**FINAL PUBLISHABLE SUMMARY REPORT**

**PUBLISHABLE SUMMARY**

**Project title:** Factors Regulating the Input of Terrestrial Material and Patterns in Food Web Structure in African Inland Aquatic Systems

**Aims**

The aim of the study was to develop a better understanding of the main sources of energy and the food web structure in (sub)tropical east African systems. The specific objectives were to determine the importance of imported (terrestrial) material for consumer communities and to describe food web organisation in those freshwater and estuarine systems.

**Methods**

Five systems whose catchments differ in C3 and C4 vegetation cover were sampled: the Zambezi in Mozambique (catchment with a C3/C4 cover of 61/39%), the Tana in Kenya (36/64%) and the Betsiboka (42/58%), Rianila (85/15%) and Pangalanes Canal (85/15%) in Madagascar. As C3 and C4 vegetation differ strongly in δ13C signatures, we anticipated that terrestrial subsidies would be reflected in a gradient in estuarine consumer δ13C values, following the relative importance of C3 (characterised by low δ13C) vs. C4 (characterised by high δ13C) cover. Sampling included a range of aquatic biogeochemical parameters, primary producers, macroinvertebrates and fish of different trophic ecologies (phytodetritivores, herbivores, planktivores, carnivores and piscivores) and was done both before and after the 2010/2011 wet season. Samples were processed and their carbon and nitrogen stable isotope composition analysed with an isotope ratio mass spectrometer coupled with an element analyser at the laboratory at the KU Leuven.

Based on stable isotope data, Bayesian mixing models were run for each site and season, and used to quantify the contribution of the main classes of producers to consumers. Bayesian community-wide metrics were also used to describe food web organization for each site and season. Metrics used were δ13C and δ15N range, mean distance to centroid, mean nearest neighbour distance and standard deviation of nearest neighbour distance. The first three provide information on the trophic diversity within a food web, by giving a measure of the spacing of the different components in the δ13C-δ15N space, while the last two metrics are related to trophic redundancy. Isotopic niches of fish communities were also quantified for each site and season based on Bayesian standard ellipse areas. Here, only fish species were considered because the taxonomic and trophic composition of invertebrates collected varied greatly between systems, so results would not be comparable.

**Results and Conclusions**

***Importance of terrestrial subsidies for aquatic food webs***

For estuarine sites, stable isotope results agreed well with the type (C3 vs. C4) and dominance of terrestrial vegetation and impacts (urbanisation, farmland) in the rivers’ catchments. Bayesian mixing models indicated that the importance of C3, C4 and aquatic primary producers differed between systems and seasons, and confirmed that terrestrial subsidies are important for aquatic food webs. For example, at the highly turbid C4-dominated Betsiboka, where C3 producers are scarce and waters very turbid, C4 material was the most important contributor to animal nutrition, contributing up to 61–84% (95% CI) to phytodetritivorous fish. At the other C4-dominated estuary, the Tana, extensive areas of mangrove forest are present and waters are less turbid, so mixing models indicate that consumers rely on a combination of C4, C3 and planktonic sources. For the less turbid C3-dominated estuaries, terrestrial subsidies were not as important and consumers relied on a combination of sources. At the Zambezi, where aquatic sources more limited, both C3 and C4 producers were important for all trophic guilds and plankton also had some importance. At the clear water Rianila and Pangalanes Canal, terrestrial sources had some importance, but this was much lower than at the Zambezi or the two C4-dominated estuaries. No single source dominated and consumers seemed to rely on both terrestrial and on a combination of aquatic sources.

Overall, this large-scale study demonstrates that terrestrial subsidies are important for aquatic food webs in east African estuaries, and that carbon of terrestrial origin is transferred through several trophic links, from invertebrates to higher trophic level fish, and its influence is not limited to low trophic level species such as detritivores. The importance of terrestrial sources was also found to depend on factors such as turbidity and availability of aquatic sources: while in clear systems, where aquatic producers are abundant, food webs rely on a combination of terrestrial and aquatic sources, in highly turbid systems there is a stronger dependence on imported organic matter. Results also show that the ecological health of the overall catchment directly affects the downstream estuaries at the most fundamental level, and activities that alter the turbidity and productivity of rivers and estuaries (e.g. river regulation, removal of riparian vegetation, deforestation and conversion of land to grazing land) affect food webs well beyond the area of impact. This implies that rivers, along with their catchments and estuaries should be managed as open systems.

For freshwater sites, data analysis was not as straightforward as for estuarine sites due to temporal and spatial variation in aquatic producer stable isotope composition and to the frequent overlap in δ13C and/or δ15N between distinct sources. Data analysis for the freshwater reaches of the rivers is currently underway.

***Patterns in food web structure***

For the estuarine sites, trophic length (estimated based on δ15N and using invertebrate primary consumers as a baseline) varied between 3.8 (Betsiboka) and 4.7 levels (Zambezi) (4.2 ± 0.3) and did not vary seasonally for any estuary. Food web structure differed the most at the semi-isolated Pangalanes Canal, where both trophic diversity and trophic redundancy were lower than at the other estuaries. Among the four open estuaries, the Betsiboka and Tana (C4-dominated) had more compact food webs, with lower trophic diversity than the Zambezi and Rianila (C3-dominated), probably due to the limited availability of aquatic sources that result from the high loads of suspended sediment at the first two estuaries. At the Pangalanes Canal and Betsiboka, there was seasonality in trophic structure, reflected by an increase in trophic diversity and decrease in trophic redundancy from the pre- to the post-wet season. For the Pangalanes Canal, this probably resulted from the higher availability of both terrestrial and aquatic sources at the post-wet season, which allowed consumer diets to diversify. For the Betsiboka, where waters are highly turbid and aquatic primary productivity low, seasonal changes probably resulted from the input of terrestrial organic material during the wet season.

Overall, the comparative analysis of community-wide metrics was useful to detect patterns in trophic structure and identify differences/similarities in trophic organisation related to local conditions. This was the first study to apply this approach to a comprehensive dataset of estuarine biota. Results will allow for future comparisons with similar datasets from a range of aquatic ecosystems, to identify large-scale patterns in these metrics and describe general patterns in food web organisation across different ecosystem types. This methodology can provides complementary information to mixing models and other approaches to the analysis of stable isotope data, and is likely to find new applications in the future (e.g. comparing food web organization before and after impacts, or monitoring of ecological recovery after rehabilitation).

Analysis of data for the freshwater reaches of the different Rivers is still underway.