



## Letter to the Editor

**Empirical clues about the fulfillment of quantum principles in ecology: Potential meaning and theoretical challenges**


## ARTICLE INFO

## Keywords:

Boltzmann constant  
Quantum mechanics  
Ecological state equation  
Ecosystem ecology  
Evolutionary ecology  
Species diversity

## ABSTRACT

A new and wide area of theoretical and methodological overlap between ecology and conventional physics has emerged from the development of an ecological state equation and its consequences. Specifically, the discontinuous (discrete) increase of the ecological equivalent ( $k_e$ ) of Boltzmann's constant ( $k_B$ ) suggests a startling hypothesis: most general principles of quantum mechanics could be valid at the ecosystem level. In this paper, we show a single result supported on previous theoretical results as well as on already published data: that a significant and robust straight line adjustment with an intercept at the coordinate's origin between the mean value of eco-kinetic energy per individual and  $k_e$  at the inter-taxocenosis scale has a regression constant (slope) whose mantissa coincides with the Planck's constant mantissa at the 1000th level. From this result, we propose two simple equations, with increasing exactness, to assess the expected mean values of individual eco-kinetic energy per survey at the inter-taxocenosis level with a reliable statistical adjustment in comparison with the respective observed values. This result means that the evolutionary process as a whole could be understood as a "staggered propulsion" of a tiny initial clot of life that has been ecologically driven across a discontinuous evolutionary gradient of exchange of information by trophic energy with an increment rate ruled by constant quantum parameters. The potential meaning of this finding for evolutionary ecology and our understanding of the ecosystem functioning is analyzed, and the future challenges to develop a holistic theoretical framework based on this result are stated.

© 2015 Elsevier B.V. All rights reserved.

## 1. Introduction

The recent proposal of an ecological state equation (ESE; see Eq. (1)) that is structurally equivalent to the ideal gas state equation ( $2N\frac{1}{2}m \cdot v^2 = N \cdot k_B/T$ ; where  $N$ : number of molecules;  $m$ : molecular mass;  $v$ : molecular velocity;  $k_B$ : physical Boltzmann constant =  $1.3806504 \times 10^{-23}$  J/K/mol; and  $T$ : absolute temperature), has two main epistemological consequences: (1) the orthodox point of view against the validity of conventional physics to explain the ecosystem functioning (e.g. Margalef, 1991, pp. 884, 894–895, 904–905; Månsson and McGlade, 1993; Ulanowicz, 2004, p. 341) seems to be an inaccurate reflection of reality. Therefore, the approach to understand the ecosystem functioning based on conventional physics (e.g. Lindeman, 1942; Odum, 1968, 1969; Gallucci, 1973; Jørgensen and Fath, 2004) could have been neglected by mainstream ecological research before producing its most valuable results. (2) A new wide field of research would be opened to derive new knowledge from the theoretical and methodological overlap between ecosystem ecology and several branches of conventional physics.

$$2N_p(E_{ep}) = (N_p \times k_e)/H_p \quad (1)$$

$$2E_{eTp} = (N_p \times k_e)/H_p$$

where

$H_p$ : ecological information assessed as species diversity per plot =  $-\sum[(n_i/N) \ln(n_i/N)]$  (Shannon, 1948).

$n_i$ : number of individuals of species  $i$  at the plot level.

$$N = \sum n_i.$$

$k_e$ : ecological equivalent of Boltzmann constant =  $m_{ep} \cdot I_e^2 \cdot H_p = 1.3806504E\varphi J_e \cdot \text{nat}/\text{individual}$ ,  $k_e$  was empirically assessed for the first time (with  $\varphi = 2$  in ruderal vegetation) by Rodríguez et al. (2012, 2013a) starting from the slope trend to 0 in the correlation between  $(2N_p\frac{1}{2}m_{ep}I_e^2H_p)/N_p = m_{ep} \cdot I_e^2 \cdot H_p$  and  $(1 \cdot I_e^2)/(s_o/m_{eTp})$  in a fully equivalent way to the calculation of  $k_B$ . That is to say,  $k_B$  was also assessed, more than a century ago, starting from a slope trend to 0 in the correlation between  $PV/NT = (2N\frac{1}{2}mv^2)/NT = mv^2/T$  and  $((1 \cdot v^2)/(s_f/m_T)) = P$ . Where  $m_T$ : total physical mass ( $N \cdot m$ );  $m_{eT}$ : total biomass ( $N \cdot m_e$ ) per plot ( $p$ ), macrostate ( $m$ ) or survey ( $s$ ), depending on the studied scale;  $s_f$ : physical space occupied by the gas;  $s_o$ : mean space per plot or macrostate in the ecosystem;  $V$ : gas volume; and  $P$ : gas pressure. Rodríguez et al. (2013a) performed additional empirical assessments of  $k_e$  (several of these values are included in Appendix A, Table A1, column  $k_{e(o)}$ ), showing that  $k_e$  seems to be a general pattern under stationary and quasi-stationary ecological conditions (SEC).

$N_p$ : total number of individuals per plot.

$E_{ep}$ : mean eco-kinetic energy per individual per plot =  $\frac{1}{2}m_{ep} \cdot I_e^2$ .

$E_{eTp}$ : total eco-kinetic energy per plot =  $N_p \cdot E_{ep}$ .

$m_{ep}$ : mean individual biomass per plot in kg.

$l_e$ : a dispersal statistical indicator, expressed in  $\delta$  units, with the appropriate features to replace  $v$  (physical velocity) in an analytically invariant way in regard to the replacement of  $T$  by  $H$  from the ideal gas state equation to Eq. (1), by allowing in such a way the application of physical methods to describe the ecosystem functioning. For additional details about the structure, meaning and calculation of  $l_e$  see Appendix A, Section 2; as well as Rodríguez et al. (2012, 2013a,b, 2015).

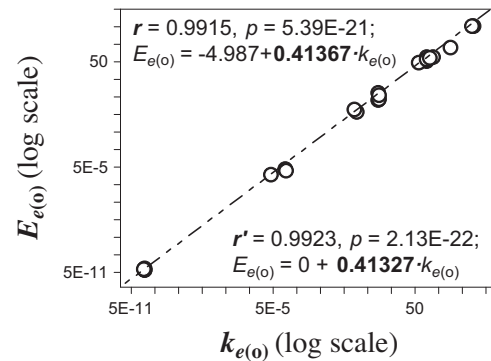
The publication of additional and complementary results (see Rodríguez et al., 2013a, 2015) indicates that the ESE applies despite body size, taxon, or environment type, because the mantissa of  $k_e$  (it indicates the rate in which an individual exchanges information by eco-kinetic energy, and vice versa) of the Boltzmann constant ( $k_B$ ) is the same for all the stationary ecological assemblages, but  $\varphi$  undergoes discrete variations ( $k_e DV$ ) across a succession of integer values ( $-x_i, \dots, 0, \dots, +x_i$ ). Thus,  $k_e$  can be seen as a “universal ecological constant” in a similar fashion as  $k_B$  is seen in conventional physics.

This result involves several unexpected aftermaths. One of them is analyzed in this article given that different values of  $k_e$  and  $E_e$  (sequentially linked to the application of ESE to several kinds of ecological assemblages) are used here as stationary benchmarks to empirically derive clues about the fulfillment of quantum principles in evolutionary biology and ecosystem ecology.

The most recent developments (see Rodríguez et al., 2013b) of this interdisciplinary approach to ecosystem ecology yields two main general results: (1) the old and seemingly unfruitful debate between the competitive exclusion principle (CEP: one species  $\leftrightarrow$  one niche: those species that perform the same ecological function cannot coexist; see Hardin, 1960; Darlington, 1972; Gordon, 2000; Wang et al., 2005), and the hypothesis of full functional redundancy (HFFR: several species  $\leftrightarrow$  one niche; see Lawton and Brown, 1993; Walker, 1992; Wohl et al., 2004; Petchey and Gaston, 2006; Mayfield and Levine, 2010), would be a function of our poor understanding about the inherent uncertainty in the ecological niche assessment (UEN). (2) The gap between theoretical and empirical ecology in those cases where the diversity of closely related species is too high could be narrowed by introducing a stationary wave model of species coexistence (WMSC, see theoretical explanations and empirical examples in Rodríguez et al., 2013b, pp. 8–11). This model is based on the concurrency between transient equilibrium nodes of CEP, isolated from each other by wide antinodes of limited functional redundancy bounded by the above-mentioned nodes, and vice versa (in a similar way to the standing waves on a string). In such a way, perfect competition would depend on strong inter-specific relationships performed on tiny transient points (nodes) that would act as functional barriers (constraints) between successive dynamic wide areas of coexistence (antinodes) under alternative ecological conditions of partial functional redundancy.

If we take into account ESE,  $k_e DV$ , UEN and WMSC simultaneously, then the most rational hypothesis, despite its bizarre appearance, is that the ecosystem functioning could be ruled by a set of principles that share some common features with the theoretical framework established by quantum mechanics. As a result, CEP and HFFR can be simultaneously consistent with each other, and this combination could be the best support to reach the highest values of  $H$ . This could be the best explanation of ecosystem structure, assuming that a future wave model of the ecosystem functioning based on parameters equivalent to quantum indicators could be theoretically and empirically plausible.

A reliable scientific model, in spite of its very strange nature, is by norm the remaining result after all the obstacles and probable alternative explanations have been removed. Thus, this document



**Fig. 1.** Pearson's linear correlation between the observed mean value of eco-kinetic energy ( $E_{e(o)}$ ) per individual per survey and the observed mean value of  $k_e$  per survey ( $k_{e(o)}$ ).  $r$ : correlation with intercept ( $a$ )  $\neq 0$ .  $r'$ : correlation with intercept ( $a$ ) = 0. The logarithmic scale was used to palliate the graphical distortion due to the width of the spectrum of  $E_{e(o)}$  values (from  $6.7486E-11 J_e$  to  $6.0213E+3 J_e$ ) and  $k_{e(o)}$  values (from  $1.3807E-10$  to  $1.3807E+4$ ); but correlations were calculated from original values. Number of included surveys = 24 (some points are either clustered or overlapped in the graph due to their similar  $k_{e(o)}$  values). Total number of species = 750. Total number of individuals = 88,701,067.

is based on a correlation between the observed mean value of eco-kinetic energy per individual ( $E_{e(o)}$ ) per survey and the respective observed value of the ecological equivalent ( $k_{e(o)}$ ) of Boltzmann constant ( $k_B$ ), across a wide taxonomic spectrum of ecological assemblages. This single test seems to be consistent enough as to support the probable existence of an ecological equivalent ( $h_e$ ) of Planck's constant ( $h$ ). This is the first solid step in order to test the above-mentioned hypothesis. This paper also analyzes the potential ramifications from the existence of  $h_e$  in order to improve the reliability of environmental management. Accordingly, the final section of this article explores some factors that are essential to develop a consistent theoretical framework useful to understand several ecological phenomena that cannot be explained by means of conventional classical physics models.

## 2. Correlation between $E_{e(o)}$ and $k_{e(o)}$

Fig. 1 shows the correlation analysis between the observed mean value of individual eco-kinetic energy ( $E_{e(o)} = E_{eTp}/N_p$ ; see Eq. (1), above) at the survey level and the respective observed (o) value of  $k_e$  that was calculated by using the same set of data as well as the same general procedures used by Rodríguez et al. (2013a). Table A1, Appendix A, includes the original set of data used to perform all the calculations in this document; only data from ma1 to css in Table A1 were used to obtain Fig. 1.

One of the values of Planck's constant, depending on the selected units, is (Tipler and Mosca, 2010):

$$h = 4.13566727E - 15 \text{ eV s,}$$

where eV s means “electronvolt  $\times$  second”. 1 eV s is the amount of energy ( $1 \text{ eV} \approx 1.602176462E-19 \text{ J}$ ) gained, or lost, per second by a single electron moved across an electric potential difference of 1 V ( $1 \text{ eV} \times 4.1356673E-15 \text{ eV s} = 6.62606876E-34 = \text{value of } h \text{ in J} \cdot \text{s}$ ).

The coefficient of regression (slope,  $b$ ) of the Pearson product-moment correlation coefficient ( $r$ ), for  $E_{e(o)}$  vs.  $k_{e(o)}$  with intercept ( $a$ ) at  $-4.9870 J_e$  in Fig. 1 is  $4.13674E-1 J_e$  per individual per  $\nabla k_e = 1 J_e$ : “eco-Joule”; it is an ad hoc unit that directly results from the calculation of  $E_{ep}$  (see Eq. (1), above) taking into account the general fulfillment of the first law of thermodynamics (universal equivalence and free conversion between all the types of energy). Therefore, if the kinetic energy in physics is  $E = \frac{1}{2} m \cdot v^2$  (where  $m$ : physical mass in kg, and  $v$ : velocity in  $\text{m}^2/\text{s}^2$ ;  $E$  is expressed in Joules =  $\text{kg} \cdot \text{m}^2/\text{s}^2$ ), it is completely licit to assume that in ecosystem

Download English Version:

<https://daneshyari.com/en/article/6296676>

Download Persian Version:

<https://daneshyari.com/article/6296676>

[Daneshyari.com](https://daneshyari.com)