



## Molecular systematics of Serrasalmidae: Deciphering the identities of piranha species and unraveling their evolutionary histories

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### Abstract

Piranhas and their relatives have proven to be a challenging group from a systematic perspective, with difficulties in identification of species, linking of juveniles to adults, diagnosis of genera, and recognition of higher-level clades. In this study we add new molecular data consisting of three mitochondrial regions for museum vouchered and photo-documented representatives of the Serrasalmidae. These are combined with existing serrasalmid sequences in GenBank to address species and higher-level questions within the piranhas using parsimony and Bayesian methods. We found robust support for the monophyly of *Serrasalmus manuelei*, but not for *Serrasalmus gouldingi* when GenBank specimens identified as *S. gouldingi* were included in the analysis. “*Serrasalmus gouldingi*” sequences in GenBank may, however, be misidentified. Linking of juveniles to adults of the same species was greatly facilitated by the addition of sequence data. Based on our sampling and identifications, our data robustly reject the monophyly of the genera *Serrasalmus* and *Pristobrycon*. We found evidence for a well-supported clade comprised of *Serrasalmus*, *Pygocentrus*, and *Pristobrycon* (in part). This clade was robustly supported in separate and combined analyses of gene regions, and was also supported by a unique molecular character, the loss of a tandem repeat in the control region. Analysis of specimens and a literature review suggest this clade is also characterized by the presence of a pre-anal spine and ectopterygoid teeth. A persistent polytomy at the base of this clade was dated using an independent calibration as 1.8 million years old, corresponding to the beginning of the Pleistocene Epoch, and suggesting an origin for this clade more recent than dates cited in the recent literature. The sister group to this clade is also robustly supported, and consists of *Catoprion*, *Pygopristis*, and *Pristobrycon striolatus*. If the term piranha is to refer to a monophyletic clade, it should be restricted to *Serrasalmus*, *Pygocentrus*, and *Pristobrycon* (in part), or expanded to include these taxa plus *Pygopristis*, *Catoprion*, and *Pristobrycon striolatus*.