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Evolution of Predator-prey Body-size Ratio: Spatial Dimensions of Foraging Space

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Abstract : It has been widely observed that marine food webs have significantly larger predator–prey body-size ratios compared with their terrestrial counterparts. A number of hypotheses have been proposed to account for such difference on the basis of primary productivity, trophic structure, biophysics, bioenergetics, habitat features, energy efficiency, etc. In this study, an alternative explanation is suggested based on the difference in the spatial dimensions of foraging arenas: terrestrial animals primarily forage in two dimensional arenas, while marine animals mostly forage in three dimensional arenas. Using 2-dimensional and 3-dimensional random walk simulations, it is shown that marine predators with 3-dimensional foraging would normally have a greater foraging efficiency than terrestrial predators with 2-dimensional foraging. Marine prey with 3-dimensional dispersion usually has greater swarms or aggregations than terrestrial prey with 2-dimensional dispersion, which again favours a greater predator foraging efficiency in marine animals. As an analytical tool, a Lotka-Volterra based adaptive dynamical model is developed with the predator-prey ratio embedded as an adaptive variable. The model predicts that high predator foraging efficiency and high prey conversion rate will dynamically lead to the evolution of a greater predator-prey ratio. Therefore, marine food webs with 3-dimensional foraging space, which generally have higher predator foraging efficiency, will evolve a greater predator-prey ratio than terrestrial food webs.

Keywords : predator-prey, body size, lotka-volterra, random walk, foraging efficiency
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