Potential disruption of thyroid hormones by perfluoroalkyl acids in an Arctic seabird with associations to reproduction

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ABSTRACT

Arctic climate change is occurring at an unprecedented rate, and may cause challenges to avian thermoregulation and endocrine regulation. Seabirds are long-lived predators and sentinels of marine pollutants and ecosystem health. Through long-range transport, endocrine disrupting compounds such as perfluoroalkyl acids (PFAAs) have been detected in Arctic wildlife, such as seabirds. There is evidence that PFAA exposure leads to the disruption of thyroid hormones (THs), such as thyroxine (T4) and triiodothyronine (T3) in seabirds, which play important roles in metabolism, incubation, and thermoregulation. Here, we investigate the relationships between PFAAs and THs [total T4 (TT4), free T4 (FT4), total T3 (TT3) and free T3 (FT3)] in blood samples collected in 2016-2018 from 114 male and female thick-billed murres (*Uria lomvia*) at a colony located in northern Hudson Bay. Also examined were the relationships between THs and PFAAs on fitness-associated reproductive traits. While FT3 increased with several PFAAs, TT3 was negatively correlated with PFOS, PFDoA, PFTrDA, and PFTeDA in murres, suggesting thyroid disruption. Body mass was positively associated with TT3 concentrations in murres, whereas several PFAAs were negatively correlated with body mass, particularly PFDoA, PFTrDA, and PFTeDA. Higher TT3 concentrations were associated with later hatch dates in murres, whereas PFDoA and PFTeDA corresponded with earlier hatch dates. Consequently, TT3 concentrations were highest in males and females in 2018, a year in which hatch dates of murre chicks were delayed relative to 2017. As an Arctic seabird experiencing several indirect effects of climate change, the interaction of PFAAs on thyroid activity may cause additional stress to murres.

INTRODUCTION & OBJECTIVES

•Long-chained perfluoroalkyl acids (PFAAs) are persistent and biomagnify in Arctic ecosystems.

•PFAAs are endocrine disrupters that affect thyroid activity.

Overall Objective: To examine potential effects of PFAAs and thyroid activity on reproduction in thick-billed murres.

Predictions:

- •Thyroid hormones may decline with PFAAs as a result of a competitive affinity for binding proteins.
- •Total triiodothyronine (TT3) will increase with body condition and a later hatch date.

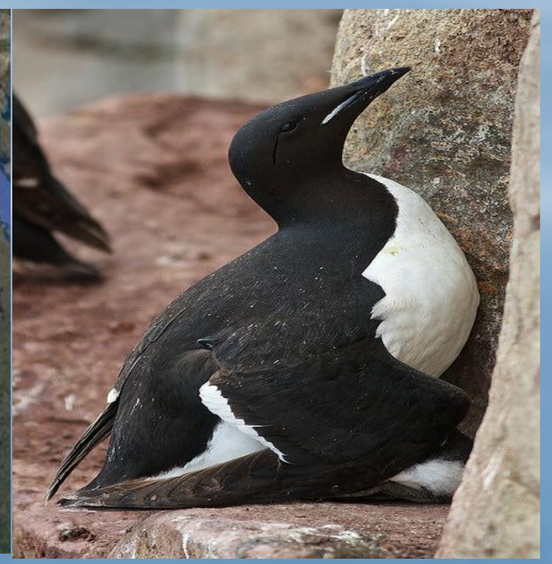


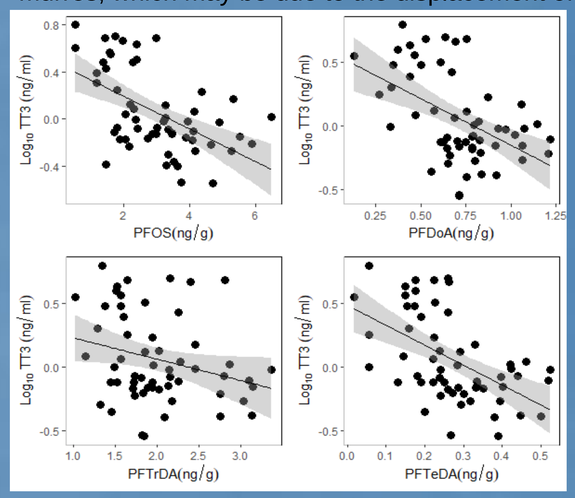
Figure 1. Study site at thick-billed murre colony on Coats Island in northern Hudson Bay, Nunavut, Canada

METHODOLOGY

- We collected blood samples (6 mL) for thyroid hormones (n=114) and 22 perfluoroalkyl acids (n = 65) incubating and chick-rearing thick-billed murres between July to August 2016-2018, from the 'West colony' on Coats Island in northern Hudson Bay, Nunavut, Canada.
- We used linear models to examine the relationship between thyroid hormones and PFAAs with body condition (body mass) and reproductive traits (hatch dates).

RESULTS

- TT3 decreased with PFOS, PFDoA, PFTrDA, PFTeDA, ∑PFCA7 and ∑PFAAs, which suggests a potential disruption to thyroid function and reduced conversion of T4 to T3.
- FT3 increased with PFOS, PFNA, PFDA, PFDoA, PFTrDA, PFTeDA, ∑PFCA7 and ∑PFAAs in murres, which may be due to the displacement of T3 from binding proteins.



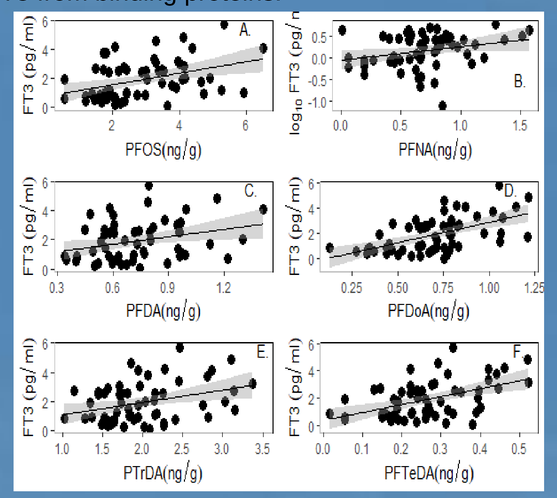


Figure 2. Linear regression of the relationship between A) TT3 , B) FT3 and PFAAs in the blood plasma in adult thick-billed murres (*n*=57). The shaded area represents the 95% confidence intervals around the predicted values

RESULTS

- Total body mass increased with TT3.
- All PFAAs had negative correlations with total body mass.
- Increases in TT3 associated with a later hatch date; higher PFDoA and PFTeDA correlated with an earlier hatch date.

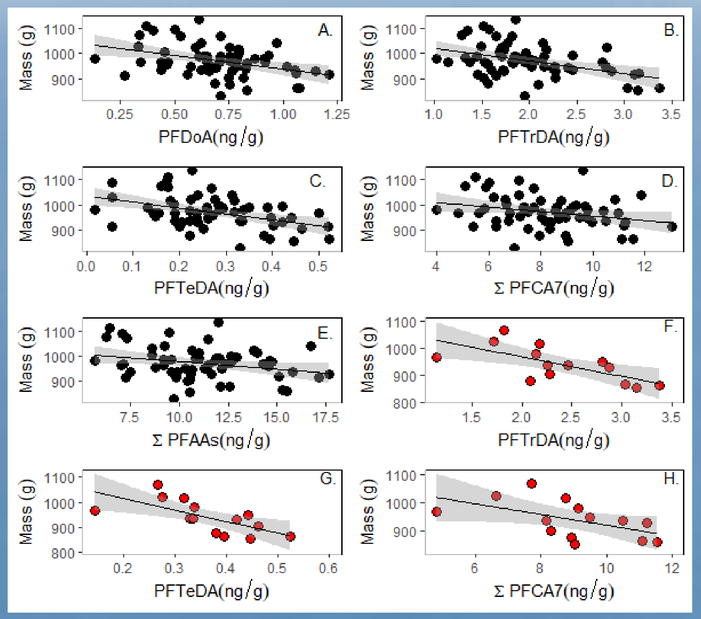


Figure 3. Linear regression of the relationship between total body mass and PFAA exposure in the blood plasma of individual (black; *n*= 61), and female (red; *n*= 14) adult thick-billed murres. The shaded area represents the 95% confidence intervals around the predicted values

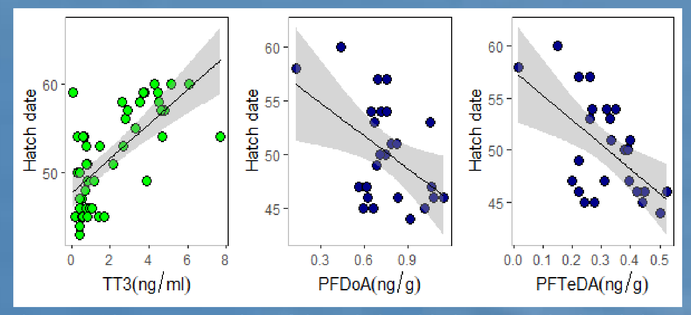


Figure 4. Linear regression of the relationship between the hatch (*n*= 52) dates and A) TT3 and B) PFAAs in the blood plasma of adult thick-billed murres. The shaded area represents the 95% confidence intervals around the predicted values. Hatch dates are listed as the number of days since June 1.

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