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Research note

Using taxonomically-relevant condition proxies when estimating the conservation impact of wildlife tourism effects

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ABSTRACT

Meyer et al (2019) recently proposed that the nutritional condition of white sharks is unaffected by cage diving tourism. This conclusion was reached after analysing changes in the fatty acid profile of muscle samples collected from sharks that had spent more time around cage diving and contrasting them to sharks relatively unexposed to these activities. Here we want to caution on the interpretation of these results which do not fully take into consideration the way energy metabolism functions in elasmobranchs. We provide some alternative metabolic targets which could be retrieved from the field and would be more relevant to estimate the potential population consequences of tourism disturbances on white sharks.

Numerous studies over the past 30 years have shown that interactions between wildlife and tourism activities can perturb the activities of the targeted animals (Green & Higginbottom, 2000). Yet, it has been difficult to place these perturbations in a conservation context because of the challenge to understand how repeated behavioural and physiological disruptions can affect the demographic contributions of the affected individuals (Pirotta et al., 2018).

Recent analytical advances have helped to tackle this inferential challenge (Pirotta et al., 2018). The impact of tourism and recreation is broader than once thought as we have more than 2350 animal species for which tourism and recreational interactions are listed as a conservation threat on the IUCN Red List (Threat 6.1). Understanding the conservation relevance of repeated, short-term tourism impacts on individual animals hinges on incorporating them in condition-mediated population models (Christiansen & Lusseau, 2015). It is therefore important to understand how exposure to perturbations can affect the condition of individuals and therefore their demographic contributions (through survival and/or reproduction). Studies like Meyer, Pethybridge, Beckmann, Bruce, and Huveneers (2019) (Meyer et al., 2019) are therefore crucial both to understand tourism conservation impacts and to define appropriate management plans.

The condition of an individual is often estimated in the conservation ecology literature using a proxy of the volume of its fat depots with the assumption that the more fat an individual has, the better its condition will be (New et al., 2014). However, if we want to estimate 'condition' in an ecologically-relevant manner, that is as a measure of how much an individual will be able to contribute to population growth rate, then we need to carefully understand how energy metabolism functions in the species of interest. More specifically, we cannot assume that adipose biology functions in all species in the same manner as model organisms when nutrient levels are perturbed. Subcutaneous and muscle fat density is indeed a useful measure of ecologically-relevant condition in many terrestrial mammals as well as teleost fishes (Tocher, 2003). However, in elasmobranchs, tissues and biological functions interact differently to maintain energetic homeostasis.

While indeed it may be possible to estimate dietary shift from lipid profile in elasmobranch muscles (Semeniuk, Speers-Roesch, & Rothley, 2007), there is still more work needed to understand the temporal scale at which fatty acid (FA) profile can be interpreted and how preferential accumulation in different tissues may mean that tissue-specific predator FA profile can differ from its prey consumption (Mohan, Mohan, Connelly, Walther, & McClelland, 2016; Nielsen, Clare, Hayden, Brett, & Kratina, 2017; Pethybridge, Parrish, Bruce, Young, & Nichols, 2014). However, it is unlikely that we can infer nutritional stress from the same tissue.

Elasmobranchs rely on their liver for lipid storage. Indeed, Pethybridge et al. (2014) recommend using liver biopsies over muscle biopsies for dietary inferences. Using their 2014 study, where both muscle and liver of white sharks were sampled, we can show that there is little concordance between the muscle and liver lipid profile (Fig. 1).

Importantly, the question becomes whether measures of lipid metabolism are ecologically-relevant measures of condition for elasmobranchs. In addition to the fact that extrahepatic lipid metabolism is limited in these species, ketone bodies play a much greater role in

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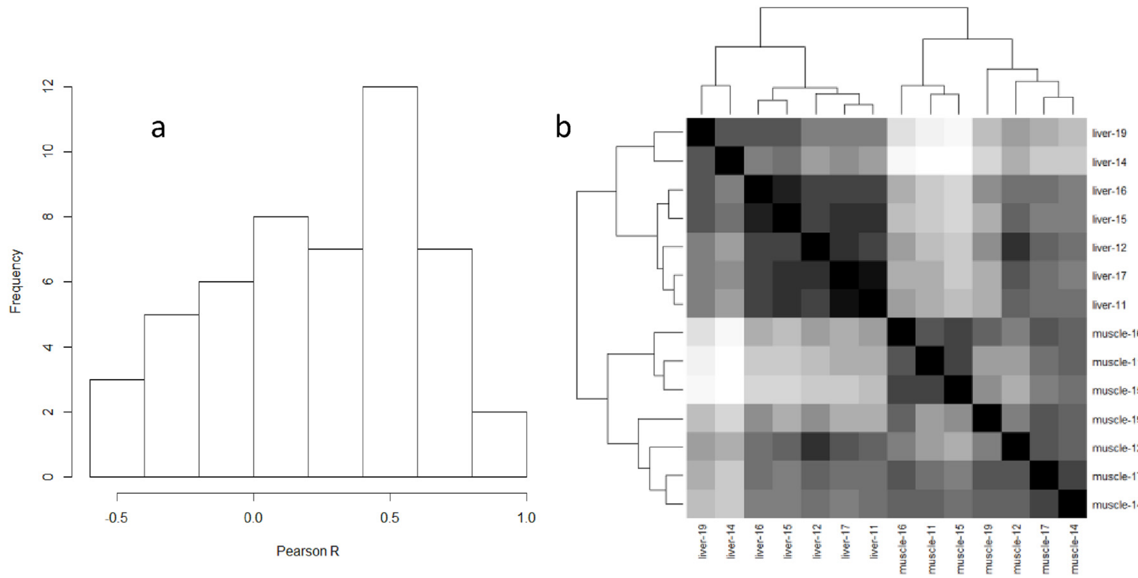

Fig. 1. a) Distribution of Pearson r correlation between muscle and liver % weight mass of 50 lipids (n = 7 white sharks). Muscle and liver concentration were concordant for only one out of the 50 lipids (18:0 FALD; Pearson r = 0.96, p_{adj} = 0.04, BH adjusted p-values for multiple testing). b) heatmap of the clustered sample similarities (based on Manly dissimilarity distance for proportions, clustered by average linkage; black = 0 dissimilarity, white = 0.46): samples within tissues are more similar to each other than samples within individuals. Data taken from Pethybridge et al., 2014 (Supplementary Tables S1&2).

energy metabolism than they do in mammals or teleost fishes (Ballantyne, 1997; Speers-Roesch & Treberg, 2010). Indeed, it is anticipated that elasmobranchs rely on ketone bodies and amino acids as oxidative fuels in muscle tissue (Speers-Roesch & Treberg, 2010; Wood, Walsh, Kajimura, McClelland, & Chew, 2010). Studies comparing fasted to satiated sharks can help us elucidate the more appropriate energy metabolism pathways to detect nutritional stress. These studies show that amino acid and nitrogen metabolism(s) are most affected and muscle protein stores changed most in response to fasting (Wood et al., 2010).

The question remains opened whether cage diving, and its associated baiting, influence the foraging ecology of white sharks to a point that it impacts their condition and therefore their ability to survive and reproduce. Observational studies indicate that significant foraging disruption may be unlikely but the integrative impact of multiple non-lethal effects of tourism interactions on shark physiological ecology is unknown (Gallagher et al., 2015). More broadly, elasmobranch tourism can affect habitat use and foraging ecology to a point that warrant concerns for the conservation of the targeted species (Gallagher et al., 2015). The approach used by Meyer et al. (2019) will help to estimate the potential population consequences of tourism disturbances. However, it would be useful to focus on muscle amino acid and ketone bodies metabolomics profile and plasma markers of the glutamate-glutamine-urea pathway to address this issue and not lipid metabolism.

More broadly, much of our understanding of the physiology of 'condition' has been driven by the study of a small subset of species which do not represent the diversity of energy metabolism(s) present in species likely to suffer from non-lethal, condition-mediated conservation threats. This should be the focus of attention to better understand the population consequences of disturbances (Mandelman, 2012; National Academies of Sciences and Medicine, 2017).

Declarations of interest

None.

Author contribution

DL and DD discussed Meyer et al.'s findings (2019) and developed the idea for this short communication. DL drafted the short communication with input from DD.

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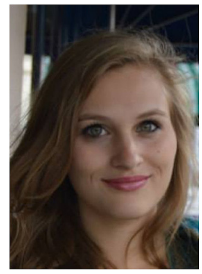

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