Trophic ecology of Japanese eels (*Anguilla japonica*) in river habitats with implications for the conservation of an endangered species

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Abstract

Declining Japanese eel (*Anguilla japonica*) populations have caused concern about the future of this ecologically and economically important species, resulting in its introduction to the IUCN Red list as an endangered species. Conservation efforts need to address the current threats (e.g. habitat fragmentation, water pollution, and overexploitation) that led to the continuous decline of wild eel populations, and rely on a profound understanding of eel ecology, as well as suitable monitoring tools. This thesis aimed to assess the trophic ecology of Japanese yellow-phase eels in rivers, adding to the understanding of the species ecology, and to introduce recent analysis methods of stable isotopes as monitoring tools for species and habitat management.

The second chapter of this thesis assessed the foraging patterns and food sources of eels along salinity gradients within rivers. Analysis of nitrogen and carbon stable isotopes revealed that eels showed plasticity in regard to their foraging behavior, utilizing fresh- and/or brackish water sites, as well as frequently moving between both habitats. The study showed the importance of riverine habitat connectivity during the growth phase of eels and provided a tool that allows the connection of habitat use and trophic ecology.

The trophic niche width and trophic niche overlap of different size classes of eels (≤ 250 mm and > 250 mm in total length) were assessed in the third chapter of this thesis, utilizing stomach content and stable isotope analysis. The study was performed in two small rivers (< 15 km length) with surrounding paddy or urban areas; as such rivers pose great potential for habitat restoration and species management. Trophic niche width and niche overlap of eels were shown to differ according to abiotic and biotic habitat conditions, indicting varying habitat suitability for different size classes of eels. As the trophic niche width reflects the diversity of energy sources assimilated by a consumer, it would pose a powerful indicator of habitat connectivity and species resilience to changing environmental conditions.

The monitoring of the species and habitat *status quo*, as well as their reaction to conservation efforts is crucial for successful conservation projects and requires suitable assessment methods. Stable isotope analysis commonly relies on the usage of white muscle tissue, representing a lethal-sampling method which is conflicting with long-term monitoring, and the work on endangered species. Therefore, epidermal mucus of eels was tested; in a laboratory feeding experiment with small eels (< 120 mm in total length); as a possible surrogate tissue, allowing a non-lethal and repeated sampling. Isotopic turnover rates and trophic discrimination factors of eel mucus were estimated using growth- and time-based

models, allowing its future application in stable isotope studies on eels (chapter 4.2 of this thesis). Furthermore, the effects of chemical lipid-extraction on different eel tissues were tested, and were proposed to be replaced by a time-saving arithmetically correction based on C:N ratios of samples (chapter 4.1 of this thesis).

In conclusion, the results of this study contributed to the understanding of the trophic ecology of yellow-phase Japanese eels in rivers, and introduced analyses of nitrogen and carbon stable isotopes as possible monitoring tools for the management and conservation of this endangered species. The use of epidermal mucus of eels for stable isotope studies was promoted through the first estimation of trophic discrimination factors and turnover rates of mucus and would allow the application of non-lethal sampling methods in the future, as well as repeated-measure studies. The establishment of monitoring tools is crucial for the success of management efforts such as habitat restorations and species conservation, as such measures should be stepwise-adaptive and process-orientated. Furthermore, small rivers in urban and agricultural areas were discussed to hold great potential for future eel habitat restoration projects.