Since presence data are readily provided in a cost effective way, application of quantum analysis to such data should have considerable utility. To expend utility, we consider building and mapping niche based distribution models based on quantitative and presence data. It is likely that holistic information obtained from quantum analysis for biological communities can have a profound potential to create the ecological base for preparation of potential energy based management plans. This should be especially important to detect priority conservation areas of biological communities.

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REFERENCES

Orlóci, L., 2013a. Quantum Ecology. The energy structure and its analysis. SCADA Publishing, Canada, Online Edition: https://createspace.com/4406077 (Date: 12. 12.2014).

Orlóci L., 2013b. Quantum analysis of primary succession. the energy structure of a vegetation chronosere in Hawai'i Volcanoes National Park, SCADA Publishing, Canada, Online Edition: https://createspace.com/4452597 (Date: 12.12.2014).

Orlóci, L., 2014. The vegetation process. A holistic study of long-term community energetics in East Beringia. SCADA Publishing, Canada, Online Edition: https://createspace.com/4760258 (Date: 12.12.2014).

Orlóci, L., 2015a. Energy based vegetation mapping. A case study in statistical quantum analysis. 2nd enlarged edition. SCADA Publishing, Canada Online Edition: https://createspace.com/5750582

Orlóci, L., 2015b. Quantum Ecology. Energy structure and its analysis. 2nd edition, SCADA Publishing, Canada. Online Edition: https://createspace.com/5750582 (Date: 07.10.2015).

Ozkan, K., 2016. Quantum analysis of a plant metacommunity. *Journal of the Faculty of Forestry Istanbul University* 66(1): 30-45. DOI: 10.17099/jffiu.63195

Warwick, R.M., Clarke K.R., 1995. New "Biodiversity" Measures Reveal a Decrease in Taxonomic Distictness with Increasing Stres, *Marine Ecology Progress Series* 129: 301-305.