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Review of the phd thesis by Anne N.M.A. Ausems “Reconstructing important phases of the annual cycle of four species of storm petrels using stable isotope analyses and ptilochronology“

The rationale and main research question of the thesis was to present the feeding ecology and patterns of distribution of four species of storm petrels. The geographic scale of the study is impressive – across the whole Atlantic, from the boreal islands to the Antarctic Peninsula. The object of study is very important – most numerous, yet little known oceanic birds, that are likely sensitive indicators of the state of the surface ocean ecosystem. Due to their small size, open sea occurrence and nesting in hidden places, those birds are difficult to study, despite their importance for the conservation and ecosystem understanding.

The two species from *Hydrobatidae* family were studied in the Boreal domain (Faroe islands) and two other species from *Oceanitidae* family in maritime Antarctic – King George Island, South Shetlands. Material was collected during breeding seasons of 2017 and 2018.

The main method used was a stable isotope analyses (carbon, nitrogen and oxygen) in blood and feathers. These elements are informative for the trophic level exploited as well as the geographic area, both in a long time range (blood chemistry) and shorter (feathers chemistry). Additionally the growth rings in feathers were analysed (ptilochronology) that indicates growth rates and intensity.

Material for analysis was very rich and collected with proper observation of methodology needed for advanced biochemical analyses, as well as approved by the Ethical Commission. Impressive is the quality of the statistical treatment of the material with advanced techniques supported by the R program.

The main scientific problem of the work is the co-existence of similar species, exploiting the same type of food and same marine region. In theory such situation may never exist, as one of the species shall change its habits to avoid the direct competition.

Thesis consists of three co-authored papers published in the internationally recognized journals of high level impact factor (STOTEN, PeerJ and Plos One). Co- authors provided statement indicating leading role of Anne Ausems in writing and editing the manuscripts.

First paper, published in PeerJ presents the differences in feathers growth rates between southern and northern birds. The feathers growth represents amount of energy available and thus authors demonstrated faster feathers growth in southern Atlantic birds compared to their northern equivalents – the reason is both the food availability and phenology of moulting that may partly overlap with the nesting period, thus the energy resources are distributed differently.

Second paper published in STOTEN, shows that food of higher energetic value was given to the nestlings, compared to the adults – that pattern was consistent in both analysed species. High level of trophic niche overlap was found in two species from the southern area. Very interesting is the observation, that isotope characteristics of birds before nesting is wider (more food sources exploited) compared to the chick feeding period (limited foraging range).

Third paper published in PLOS One, presents the moulting pattern of four storm petrel species, based on the isotopes occurrence in feathers and distribution of carbon and oxygen isotopes in the environment. Authors presents the differences in morphology within populations of two species that are linked with migration to different moulting areas. Large scale geographic model was presented with indicated most probable moulting grounds for the analysed populatons.

All together the three papers present coherent story about the use of indirect methods for the analysis of the annual life cycle of seabirds, and most interestingly the thesis presents novel data on the sympatric occurrence of closely related species. Thesis shows, that large and productive system like Southern Ocean may host sibling species with highly overlapping niches. The great scientific value of the project was a “double check” two species pairs in two geographic regions – that gives a very broad view on the examined problem.

Questions to the author to be addressed during public defence:

How the differences in food species selection may change the isotope signal – taking into account the same trophic level – e.g. replacement of one krill species by the other (e.g. both krill species are herbivores, while one feeds on ice-diatoms, and other on pelagic microplankton ? )

How the storm petrel species evolved, considering their present sympatric occurrence ? In other examples the today sympatric species, were once separated (e.g. by glaciation) and recently after the barrier was gone, the species occur together, what results in overlapping niches and habitats. What might be the driving factor for the storm petrels speciation ?

The oceanic surface food is apparently very abundant (yet dispersed), and the habitat is huge. Why only few seabird species reached for this supply and space ? (to compare with similar sympatric and omnivorous species of passerines (dozens of similar bird species in reeds or bushes, or invertebrates – eg. 10 to 12 sibling crustaceans in one place).

Considering the difficulty of food items determination in petrels (fast digestions) and their ability to feed on very small sized prey, do you think they may feed on the oil droplets that are excreted by crustaceans and the fish alike, this looks like ready to use food commonly found on the sea surface ?

I am convinced, that presented thesis represent high scientific standard, expected level of novelty and originality. It meets the requirements expected by Polish regulations for the PhD degree. According to administrative tradition, I recommend the dissertation for the next steps of the PhD procedure. Furthermore the scope of the project was so ambitious, the outcome so good and completed dissertation was outstanding that it should be awarded by the Faculty. The title for the award is for discovering new information about the ecological evolution of oceanic bird species.