A re-evaluation of species diversity within the *Labeo* (Cypriniformes: Cyprinidae) with papillary lips from the Congo basin

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Introduction

The African representatives of the genus *Labeo* Cuvier, 1816 are some of the largest and commercially most important African freshwater fish. Yet, their taxonomy is confusing and species identification is often difficult. Traditionally, identification keys relied heavily on the shape of the dorsal fin. This is, however, a qualitative character. This study focuses on the *Labeo* with papillary lips from the Congo and the Zambezi basins: *L. altivelis* Peters 1852, *L. lineatus* Boulenger 1898 and *L. weeksii* Boulenger 1909. The first species occurs in the Zambezi and adjacent river basins (Za) as well as in the Bangweulu-Mweru region (BM) of the Congo, the other two are Congo basin endemics and absent from the Bangweulu-Mweru ecoregio (Co). *Labeo lineatus* and *L. altivelis* have a convex dorsal fin whereas *L. weeksii* has a concave. Besides studying the distinctness of these species, differences in dorsal fin shape were quantitatively examined. intra- and interspecific variation in dorsal fin shape was investigated.

Materials & methods

188 specimens, including types, were studied using 18 meristics and 21 linear measurements. Two lengths were taken on the dorsal fin: one of an anterior fin ray, the last unbranched dorsal ray (LUDR) and one of a median dorsal fin ray, the 5th branched dorsal ray (5th BDR). These allow quantification of the dorsal fin shape.
For specimens from the Congo basin, allometric coefficients (k) of these fin ray measurements versus standard length (SL) as well as versus each other were calculated using bivariate regression. Probabilities that these differ from isometry (k=1) are given.

Results

Analysis of measurements

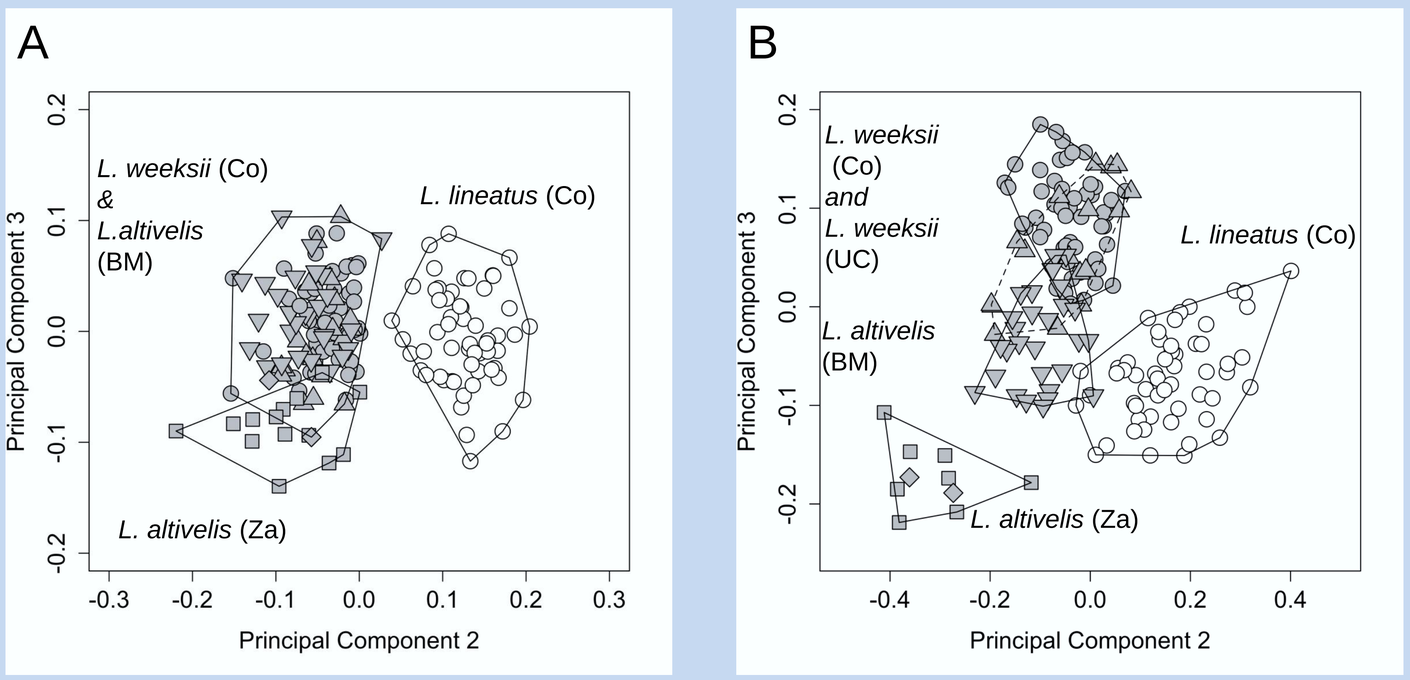

Fig. 1: PCA without (A) and with (B) the two measurements on the dorsal fin with UC Upper Congo.

A first PCA is performed without the two dorsal fin measurements (Fig. 1A). Here, two main groups can be identified. The first group contains specimens identified as *L. lineatus* whereas all *L. weeksii* and *L. altivelis* fall in a second group. This separation is mostly based on measurements that indicated a wider head and a shorter dorsal fin base. Both groups can also be separated with a meristic: the number of branched dorsal fin rays. This is 11 in the first and 12-14 in the second group. Although PC2 allows for an incomplete separation between Zambezian *L.* altivelis and Congolese *L. altivelis* and *L. weeksii*, values for the latter two groups completely overlap. No meristic character was found to differ between *L. altivelis* and *L. weeksi*.

A similar analysis is performed with the two measurements of dorsal fin rays (Fig. 1B). This also shows the two groups identified in the previous analysis. However, the second group is more structured. Here a complete separation is visible between Zambezian *L. altivelis* and *L. altivelis* and *L. weeksii* specimens from the Congo. *Labeo altivelis* specimens from Bangweulu-Mweru, however, had values intermediate between *L. weeksii* and *L. altivelis* from the Zambezi. Most of the overlap between Bangweulu-Mweru *L. altivelis* and *L. weeksii* was caused by specimens from intermediate localities in the Upper Congo (Lualaba).

Allometric growth of fin length

species	LUDR vs. SL	5th BDR vs. SL	5thBDR vs. LUDR
	k	k	k
***L. lineatus* (Co)**	0.83 ±0.03 ***	1.09 ±0.04 *	1.29 ±0.04 ***
***L. weeksii* (Co)**	1.27 ±0.06 ***	1.15 ±0.05 **	0.83 ±0.04 ***
***L. altivelis* (BM)**	1.05 ±0.05	1.40 ±0.06 ***	1.28 ±0.06 ***

Table 1: Allometric coefficients (k) of ratios of fin ray lengths and p-value for k=1 with *,** an *** significant at the 0.05, 0.01 and 0.001 significance level

Allometric coefficients were calculated for both measurements of dorsal fin rays vs. SL and vs. each other (Table 1). The negative allometry (k<1) of 5th BDR vs LUDR shows that the dorsal fin in *L. weeksii* becomes more concave during growth whereas the positive allometry in this character (k>1) shows that *L. lineatus* and *L. altivelis* will obtain a more convex fin with increased size. The process is, however, different. in *L. lineatus* the convex fin is obtained by a reduced growth of the anterior rays whereas the median rays have a (slightly) positive allometric growth. In *L. altivelis* and *L. weeksii*, both fin rays are positively allometric. The differences in fin shape are caused by the differences in allometric growth.

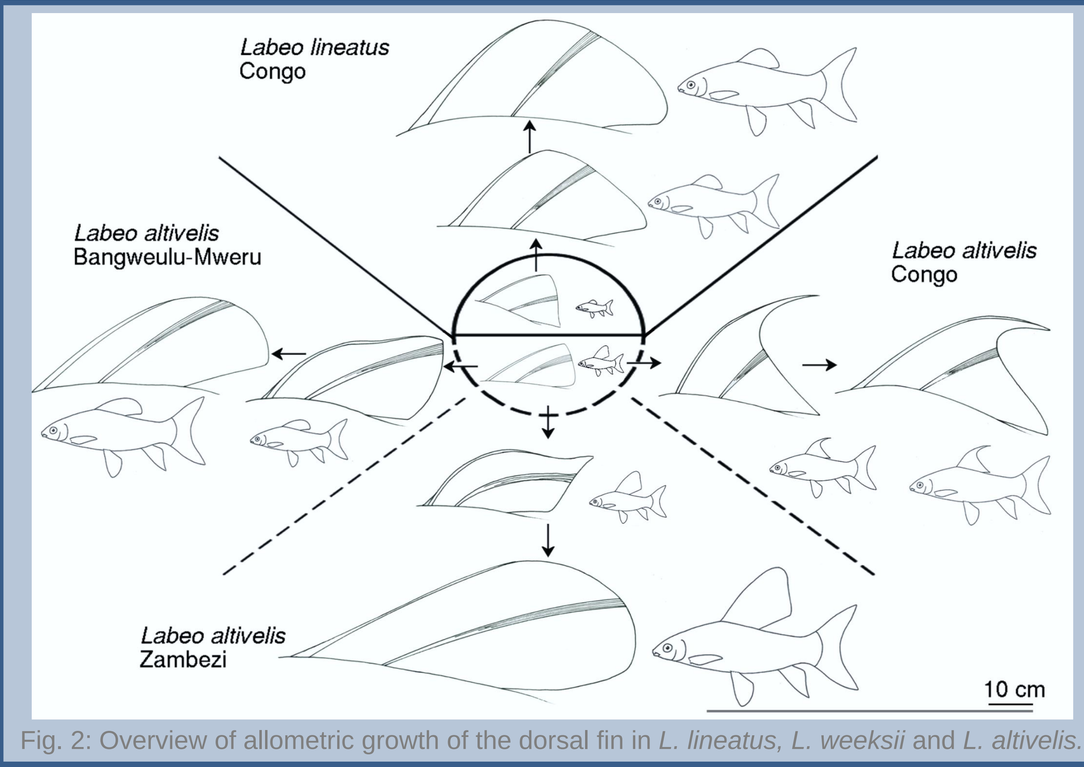

Fig. 2: Overview of allometric growth of the dorsal fin in *L. lineatus, L. weeksii* and *L. altivelis.*

Discussion

The distinction between *L. lineatus* and the other species studied was reaffirmed. *Labeo weeksii* and *L. altivelis,* however, could only be separated by the dorsal fin shape. Yet, these distinct fin morphologies are formed by differences in allometric growth. Dorsal fin shape was shown to be remarkably stable within *L. lineatus*: it is small and with a straight edge, regardless of the size or geographical origin of the specimens. In *L. altivelis* and *L. weeksii*, the dorsal fin becomes larger with increasing size. Although large specimens can have very different dorsal fin shapes, this is not the case in small individuals. Moreover, although the dorsal fin shape can be used to separate some geographically disjunct populations, specimens from intermediate localities have intermediately shaped fins. For example, Bangweulu-Mweru *L. altivelis* are intermediate between *L. weeksii* and Zambezian *L*. altivelis, and Upper Congo *L. weeksii* cause overlap between Bangweulu-Mweru *L. altivelis* and Congolese *L. weeksii*. As geographic variation in dorsal fin shape is also known in Southern African *L. altivelis*, the status of *L.* weeksii versus *L. altivelis* should be reevaluated.

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