Abstract for the general public: P. Koteja - Experimental evolution of the thrifty and spendthrift genotypes….

Obesity and co-occurring disorders have become major medical issues in a large and rapidly increasing part of the World. The immediate reasons may seem obvious: a practically unlimited access to calorie-rich food, although often nutritionally deficient (so called “Western diet”), and technologies relieving from the demand of a noteworthy physical activity. However, despite great progress of knowledge, the question why humans are so vulnerable to these conditions, remains subject of debate and intensive research. The question is important, because the knowledge of molecular, biochemical and neuropsychological mechanisms underlying the limited ability to control energy balance helps to develop therapeutic and preventive measures.

The question is interesting also from the evolutionary biology perspective, and, remarkably, the evolutionary perspective contributed to the progress in medicine. According to the “thrifty genotype” hypothesis, the vulnerability to adverse effects of comfort and freedom from hunger is a byproduct of natural selection acting in previous generations. In the past, the selection favored the ability to cope with food scarcity combined with high demands of physical activity. In addition, evolution apparently equipped us with developmental and epigenetic mechanisms, which prepare an individual’s physiology for the expected poor nutritional conditions, if such conditions were experienced early in life or by the parents. This probably explains why the adverse effects of food excess are especially profound in populations that encountered a rapid change from reoccurring famine to a nearly permanent feast. The hypotheses have been supported by results of many studies. However, to declare the thrifty genotype hypothesis as confirmed, equally strong evidence should be provided for the logically complementary “spendthrift genotype” hypothesis: natural selection favoring a high performance under the conditions of unlimited food resources should result in ability prevent or reduce the adverse effects of the excess. This hypothesis was approached much less frequently, and the results are inconsistent.

The main objective of the project is to test both the thrifty and the spendthrift genotype hypotheses within the framework of a single, unique experimental evolution model system. In this experiment, we maintain lines of a common rodent, the bank vole, selected for three distinct physiological and behavioral performance traits: ability to grow on low-quality food containing a lot of grass ("Herbivorous” lines), high capability of aerobic exercise (“Aerobic” lines), and eagerness to hunt crickets (“Predatory” lines). In 25 generations, individuals that performed best in the respective trials were reproduced. In Herbivorous lines, the selection required coping with temporary malnutrition, so it favored evolution of the thrifty genotype. In contrast, in Aerobic and Predatory lines, the selection resulted in an increased metabolic rate and locomotor activity, so it favored evolution of the spendthrift genotype. Therefore, we predict that the Herbivorous voles will be more susceptible, whereas the Aerobic and Predatory ones less susceptible to the adverse effects of Western diet, compared to voles from unselected Control lines.

To test these predictions, we will perform an experiment, in which voles representing all the selection directions will be reared in three diet conditions: 1) on the standard laboratory-rodent diet (with well-balanced nutrients and energy), 2) on the Western diet, and 3) on the Western diet till achieving maturity, and then on the standard diet. The third group is included to study the ability to reverse the adverse effects of Western diet. We will monitor changes of body mass, fat content and blood glucose level during the growth of the voles, and measure several traits characterizing their vigor, physiological performance, and energy balance – such as the locomotor activity and its daily pattern, running performance, the aerobic exercise capacity (the gold standard in the assessment of physical fitness), basal metabolic rate, daily food consumption, and body temperature. Eventually, biochemical analyses of blood will be performed, such as in a typical medical diagnostics, and tissue samples will be preserved for further analyses (in future projects). We will also measure females reproductive success and their offspring performance. We predict that rearing voles on the Western diet will compromise the performance traits and health indexes more in the Herbivorous lines, and less (if at all) in the Predatory or Aerobic lines, compared to the Control lines.

The immediate outcome of the project will be a comprehensive verification or falsification of predictions of the thrifty and spendthrift genotype hypotheses on the unique animal model, at the level whole-animal performance. The project will also provide a basis for further investigation of biochemical and molecular mechanisms underlying the expected differences between the lines selected in distinct directions. The collected tissue samples will be immediately ready for such analyses, and the results can be interpreted jointly with the results of genomic analyses, which are already under way. Last but not least, the experiment offers a valuable educational tool in the context of public (non-academic) debate concerning Darwinian theory of evolution, because it let us directly observe evolution in the time frame of only several generations.