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Matemaattis-luonnontieteellinen		Eläintieteen laitos	
Tekijä — Författare			
Timo Pakkala			
Työn nimi — Arbets titel			
The fractal dimension in biological patterns and processes. Part 1. The geometric background and its basic implications.			
Oppiaine — Läroämne			
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<p>The fractal dimension concept was developed to describe, indicate and explain the spatial and temporal patterns in complex fractional objects and sets. These systems could be analysed better using fractional dimensions than normal integer dimensions of the Euclidean geometry. The fractal dimension, in general, describes the amount of inner details or the complexity of the infrastructure of a system at different scales. Although the fractional dimensions are concepts of classical topology and measure theory from the nineteenth century, the breakthrough of the fractal geometry happened in the early 1980s. The rapid development of fast computers and the digital image processing technique combined to a less formal geometry with several applicable connections to the geometry of nature made fractal geometry popular in many sciences.</p> <p>The fractal geometry offers methods to study the heterogeneity of a system and its spatial and temporal scales by a quantitative measure, the fractal dimension. These properties have interested also biologists to use the fractal dimension in many different connections partly as an indicator of the complexity of a system, but also in evaluating the borders of a system or its subparts. There has also been a tendency to see the fractal dimension as a system 'megaparameter' and also as a sort of universal law or rule affecting also the evolution of the system. The evidence suggests, however, that it may rather be used as a relative measure of complexity. The importance of the fractal dimension in biological systems may essentially be the possibility to observe its changes at different spatiotemporal scales and compare the fractal dimensions in systems of a same like.</p> <p>Even though the implications of the fractal dimension concept are perhaps not strictly testable because of the inductive nature of the theory and its inherent, hidden structure, it has many applicable areas in biology. The analysis of borders, surfaces, frequency distributions and point patterns at different scales are examples of using the fractal dimension in biological pattern analysis. The temporal properties of the fractal dimension can be used in the analysis of nonlinear dynamics, time-series and temporal dispersion or diffusion. If the spatial and temporal properties of the fractal dimension are connected, it can be used in relatively tightly integrated systems as in physiology, but also in more diffuse and complex processes as in population dynamics or in hierarchial systems of landscape ecology.</p> <p>Besides a geometrical description of biological systems at different scales, fractal geometry and dimension are tools for new ideas of complexity, determinism and chaos. Very complex structures and dynamics may be created by using simple, recursive algorithms revealing delicate lines between order and chaos in nature. Fractal geometry and its dimensions form an extensive basis to construct and compare different heterogenous and informational structures using modern computer image processing and analysing techniques.</p> <p>As many biological systems contain simultaneously ordered, random and chaotic elements, the fractal dimension approach should be properly restricted to relevant biological scales and be used together with other methods measuring spatiotemporal patters and processes. As the fractal geometry and the concept of the fractal dimension are still in many ways in formative phases of development, it may be too early to evaluate its total implications to biological systems. The history of biological systems and models has, however, shown that instead of a single, dominating theory or paradigm, it is perhaps more useful to try to combine several 'objective' methods and approaches with biological knowledge, which may sometimes be 'subjective' or specific to certain systems. This may be the only way to at least partly understand, what <u>really</u> happens in nature.</p>			
Avainsanat — Nyckelord			
Fractals, spatiotemporal scales, biological system dimensions			
Säilytyspaikka — Förvaringställe			
Eläintieteen laitoksen kirjasto			
Muuta tietoja — Övriga uppgifter			