Available online at www.sciencedirect.com
SCIENCE DIRECT®
Molecular Phylogenetics and Evolution 35 (2005) 76–84
MOLECULAR PHYLOGENETICS AND EVOLUTION
www.elsevier.com/locate/ympev

Phylogenetic relationships of salangid fishes (Osmeridae, Salanginae) with comments on phylogenetic placement of the salangids based on mitochondrial DNA sequences

Cuizhang Fu[a], Jing Luo[b], Jihua Wu[a], J. Andrés López[c], Yang Zhong[a], Guangchun Lei[d], Jiakuan Chen[a,*]

[a] *Ministry of Education Key Laboratory for Biodiversity Science and Ecological Engineering, Institute of Biodiversity Science, Fudan University, Shanghai 200433, China*
[b] *Department of Biology, University of Konstanz, Konstanz 78457, Germany*
[c] *Department of Zoology and Genetics, Iowa State University, Yames, IA 50011, USA*
[d] *College of Life Sciences, Peking University, Beijing, 100871, China*

Received 17 December 2003; revised 18 November 2004
Available online 21 January 2005

Abstract

We used partial DNA sequences of cytochrome *b* and 16S mitochondrial genes to determine the phylogenetic placement of salangid fishes and the generic relationships within the salangids. Our molecular data strongly support the monophyly of salangid fishes, the inclusion of salangids in the Osmeridae, and the sister group relationship between salangids and osmerids. Our analyses suggest that *Plecoglossus* can be separated from all the other salangids and osmerids. *Mallotus* and *Hypomesus* are clustered within Osmerinae, rather than allied with Salanginae. As regards the relationships within the salangids, our analyses are incongruent with all previous classification hypotheses. Our phylogenetic analyses support the sister group relationships between *Protosalanx* and *Neosalanx*, and between *Salanx* and *Hemisalanx*. More evidences show that *Leucosoma* is more closely related to the *Salanx–Hemisalanx* clade, while *Salangichthys* forms part of an unresolved basal polytomy.

Keywords: Osmeroidei; Osmerid; Salangid; Salangidae; 16S; Cyt b; Phylogeny

1. Introduction

The salangids (Osteichthyes: Osmeridae *sensus* Johnson and Patterson, 1996) contains 17 species in six genera, i.e. , *Protosalanx* (1 species), *Hemisalanx* (2 species), *Salanx* (2 species), *Neosalanx* (9 species), *Leucosoma* (1 species), *Salangichthys* (2 species) (Zhang and Qiao, 1994). The salangids show anadromous, marine and freshwater lifestyles, and are distributed in the sea coasts, rivers, and lakes of East Asia including Japan from Sakhalin, Vladivostok, and the Amur River to northern Vietnam (Roberts, 1984; Zhang and Qiao, 1994). Salangid species diversity is greatest in China and Korea (Roberts, 1984; Wang et al., 2002). The salangids are characterized by a translucent, scaleless body, except for one row above and fin base in adult males, strongly depressed head, and a poorly ossified skeleton (Nelson, 1994). They are thought to be possibly neotenic (Roberts, 1984; Nelson, 1994). Consensus has not been reached regarding the phylogenetic relationships of salangid fishes and the systematic position of salangids.

* Corresponding author. Fax: +86 21 65642468.
E-mail address: jkchen@fudan.edu.cn (J. Chen).

1055-7903/$ - see front matter © 2004 Elsevier Inc. All rights reserved.
doi:10.1016/j.ympev.2004.11.024

1.1. Systematics of salangids

Regan (1908) classified all salangids as the subfamily Salanginae, divided into two groups based on the shape of the premaxillaries (Fig. 1A). One of these groups included *Protosalanx*, *Hemisalanx*, and *Salangichthys*; the remaining genera (*Salanx*, *Parasalanx*, and *Leucosoma*) were grouped together. Fang (1934) reported that *Parasalanx* is a synonym of *Salanx*. Wakiya and Takahasi (1937) proposed two new subfamilies Protosalanginae and Hemisalanginae, and a new genus *Neosalanx*. They divided the salangids into three subfamilies and six genera. Protosalanginae includes *Protosalanx*, *Salangichthys*, and *Neosalanx*; Hemisalanginae includes *Hemisalanx*; and Salanginae includes *Salanx* and *Leucosoma* (Fig. 1B). Roberts (1984) divided the salangids into three subfamilies and four genera based on analysis of osteological characteristics. He proposed a new subfamily Salangichthyinae for *Salangichthys* and *Neosalanx*. Other two subfamilies are Protosalanginae with only the genus *Protosalanx* and Salanginae, with the genus *Salanx*. The genus *Salanx* is further divided into three subgenera (Fig. 1C). Zhang and Qiao (1994) classified the salangids into two subfamilies, six genera based on analysis of osteological characteristics and the disposition of the filaments on the egg membrane. A new subfamily Neosalanginae was proposed for *Protosalanx*, *Salangichthys*, and *Neosalanx*, and another subfamily Salanginae contains *Hemisalanx*, *Salanx*, and *Leucosoma* (Fig. 1D). Thus, the phylogenetic relationships of the salangids based on morphological studies has been much controversial.

1.2. Placement of the salangids

McDowall (1969) and Nelson (1972) placed the salangids in the Osmeroidei, completing the current division into Northern (Osmeroidea) and Southern Hemisphere (Galaxioidea) groups. However, there is disagreement concerning the phylogenetic placement of the salangids. Gasoline (1960) suggested a close relationship of salangids, osmerids, and plecoglossids, distinguishing them from the Southern Hemisphere (Galaxioidea) groups. In contrast, Greenwood et al. (1966) thought that the salangids were part of the Southern Hemisphere galaxioid lineage. Weitzman (1967) suggested that the salangids may represent a separate group, and not constitute part of the galaxioids or osmerids. McDowall (1969) concluded that the salangids are not part of the galaxioid radiation, considering them to be an offshoot of salmonids. Rosen (1974) presented evidence from the caudal skeleton which shows that the salangids belong to Osmeroids, but no evidence about their placement within the group. Fink and Weitzman (1982) agreed with Rosen (1974) and placed the salangids as *incertae sedis* in Osmeroidei. Fink (1984) put forward two hypotheses on the placement of the salangids within Osmeroidei. One hypothesis claimed that the numerous reductive traits of the salangids place them within the Southern Hemisphere clade (Fig. 2A); another hypothesis showed a close relationship of the salangids, osmerids and plecoglossids based on their sharing a complex caudal skeleton character (Fig. 2B). Roberts (1984) also speculated that the salangids have generally been associated with Osmeridae. Howes and Sanford (1987) indicate

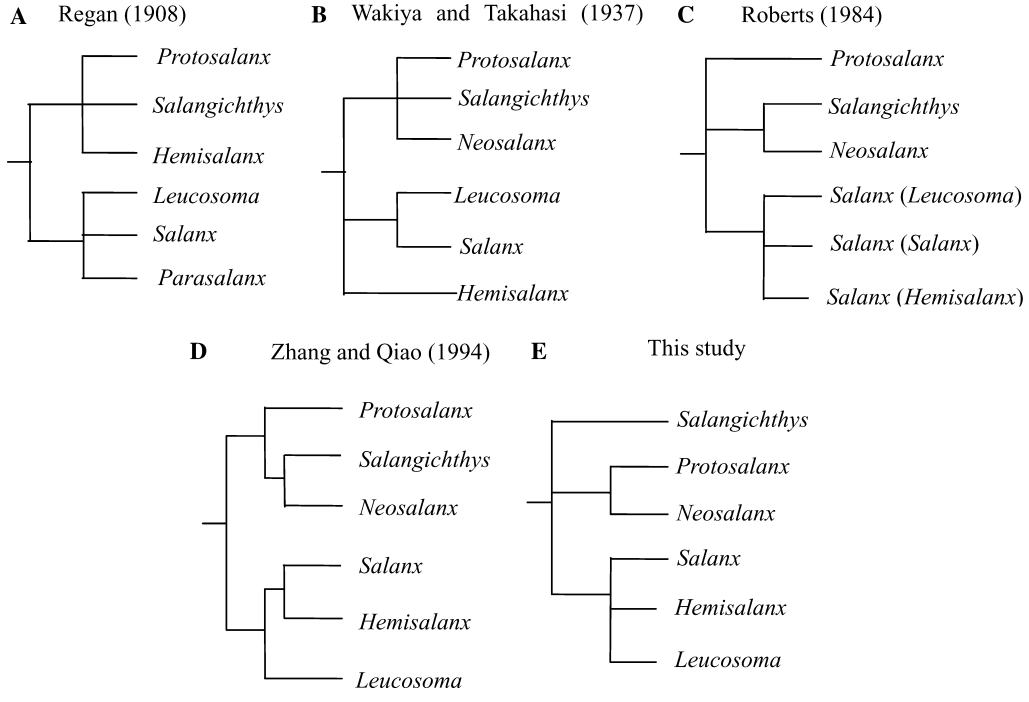

Fig. 1. Five alternative hypotheses for phylogenetic relationships of salangid fishes based on morphology (A–D) and molecules (E).