Role of Gut Microbiome in Rock Ptarmigan Health and Population Cycles

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Objectives

• Examine microbial diversity in the Icelandic rock ptarmigan ceca.
• Explore the relationship between rock ptarmigan’s microbiome and their health and population cycles.

Introduction

Rock Ptarmigan (Lagopus muta)

• Medium-sized game bird found in sub-Arctic and Arctic regions.
• Lives in rocky habitats above the tree line desolate of shrubs and vegetation in high Arctic or high-alpine tundra.
• Diet consists of catkins, seeds, insects, buds, and berries.
• Sometimes digest chemically defended plants that contain toxic plant secondary metabolites (PSM).

Preliminary Findings

• Some temporal shifts in species richness inecal microbiome may relate to diet and body condition.
• Ptarmigan weight is independent of cecum length.
• Longer ceca length may relate to lower body condition and health.

Hypothesis

We hypothesize that the cecal microbiome plays a vital role in the overall health of Icelandic rock ptarmigan.

Methods

Collect cecal samples (100 per yr.) for 10 years
Record health, demographic, and morphology measurements: weight, cecum length, age, etc.
Amplify 16s rRNA V3/V4 region using amplicon sequencing (DNA extraction, PCRs, library pools)

Quality checks and assessments with Mothur

Bioinformatics using R programming

Figure 1: Ptarmigan and gyrfalcon population cycles in North America. There is a residence time of dry matter, which controls how much energy used. The efficiency depends on factors like food quality, cecum size, and herbivores, especially ptarmigan. Some help degrade PSMs.


Figure 3: Total bacterial species in each cecal content sample taken from collecting years of 2007, 2008, 2010, 2012.

Population Dynamics

• May vary in cycle periods depending on geography and their ecological interactions.
• Multiannual cycles that fluctuate every 10-11 years.
• Overall negative trend in their cyclic patterns, especially in recent years in Iceland.
• Small game hunters and the gyrfalcon (Falco rusticolus) contribute to pattern, but ptarmigan health may also.

Cecal Microbiome (Gut)

• Ferments or breaks down the complex food molecules from the small intestine to the large intestine.
• Rich in microbes that play an essential role in processing food in herbivores, especially ptarmigan. Some help degrade PSMs.
• The efficiency depends on factors like food quality, cecum size, and residence time of dry matter, which controls how much energy used.
• There is little known about the cecum’s multifunctionality and how it differs between species, ecological exchanges, and gut morphology.

Discussion

• No major significance between cecum length and alpha species diversity or weight and alpha species diversity.
• No significant difference in alpha diversity across years, which may indicate cecal microbiome structure is highly specialized.
• The lack of diversity in our findings seem to support other research that the cecum has less variability compared to other gut regions (Drovetski et al. 2019).
• Some temporal shifts in species richness in cecal microbiome may relate to diet and body condition.
• We’ve found that cecum length varies, while ptarmigan weight stays relatively the same for some samples.
• In juveniles, their ceca, on average, were longer compared to adults. They also had lower body condition and health metrics.
• The beta diversity of some samples did not have any differences between collection years.
• Without a complete analysis, our hypothesis is not supported yet, but foresee it being proven when finished.
• Analysis of the full dataset may reveal possible health factors that may relate to the cecal microbiome.

Results

We found that cecum length varies, while ptarmigan weight stays relatively the same for some samples.

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Future Directions

• More studies conducted on rock ptarmigan of other regions of the world that are seeing declines like Greenland.
• Use geographic information system(GIS), to track their scavenging patterns and relate the diet and habitat to the changes in the gut microbiome.
• Improve and run data for this large of a sample size at UAF. We would experience crashes, when trying to process more than 400 samples.
• Research the environment of rock ptarmigan and whether climate change impacts are affecting them or other bird species.
• Study further microbial communities in other parts of the gut microbiome.
• Better understanding of how the ceca fermentation process.

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