SCIENTIFIC REPORTS

OPEN

Body size is more important than diet in determining stable-isotope estimates of trophic position in crocodilians

Received: 30 May 2017
Accepted: 4 January 2018
Published online: 31 January 2018

Francisco Villamarín[1,2], Timothy D. Jardine[3], Stuart E. Bunn[4], Boris Marioni[5] & William E. Magnusson[1]

The trophic position of a top predator, synonymous with food-chain length, is one of the most fundamental attributes of ecosystems. Stable isotope ratios of nitrogen (δ^{15}N) have been used to estimate trophic position of organisms due to the predictable enrichment of ^{15}N in consumer tissues relative to their diet. Previous studies in crocodilians have found upward ontogenetic shifts in their 'trophic position'. However, such increases are not expected from what is known about crocodilian diets because ontogenetic shifts in diet relate to taxonomic categories of prey rather than shifts to prey from higher trophic levels. When we analysed dietary information from the literature on the four Amazonian crocodilians, ontogenetic shifts in dietary-based trophic position (TP_{diet}) were minimal, and differed from those estimated using δ^{15}N data (TP_{SIA}). Thus, ontogenetic shifts in TP_{SIA} may result not only from dietary assimilation but also from trophic discrimination factors (TDF or Δ^{15}N) associated with body size. Using a unique TDF value to estimate trophic position of crocodilians of all sizes might obscure conclusions about ontogenetic shifts in trophic position. Our findings may change the way that researchers estimate trophic position of organisms that show orders of magnitude differences in size across their life span.

The trophic position of a top predator is an important component of food-web structure because it reflects the number of steps that energy takes to reach it from basal resources. This is synonymous with food-chain length, which is considered to be one of the most fundamental attributes of ecosystems[1–3]. During recent decades, stable isotope ratios of nitrogen (δ^{15}N) have been widely used to estimate trophic position of organisms as a continuous measure[4], and this use has become the standard for most food web studies. The use of δ^{15}N as a surrogate of trophic position is based on the knowledge that the tissues of consumers become ^{15}N-enriched relative to their diets[5–7]. The mechanism underlying this pattern has been traditionally thought to be related to the higher rate of excretion of light isotopes (^{14}N) in relation to heavy isotopes (^{15}N), a process that leads to isotopic discrimination[6]. More recently, isotopic discrimination has been proposed to occur both during assimilation and protein synthesis and during the excretion of endogenous nitrogen in urine[8–10], which would indicate a possible effect of metabolic efficiency on TDF values. TDF values range widely across the animal kingdom[4], with average values between 2.0[11] and 3.4‰[6] for most of the studied organisms (summarized in ref.[12]). However, crocodilians show a much wider range of TDF values than other vertebrates[13–16].

As opportunistic predators[17,18], crocodilians may strongly influence the structure of food webs in distinct ways by preying upon organisms occupying different trophic levels across aquatic and terrestrial systems[14,16,19–22]. In all species, crocodilians grow several orders of magnitude both in length and mass during their lifespan. Such marked shifts in size are likely to be associated with decreased metabolic and growth rates[23], which strongly influence biochemical reactions and processes in the body, including protein turnover and excretion rates[24]. Therefore, it is plausible that the mechanisms leading to isotopic discrimination may undergo ontogenetic changes as well.

[1]Coordenação de Pesquisas em Biodiversidade, Instituto Nacional de Pesquisas da Amazônia - INPA, Manaus, Brazil. [2]Universidad Regional Amazónica - Ikiam, Tena, Ecuador. [3]School of Environment and Sustainability, University of Saskatchewan, Saskatoon, Canada. [4]Australian Rivers Institute, Griffith University, Brisbane, Australia. [5]Programa de Pós-Graduação em Biologia de Água Doce e Pesca Interior - INPA, Manaus, Brazil. Correspondence and requests for materials should be addressed to F.V. (email: francisco.villamarin@ikiam.edu.ec)