# A multidisciplinary approach to assess the intermittent breeding pattern observed in southern elephant seals at Marion Island in the Southern Ocean

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**Summary**

The fecundity and survival of breeding females often regulate the population demography of mammals. In turn, their fitness correlates to their diet and foraging success. Our aim is to use a combination of endocrinology, bulk (whole sample) and amino acid-specific carbon- and nitrogen isotopic values (AA-CSIA), measured chronologically along the length of adult female southern elephant seals (SES; *Mirounga leonina*) whiskers, to assess the cause of the recently observed adult female reproductive failure. We also aimed to evaluate the assumption that the biomolecule composition of intrauterine grown whiskers sampled from pups reflects the stable isotope values of their mothers during gestation. This project forms part of the broader objectives of the long-term (1983–ongoing) Marion Island Marine Mammal mark-recapture Program (MIMMP) in the Southern Ocean (http://www.marionseals.com/).

This funding instrument enabled us to analyze the amino acid -specific $\delta^{15}$N values in $n$ = 53 whisker segments sampled from juvenile ($n$ = 17) and adult female ($n$ = 17) SES. We combined the amino acid-specific $\delta^{15}$N data with bulk tissue (whole sample) nitrogen ($\delta^{15}$N) and carbon ($\delta^{13}$C) values, previously measured chronologically along the length the whiskers of the same individuals ($n$ = 1696 samples). The fast-associated bulk tissue $\delta^{15}$N values enriched significantly (1.8‰) from the onset of the whisker growth during the annual pelage molt until the end of the molt. We also observed significant $\delta^{15}$N enrichment (2–6‰) of most glucogenic amino acids and simultaneous

depletion (2–3‰) of alanine $\delta^{15}$N values when fasting during the molt, as compared to when foraging. Our study, therefore, provides proof-of-concept that a compound-specific isotope approach can be used as nutritional biomarker to detect changes in amino acid metabolism associated with fasting. It is evident that physiological factors have an underappreciated influence on the $\delta^{15}$N values that can lead to erroneous isotope-based dietary reconstructions. Using this information, we can now accurately identify the whisker segments grown while SES are on-land without prior knowledge of whisker growth histories. This will improve the accuracy of the adult female SES dietary reconstructions.

In the mother-pup pairs, the progressive enrichment of the fetal whisker bulk tissue $\delta^{15}$N values appears to be related to the simultaneous, offsetting depletion of the mothers' whisker $\delta^{15}$N values as gestation progresses. This is contrary to previous studies which suggested that the isotopic values of neonates reflect the biomolecule composition of their mothers in a predictable manner. In addition, the offspring glycine and serine $\delta^{15}$N values were enriched ($p < 0.001$) compared to their mothers' glycine and serine $\delta^{15}$N values, which enables us to determine the resource pool supporting fetal development during different stages of gestation. To our knowledge, this study represents the first combined bulk-and amino acid-specific stable isotope approached to determine if the fetal $\delta^{13}$C and $\delta^{15}$N values reflect that of their mothers in a predictable manner; the assumption behind the idea of using tissue sampled from offspring as a proxy for their mothers' diet.

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