Physiological mechanisms in ecological models of performance in cervids.

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Proper assessment of the consequences of environmental variation on animals depends on our ability to predict how they will perform under different circumstances. This requires two kinds of information. We need to know which environmental factors influence animal performance and their mode of action, i.e., whether a given factor acts alone or through interaction with other factors, directly or indirectly, instantaneously or after a delay. This essentially correlative process falls within the domain of ecology. We also need to know what determines the direction, rate and limits of animal responses to environmental change. This essentially experimental process falls within the domain of physiology. Physiological mechanisms are frequently poorly integrated within the correlative framework of ecological models as, for instance, where programmed responses are attributed to environmental forcing or where the effect of environmental factors is evaluated without reference to the physiological characteristics of the animal upon which they act. This paper uses field and experimental data to illustrate how the influence of environmental variables on the performance of cervids (chiefly Rangifer) is modulated by the endogenous mechanisms and traits that govern physiological and behavioural function. It draws five main conclusions: (1) Annual cycles of growth, appetite and reproduction of northern cervids are governed by the interaction of nutrition, an environmental factor, with innate circannual timers the phase of which is determined by photoperiodic synchronization. (2) Diel patterns of activity are governed by a trade-off between predation hazard and internal stimuli that govern motivation to feed. (3) The thermal load imposed by a given set of weather conditions is a function of animals’ thermal sensitivity and metabolic requirement both of which vary across the year. (4) The nutritional value of a forage plant of given chemical composition is a function of the rumen microbial environment in which it is digested which also varies seasonally. (5) Even responses to the human environment are tempered by changes in physiological capacity. Thus, the sensitivity of reindeer to ultra-violet light emitted from corona discharges on high voltage powerlines depends on seasonal variation in the structure of the visual system. Evaluating environmental factors with respect to endogenous variation in physiological function adds biological realism to models and is likely to improve understanding of the influence of environmental variation on performance in cervids.