

Short Communication

Geometrical approach to length-biomass allometry in predominantly bidimensional seaweeds

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Scosati studied experimentally length-biomass allometry in primary producers (vascular plants and unicellular microalgae), and found the allometric exponent (0.5, 95% confidence) differs significantly from the “universal” value, 0.25 suggested by Niklas and Enquist. Here, a geometrical similarity is proposed to elucidate Scosati’s findings.

Key words: Length–biomass allometry, seaweed.

INTRODUCTION

One of the most pervasive laws in biology is the allometric scaling, whereby a biological variable Y is related to the mass M of the organism by a power law (Leal da Silva, et al. 2006; He and Zhang 2004; He and Huang, 2006; He, 2005):

$$Y \propto M^b \quad (1)$$

where b is the so-called allometric exponent and Y can be, for example, the length of predominantly bidimensional seaweeds.

Niklas and Enquist (2001) suggested a “universal” scaling law for primary producers:

$$L \propto M^b \quad (2)$$

where L is the body length, M is the dry biomass and the scaling exponent $b = 0.25$ was considered to universal (Niklas and Enquist, 2001). Scosati’s findings reveal that the scaling exponent differs from remarkably from the “universal” value (Scosati, 2006):

$$L = 7.811M^{0.472} \quad (3)$$

for four phylogenetically distinct seaweed species, *Chondrus crispus* Stackhouse, *Pterocladia capillacea* (Gmelin) Santelices and Hommersand, *Fucus vesiculosus* Linnaeus, and *Laminaria saccharina* (Linnaeus) J.V. Lamouroux.

There exist various theories arisen recently to explain various biological phenomena, such as allometrical method (West et al., 1997; Kuikka, 2006)), statistical

method (Al-Suwaiyel et al., 2006)) and E-infinity theory (El Naschie, 2006; El Naschie, 2007). In particular, using a blend of the methodology of allometrical scaling and E-infinity theory it was possible to solve various basic problems in biology (He, 2006a, He, 2006b, He, 2006c, He, 2007). West and Brown (1999) modeled vascular plants using the WBE model (West et al., 1997) and the model successfully predicts a fractal-like architecture and many known scaling laws, both between and within individual plants, including allometric exponents which are simple multiple of 1/4. In this short paper, we will suggest a simple geometrical approach to explanation of Scosati’s experimental data.

GEOMETRICAL SIMILARITY

We begin by assuming that the thickness, h , of predominantly bidimensional seaweeds keeps constant, its volume, V , can be calculated as

$$V = Ah \propto A \propto L^2 \quad (4)$$

where A is the area.

The dried mass scales as:

$$M \propto V \quad (5)$$

From the scaling relationships, (4) and (5), we can immediately obtain the following scaling relationship:

$$L \propto M^{1/2} \quad (6)$$

This agrees with Scosati's equation (3). However, the 95% confidence interval for the interspecific exponent for these seaweeds is 0.5 (Scosati, 2006).

CONCLUSIONS

We give a very simple allometric approach to prediction of the length-biomass scaling relationship of primary producers, the scaling exponent agrees well with Scosati's experimental data (Scosati, 2006). Biomass of seaweeds with the present assumption scales 1/2-power; however biomass of stand-grown vascular plants and trees scales 3/8-power with the stem basal radius predicted by the WBE model. A connection of our prediction with WBE model is worth further studying.

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REFERENCES

- Al-Suwaiyel MI, Alani A, Al-Swailem A (2006). An investigation of Fibonacci-like sequences in biology and mathematics, *Int. J. Nonlinear Sci.*, 7: 133-136.
- El Naschie MS (2006). The brain and E-Infinity, *Int. J. Nonlinear Sci.*, 7: 129-132.
- El Naschie MS (2007). A review of applications and results of E-infinity theory, *Int. J. Nonlinear Sci.* 8: 11-20.
- He JH, Zhang J (2004). Fifth dimension of life and the 4/5 allometric scaling law for human brain, *Cell Biol. Int.*, 28: 809-815.
- He JH (2005). The allometry of leaf form in early plant ontogeny, *B. Math. Biol.*, 67: 1333-1337.
- He JH (2006a). Cell size and cell number as links between noncoding DNA and metabolic rate scaling, *Chaos Soliton. Fract.*, 28: 1026-1028.
- He JH (2006b). An allometric scaling law between gray matter and white matter of cerebral cortex, *Chaos Soliton. Fract.*, 27: 864-867.
- He JH (2006c). Application of E-infinity theory to biology, *Chaos Soliton. Fract.*, 28: 285-289.
- He JH, Huang ZD (2006). A novel model for allometric scaling laws for different organs, *Chaos Soliton. Fract.*, 27: 1108-1114.
- He JH (2007). Shrinkage of body size of small insects: A possible link to global warming? *Chaos Soliton. Fract.*, 34: 727-729.
- Kuikka JT (2006). Fractal analysis of organ structure, function and interactions, *Int. J. Nonlinear Sci.* 7: 239-243.
- Leal da Silva JK, Garcia GJM, Barbosa LA (2006). Allometric scaling laws of metabolism, *Phys. Life Rev.* 3 (4): 229-261.
- Niklas KJ, Enquist BJ (2001). Invariant scaling relationships for interspecific plant biomass production rates and body size. *Proc. Natl. Acad. Sci. U.S.A.* 98: 2922-2927
- Scrosati R (2006). Length-biomass allometry in primary producers: predominantly bidimensional seaweeds differ from the "universal" interspecific trend defined by microalgae and vascular plants, *Can. J. Bot.* 84 (7): 1159-1166.
- West GB, Brown JH, Enquist BJ (1997). A general model for origin of allometric scaling laws in soil. *Sci.* 276: 122-126.
- West GB, Brown JH (1999). Enquist BJ, A general model for the structure and allometry of plant vascular systems, *Nature*, 400: 664-667.