Trophic Functioning of Integrated Rice Agriculture to Fish Aquaculture in Madagascar: Insights from Stable Isotopes ($\delta^{13}C$ &$\delta^{15}N$)

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Abstract

Flooded rice fields are ecosystems favorable to growth and production of aquatic organisms. They can even play a major role in feeding and nutrition of local communities, as source of self-recruiting species or supporting production of farmed fish in association with rice. In Madagascar, integrated rice-fish culture has proven a yield net increase, without fertilizers or feed inputs, of more than 10% compared to traditional rice culture. Common carp (*Cyprinuscarpio*), have been either demonstrated to improve rice production through fertilization of rice plots. Fertilization is indeed provided through bioturbation of sediments aside from any confirmed impact on pests and weeds.

Although common carp can improve rice production, fish is often limited to small yields (av. 50kg/ha/cycle). Fish yields can however reach 500kg/ha/cycle (av. 100 days) through intensification with fertilizers and feeds. In that context, trophic characterization of rice-fish systems may improve knowledge on ecosystem functioning as well as fish and rice yields. Natural abundances of carbon and nitrogen stables isotopes ratio ($\delta^{13}C$ and $\delta^{15}N$) are often used in ecological studies to characterize trophic functioning of aquatic ecosystems. The aim of the current study was therefore, to characterize feeding behavior of common carp in rice fish integrated agriculture to aquaculture system, through stable isotopes analysis of the compartments of this aquatic ecosystem.

At the beginning of the experiment, carp larvae signature was-18.8±0.5‰ and 9.3±0.6‰, for $\delta^{13}C$ and $\delta^{15}N$ respectively. This signature suggest that larvae feeds were supplied by animal proteins (*e.g.* fish meal) and C_4 carbohydrate (*e.g.* corn).

However, following 100 days of extensive feeding in the rice plot, fish signature was depleted compared to larvae, down to -24.9±1.0 and 5.7±0.9‰, for $\delta^{13}C$ and $\delta^{15}N$ respectively. Stable isotopes signatures of produced fish were in the range of rice plot ecosystem, confirming that feeding was supplied by natural resources. Assuming a trophic enrichment factor of +1‰ for $\delta^{13}C$ and +3‰ for $\delta^{15}N$ between a prey and its predator, theoretical food source of common carp may have an average signature of -26 and 2.7‰, for $\delta^{13}C$ and $\delta^{15}N$ respectively. Such theoretical source was perfectly in between the signature of rice roots and sediments and suggests that these two sources were consumed, while zooplankton and rice leaves didn't contribute to the carp diet. This theoretical source may therefore confirm feeding behavior of common carp, which have been extensively described burrowing in sediments to find insects and larvae, while occasionally ingesting roots and sediments. In sediments however, only the signature of one individual of dysticidae larvae and one nepidae corresponded to that theoretical source, but for which any replicate was sampled. Further investigation is therefore needed to fully understand feeding behavior of common carp in rice fields including weeds signature.

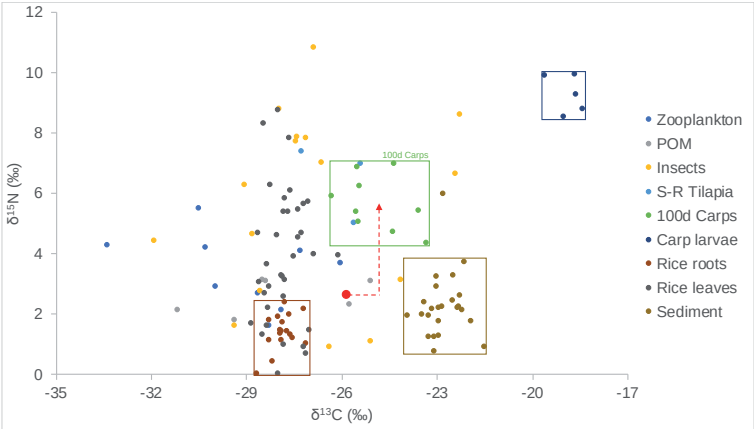

Figure 1. Dual plot natural abundances of carbon and nitrogen stables isotopes ($\delta^{13}C$ and $\delta^{15}N$) in rice fields