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Why Do You Need Mathematics to Learn Ecology?

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John Maynard Smith, one of the most influential evolutionary biologists of our time, once said "*If you can't stand algebra, then stay away from evolutionary biology*." A similar phrase can be said about ecology: "*if you can't stand mathematics, then stay away from ecology*." At the outset I should say that I am not trying to discourage readers who have not had an opportunity to have and use the great tool of mathematics, but my intention is to help young ecologists to develop into competent professionals from the beginning by emphasizing its importance.

After I started this short note, incidentally, the *Science* published a special issue on Mathematics in Biology on February 6, 2004. In this issue, Sir Robert M. May (2004) offers his overview of uses and abuses of mathematics in biology; whereas Bialek and Botstein (2004) propose ways to improve quantitative thinking of future biologists by designing a unified introductory science curriculum in colleges. The issue of improving quantitative background of biologists is very important nowadays as the science of biology has been transforming not only with advances in biological understanding, but also with dramatic advances in experimental techniques and computational analyses (Bialek & Botstein, 2004).

Application of quantitative thinking in biology dates back to the Middle Ages and earlier. Sir William Petty in about 1300 composed a table "*shewing (showing) that the People might have doubled in the several ages of the World*", starting with eight people one year after the great Flood, which was quite an accurate calculation. Leonardo of Pisa, a.k.a. Fibonacci, born in Italy, derived in early 1200s one of the first mathematical models for population growth, in this case for a closed population of rabbits (Britton, 2002). Galileo, arguably the founder of modern science, apparently realized that "*the book of nature is written in the language of mathematics*" (Bialek & Botstein, 2004). Unfortunately, in about 400 years of modern science, biology has mostly been left out of mathematical culture, whereas physics and engineering marched together with it. The consequence of that can be seen even in case of Charles Darwin, one of the great thinkers in biology, who wrote that "*I have deeply regretted that I did not proceed far enough at least to understand something of the great leading principles of mathematics; for men thus endowed seem to have an extra sense*" (May, 2004). From today's viewpoint, it is believed that, with such an "extra sense," Darwin could have easily circumvented some of the major problems in his theory of evolution by natural selection, including a setback of his theory for using the *blending inheritance* (Fisher, 1930), which was the well perceived mode inheritance in his time (under which variation could have easily been shown to be lost from generation to generation). It is possible that he could have easily grasped the idea of Mendelian genetics and used it to the benefit of his theory, rather than ignoring Mendel's correspondences with him, had he had that "extra sense."

In recent years, biology has come long ways in using mathematical tools and computing powers that took many different forms (probability theory in experimental design, pattern recognition in bioinformatics, models in ecology, evolution, statistical analyses in all fields and more) and opening up many new frontiers of interdisciplinary approach. Biological education has not kept pace with these developments in general. Ecology is no exception and this situation is especially at its worst in Mongolia where biologist and mathematicians go their own ways without their paths ever being crossed.

Ecology is a relatively young science and it has been maturing very fast in the last few decades. That means ecology has started asking some serious questions by expressing theories and experiments in mathematical terms and getting answers to those questions. Ever-increasing use of mathematical tools is the tendency that can be seen in any ecological journal over the years. However, ecological research in Mongolia is still in its