ENERGY EXTRACTION AND FIBER DEGRADATION

OF *PANAQUE MACCUS*

ON THREE DIETS VARYING IN DIGESTIBILITY

Toba Niazi
Towson University,
Department of Biological Sciences
Towson MD. 21252 USA

Jay Nelson*
Towson University,
Department of Biological Sciences
Towson MD. 21252 USA
Phone: 410-830-3945
jnelson@towson.edu
*- contact author

EXTENDED ABSTRACT ONLY-DO NOT CITE

Introduction

Relatively few studies have been performed on the nutritional physiology of Neotropical freshwater fishes. Yet, because the Amazon basin has the richest freshwater fish fauna in the world despite areas of restricted primary productivity due to canopy overhang, dystrophic and/or turbid water, we can predict intense competition for food resources among the fishes there. Intense competition for food often leads to the evolution of novel nutritional strategies. Indeed, members of the loricariid genera *Panaque* (Eigenmann and Eigenmann) and *Cochliodon* (Heckel) have been found to have wood as the only macroscopically observable item in their gastrointestinal tracts (Schaefer and Stewart, 1993). Furthermore, several species of *Panaque* have been found to consume a variety of North American temperate woods in the laboratory, and some individual *Panaque* will exhibit positive growth on a wood-only diet in the lab (Nelson *et al.*1999).

The two genera of loricariids suspected of deriving energy from wood (*Panaque* and *Cochliodon*), both possess spoon-shaped teeth thought to be specializations for gouging wood (Schaefer and Stewart, 1993). Generalized loricariids which feed primarily by scraping algae and aufwuchs from substrate (e.g. *Hypostomus*, *Liposarcus*) possess blade-shaped teeth thought to be specialized for scraping. Whether *Panaque* and *Cochliodon* possess any further specializations for exploiting wood as an energy resource is unknown. The central question we address in this study is whether the ability of one species of *Panaque* to extract carbon from their diet is dependent upon the polymeric form of that carbon in the diet.

Methods

Animals

Specimens of *Panaque maccus* (Schaefer & Stewart, 1993) were obtained from aquarium wholesalers as they arrived from South America and held in untreated water in aquaria well innoculated with the water they were transported in. These steps were taken to maximize the chance that fish retained their native gut flora. Fish were eventually transferred to individual containers that facilitated feces collection. Algal growth was restricted in these individual tanks by covering the entire tank with opaque plastic.

Collection of Feces

The fish were fed one of three diets though to vary in their fiber content (broccoli stems, carrots or wood of the red maple tree) every night. The food was taken out each morning (16h) and feces were collected at that time. The feces from four individuals on each diet were pooled and frozen immediately.

Bomb Calorimetry

Food and feces were dried and ground to pass a 1 mm mesh screen. A weighed portion of the sample was combined with a known amount of carrageenan (Tic Gums Inc.®). Deionized water was then added and pellets were molded and placed back in the drying oven 60 ºC. The pellets were weighed and fuse wire wrapped around them and placed in a Parr® 1341 oxygen bomb calorimeter. The calorimeter was then filled with oxygen to 30 atm and ignited. The temperature rise was recorded by an Instrulab® 4000 temperature detector whose output was recorded by a PowerLab® 4S analog/digital module and Chart® software running on a Power MacIntosh® 7200/120. The gross heat of combustion was calculated from the temperature rise and the energy equivalent of the calorimeter. The latter was determined by igniting benzoic acid standards. The heat of combustion was corrected for nitric acid formation by titrating the bomb washings with 0.0709 M Na_2CO_3.

Fiber analysis

Fiber decomposition was assesed by analyzing diet and feces for various fiber fractions following a micro-modification of the hot detergent procedures of Robertson & van Soest (1981),van Soest (1994) and van Soest *et al*. (1991). These methods allowed us to separate hemicellulose, cellulose and lignin/cutin fractions from soluble cellular components and starch and were quite reproducible. Degradation of the various fiber fractions were estimated from the diet-feces difference. Ash content was used as the indigestible marker.

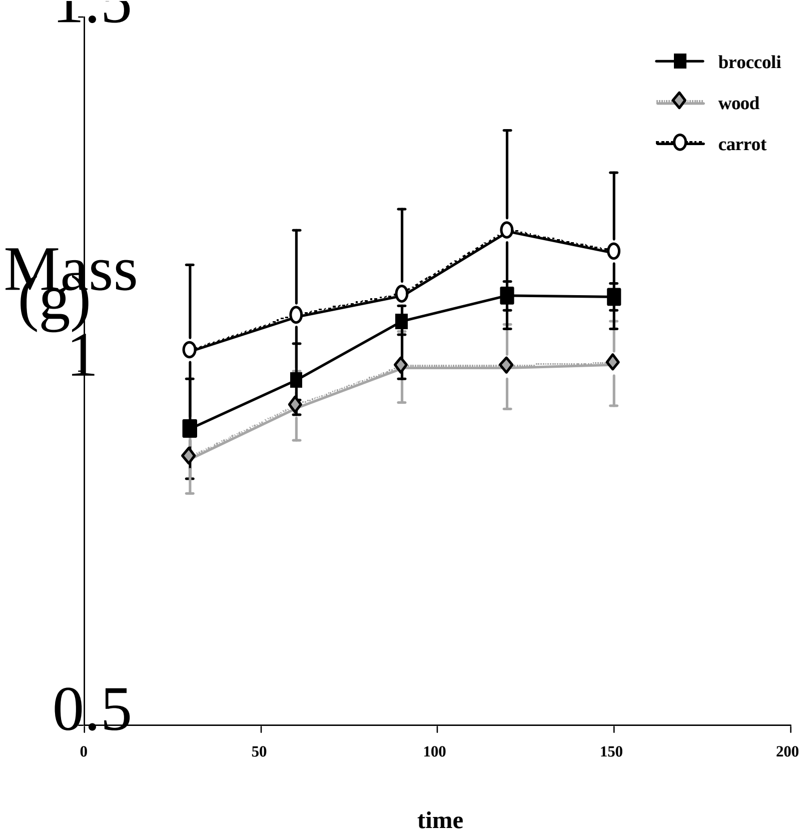
Results and Discussion

Growth

Individual *Panaque maccus* grew in the feces collection tanks despite the exclusion of algae from the water. Growth rate did not appear to depend upon diet for these animals (Figure 1).

This result is in contrast to our results for *Panaque nigrolineatus* and earlier experiments on *Panaque maccus* where growth in animals on a wood-only diet was substantially slower than in animals fed algae or vegetables. One

Figure 1: Growth of fish during feces collection period



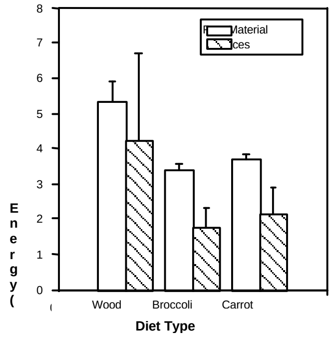
explanation for this is that the red maple used in this experiment may be more digestible than the woods used in the earlier experiments. Another rationale explanation for this result is that we were able to culture fungi from the group of *Panaque maccus* that were used for these experiments (see Nelson *et al.* this volume); we were unable to culture fungi from previous shipments of *Panaque maccus.*

It is likely that these cellulolytic fungi are involved in the fiber decomposition observed *in vivo*.

Energy Extraction

Red maple wood contained more energy per gram than either the carrot or broccoli diets (Figure 2). *Panaque maccus* extracted roughly the same amount of energy from each of the diets.

Figure 2



Energy removed from two diets by ***Panaque maccus***

Fiber Degradation

Figure 3 presents the results from the hot detergent analysis of fiber fractions in food and feces. The data is presented as the per cent composition of a particular fiber component in the dietary item minus the per cent composition for that fiber fraction in the feces of animals eating only that diet. Thus, a high positive number is indicative of dietary assimilation of that component whereas a large negative number indicates little dietary importance for that particular fiber fraction.

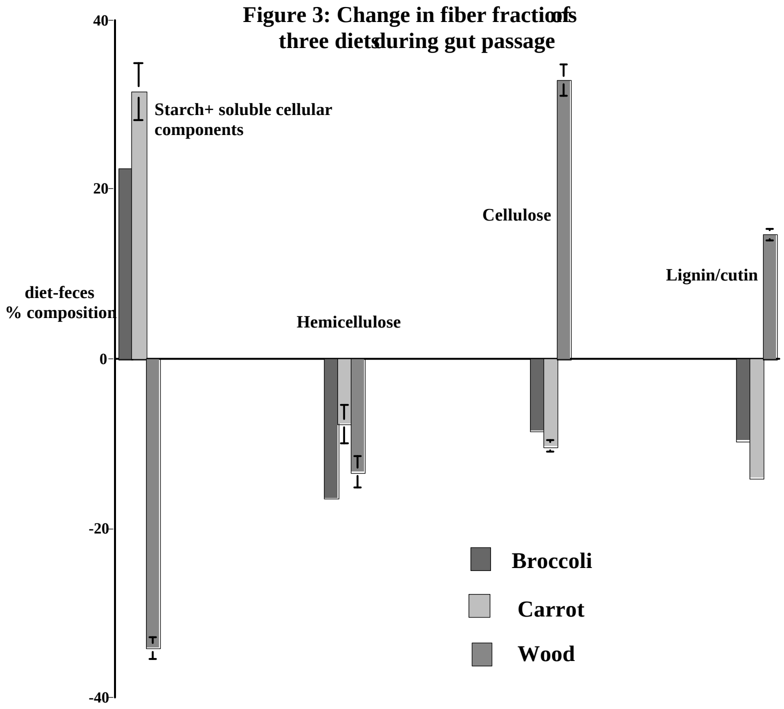


Figure 3: Change in fiber fractions of three diets during gut passage

The primary message from this analysis is that the fiber degrading ability o*f Panaque maccus* is very dependent upon what they are eating. Fish on a broccoli or carrot diet digested primarily the soluble cellular components and starch in their diet. There was very little evidence for degradation of the more recalcitrant carbon polymers. Fish on a red maple diet, on the other hand, appeared to digest primarily cellulose and the lignin/cutin fraction. The large negative number for the soluble fraction of the wood diet probably stems from the presence of bacterial and fungal material in the feces.

References

Nelson, J.A., D.J. Stewart, M.E. Whitmer, E.A. Johnson & D. Wubah 1999. Wood-eating catfishes and their aerobic, cellulolytic gut symbionts: ecological and evolutionary implications. J. Fish Biol. 54: 1069-1082.

Robertson, J.B. & P.J. van Soest 1981. The detergent system of analysis and its application to human foods. In pp. 123-158 W.P.T. James and O. Theander (eds.) The analysis of dietary fiber in food. Marcel Dekker. N.Y.

Schaefer, S. A. and D.J. Stewart 1993. Systematics of the *Panaque dentex* species group (Siluriformes: Loricariidae), wood-eating armored catfishes from tropical South America. Ichthyological Exploration of Freshwaters. 4: 309-342.

van Soest , P.J. 1994. Nutritional ecology of the ruminant. 2nd edition. Cornell Univ. Press. Ithaca.

van Soest P.J., J.B. Robertson, and B.A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. J. Dairy Science. 74: 3583-3597.