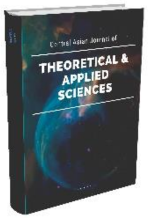

CENTRAL ASIAN JOURNAL OF THEORETICAL AND APPLIED SCIENCES

Volume: 04 Issue: 02 | Feb 2023 ISSN: 2660-5317
https://cajotas.centralasianstudies.org

The Concept of Evenness / Unevenness

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Received 24th Dec 2022, Accepted 13th Jan 2023, Online 27th Feb 2023

Abstract: *While evenness is understood to be maximal if all types (species, genotypes, alleles, etc.) are represented equally (via abundance, biomass, area,etc.), its opposite, maximal unevenness, either remains conceptually in the dark or is conceived as the type distribution that minimizes the applied evenness index. The latter approach, however, frequently leads to conceptual inconsistency due to the fact that the minimizing distribution is not specifiable or is monomorphic. The state of monomorphism, however, is indeterminate in terms of its evenness/unevenness characteristics. Indeed, the semantic indeterminacy also shows up in the observation that monomorphism represents a state of pronounced discontinuity for the established evenness indices.*

This serious conceptual inconsistency is latent in the widely held idea that evenness is an independent component of diversity. As a consequence, the established evenness indices largely appear as indicators of relative polymorphism rather than as indicators of evenness.

Key words: *concept of evenness; functional evenness; unevenness; evenness index; type representation; diversity index; abundance; representation distribution; variable difference; neighborhood evenness; variational evenness; dispersion evenness.*

Introduction. There is general agreement on the concept of evenness as far as its one extreme of complete evenness is concerned. The concept is built on the representation of types in collections of objects, and it is oriented at the degree to which the types are represented equally. Types could be alleles or genotypes represented by their frequencies in populations, species represented by their abundances in communities, crop varieties represented by the area they cover or the biomass they yield in cultivation, etc. Hence, the focus is set on the representation of types but not on their numbers. This contrasts with common notions of diversity which comprise both numbers of types and their representations. The latter explains the widespread habit to conceive diversity as combining number of types with the evenness of their representations. Quoting Hurlbert (1971, and further citations in this paper) “Species diversity is a function of the number of species present (species richness or species abundance) and the evenness with which the individuals are distributed among these species (species evenness or species equitability)”. The conceptual demands of the evenness notion on diversity measures was operationally specified as “transfer of abundance” (or principle of transfers) by Patil & Taillie (1982) and reformulated as the evenness criterion by Gregorius (2010): “diversity never decreases as the difference in frequency between two types decreases while the sum of their frequencies remains the same”). Strictly speaking, it is this criterion (further generalizations can be found in Grabchak et al. (2016) that justifies the central conception of evenness as a component of diversity and allows transformation of each diversity measure into an “effective number” of types.

Other approaches to measuring evenness abandon the diversity concept altogether and turn directly to measures of distance of observed from ideal type distributions, where the ideal is defined by a uniform distribution (all type representations equal). These approaches are chiefly motivated by problems encountered with diversity-based evenness indices that are due to the assessment of distributional characteristics and statistical inestimability of indices (Pielou (1969, p.234); Peet (1975, p.497); Gregorius (1990); Bulla (1994)). Bulla even reverses the relationship between diversity and evenness by recommending the product of his evenness measure with the number of types as a measure of diversity.
In all of the above-addressed work, the focus is set on complete evenness, and deviations from this ideal structural state are quantified in terms of normalized measures of diversity or distances of the observed type distribution from the ideal state. The smaller the values of the respective measures become, the larger the incongruence with the ideal state is scored. The structural characteristics of the type distributions which realize the minimal evenness, if they exist, could then be viewed to provide in some sense an idea of the absence of evenness. Yet, conceptual specifications of this idea are rarely, if ever, pondered. This is unfortunate, since it deprives us of any attempts to associate the absence of evenness with relevant ecological or evolutionary processes.

As a first step, common methods of quantifying evenness will therefore be checked for consistency of their lower bounds with notions of the absence of evenness. Remaining inconsistencies will be treated by turning from the absence of evenness to a concept of unevenness that is based on the specification of desirable structural characteristics of type representations. The measurement of evenness will then be designed to cover the continuum between complete evenness and complete unevenness. As was mentioned before, the established indices of evenness can be distinguished into diversity-based and distance-based methods, both of which assume their respective maximal values (usually 1) only for uniform type representations. In the following, a brief demonstration will be provided of the distributional characteristics that can be associated with index values below the maximum and particularly as the values approach their lower bounds. The results will be discussed with respect to their compatibility with the basic conceptual requirements imposed on the indices as well as their statistical implications.

Throughout this paper, the relative representations qi of s types are asPsumed to be ranked in descending order such that $q1 \geq q2 \geq . . . \geq qs > 0$ withsi=1 qi = 1. Uniform distributions of s types, i.e., q1 = q2 = . . . = qs = 1/s,will be referred to as “plateaus” of length s. Whenever s is specified, thestipulation implies that qi = 0 for all i > s. It has become clear by now that most of the shortcomings of the common measures of evenness go back to a disregard of (1) distribution characteristics (especially rare types) that lead to discontinuous transitions from polymorphism (more than one type with positive representation) to monomorphism,and (2) specification of the characteristics of type distributions that realize or come close to the greatest lower bounds (infima) of the respective index. The latter calls to attention the concept of unevenness that is thought to appear as small index values and the associated idea of low evenness. Simply conceiving of ever smaller values of the established measures of evenness as increasing unevenness is conceptually not justified. When the opposite of evenness is to be characterized, the challenge is to define complete unevenness as the analogue and counterpart of complete evenness. Apparently, the concept of the analogue is not as obvious as the concept of complete evenness. Though various approaches are conceivable, it seems compelling to conceive of unevenness as the negation of evenness and thus the entailment of inequality of type representations in the first place.

Following this, the question is as to the existence and structure of a state of maximal inequality in type representations. Herewith it must be taken into consideration that this state has to be specified for type distributions and thus for relative type representations that sum up to 1. Maximization of inequality in representations is therefore difficult to envision without suitable ordering of the representations, such as the presently used ranking in descending order. Here it becomes immediately clear that simply enlarging differences in representation between individual objects may not increase the overall inequality, since it may rather increase equality between the representations of other types. In its extreme form, this occurs as the concentration of mass to one or a few types increases, which, in turn, entails the above-argued conceptual inconsistency. Consequently, overall inequality in representation can only be enlarged by distributing the differences between types as equably as possible. In other words, unevenness should increase as all types become equally differently represented. Because of the uni-dimensionality of representations and the linear ordering implied by their ranking, maximal unevenness can be realized only if all steps in the ranked distribution have equal height. This distributional form is characterized by a linear descent of the representations and can be visualized as a stepladder. It will serve in the following as the reference for complete unevenness among a given number of types.

There are several ways to design measures that range between states of complete evenness and unevenness. Two approaches will be introduced in the following because they have intuitive appeal and demonstrate the possibility of looking at evenness from different perspectives. One approach is based on the distances of a type distribution from states of complete evenness and unevenness (the generic approach), and the other again uses the two distances but applies them to the distribution of step-heights in the ranked distribution as an indication of the deviation from states of complete evenness and unevenness (the step-height approach). We will start with an example from the generic approach, since this approach builds on perceptions that are more familiar from previous work on the topic. In a second step, a measure will be introduced that is based on the step-height approach.

General characteristics of the new evenness/unevenness measures can be demonstrated with the help of graphical representations of evenness. These include “evenness surfaces” that are drawn for the highest-dimensional case that is geometrically representable, namely for $s = 3$ types, and “evenness curves” that follow one-dimensional transects (or lines) through the frequency simplex for any number of types. The following demonstrations are based on p-distances of order $p = 1$ (i.e., $d = d1$), because these are familiar from and allow comparison with the above-cited earlier approaches to the assessment of evenness and because they operate on untransformed differences between type representations.

The presently suggested indices of evenness/unevenness cannot be used to construct indices of diversity in the usual way by multiplying the former index by the number of types (richness) and subsequent transformation. This multiplicative decomposition of diversity indices relies on their interpretation as “effective numbers” of types and is conceived to almost be a principle of diversity measurement (see e.g. equation (1) in Tuomisto (2012)). Yet according to the present demonstrations, it is just this decomposition that implies conceptual inconsistency by not distinguishing clearly between the notions of evenness of type representations and concentration of mass to or dominance by a single type, for example.

References

1. ulla L (1994) An index of evenness and its associated diversity.Oikos 70(1):167-171
2. Chao A, Ricotta C (2019) Quantifying evenness and linking it to diversity,beta diversity, and similarity. Ecology 100(12):e02852
3. ung T, Villain L, Chisholm RA (2015) Analytical formulae for computingdominance from species-abundance distributions. Journal of TheoreticalBiology 386:147-158
4. ower JC (1971) A general coefficient of similarity and some of its properties.Biometrics 27(4):857-871

5. rabchak M, Marcon E, Lang G, Zhang Z (2016) The generalized Simpson'sentropy is a measure of biodiversity. PloS ONE 12(3):e0173305
6. regorius H-R (1990) A diversity-independent measure of evenness. TheAmerican Naturalist 136(5):701-711
7. regorius H-R (2010) Linking diversity and differentiation. Diversity 2:370-394