

The role of the gut microbiome in temperature adaptations in birds

Suvi Ruuskanen¹, Charli Davies¹, Martta Liukkonen¹, Andreas Nord², Sameli Piirto¹, Antoine Stier³

¹University of Jyväskylä, Finland, ²Lund University, Sweden, ³University of Strasbourg, France

The gut microbiome varies between and within species and has been increasingly recognized as an important mediator of health and various adaptations across taxa. A key environmental factor influencing the gut microbiome is temperature, yet data across species is still scarce, and the underlying mechanisms need to be discovered. The gut microbiome has been suggested as a promising mechanism for regulating energy acquisition and heat production and may therefore contribute to cold (and winter) adaptation. To test this hypothesis, we studied environmental variation in gut microbiome in wild populations of a passerine bird, the great tit (*Parus major*), and report seasonal and population-level differences in gut microbiome across latitudes. To study the causal effects of temperature, we then sampled wild-caught birds in captive conditions kept under either summer or winter temperatures. Despite the strong effects of captivity, we showed compositional differences across temperatures. Importantly, to elucidate the causal role of the gut microbiome in cold adaptations, we performed experimental manipulations using antibiotics and reciprocal transplants and measured associated responses on metabolism. We showed that gut microbiome disruption led to lower metabolic rates, whereas transplants from cold-adapted allowed warm-adapted individuals to maintain higher body temperature. Finally, we studied multiple environmental contaminants that may further disrupt the gut microbiome. All in all, the data points to the key importance of the gut microbiome in mediating temperature adaptations and suggests that temperature-GM- associations should be considered in animal studies.