WARM WATER FISH: THE CARP FAMILY

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Keywords: warm water fish, carp, brackish water, morphology, barbels

Contents

Summary

Among the Cypriniformes the cyprinids constitute one of the most important and the most extensively studied family. The cyprinid family, which has about 220 genera and 1700 species, includes the carps, which are the most widely exploited freshwater fish either by fishing or farming. Cyprinids have colonized large varieties of water bodies in most continents (except Australasia and South America). They have been successfully introduced in regions where they are not native sometimes with negative effects on the environment. They are strictly freshwater fish and have successfully colonized a large variety of biotopes. They show a large flexibility in the response of growth and other functions to environmental condition and complex social interaction. The density and biomass may be high in natural water and the production may reach 500 kg/ha per year in the case of a dominant species. Some cyprinids, carp, goldfish are fully domesticated, actively propagated and selected by man so that they are by far the most advanced group produced in farmed operations (aquaculture has yielded 11.5 million tones of carps in 1996 i.e. 45% of the total fish production). Technologies of production are well established, and mass production is easily achieved. However, production remains concentrated mainly in Asia especially in China. The cost of production is reasonably low, potentially allowing a large market to grow through an increasing demand.

1. Introduction

The carp family recognized by Cuvier 1817 is highly diversified and raises original

evolutionary problems although the taxonomy and classification of sub-groups are unsatisfactory. There are at least 210–220 genera and 1700–2010 species in cyprinids, which is the most diversified among the freshwater fish families. The cyprinids are placed in the order of the Cypriniformes (2662 species), which is part of the group of Otophysi including the Characiformes (1335 species), Siluriformes (2211 species), (see *Catfishes*), and Gymnotiformes (55 species). The Otophysi and the Anatophysi (Gonorhynciformes) constitute the super order of the Ostariophysi. Most of the Ostariophysi live in freshwater (with the exception of Siluriformes, in which 211 marine species are found). The common carp *Cyprinus carpio* and the so-called phytophagous "Chinese carps" are the most well known cultivated cyprinids but there are many other species, which are familiar to the anglers, aquarists, and fisheries-biologists (barbs, minnows, roach, rudd, dace, and bitter ling). The common carp, which originates from Western Asia, is probably represented under its wild form only by the sub-species *Cyprinus carpio haematopterus* in the Amur basin and lakes, and rivers of Southeastern China and *C. Carpio carpio* in central Europe, Caucasus, and Central Asia. These "wild" populations are highly contaminated by domestic carp cultivated for centuries. In fact the common carp and another cyprinid, the goldfish *Carassius auratus* are, with some salmonids, among the few well-domesticated fish species.

2. Biogeography

The specific diversity of cyprinids is very large in China, in Japan, in South East Asia but lesser in Africa and in North America although in this latter 53 genera and 286 species (118 belonging to the genus *Nototropis* alone) have been identified (see Table 1). The European cyprinids show strong affinities with those of Siberia and East Asia. The earliest fossil cyprinids are of Eocene age in Eurasia (London basin and Kazakhstan), and Oligocene in North America: this suggest that a major diversification of species occurred during early Eocene (Ypressian) and that cyprinids probably dominated freshwater ichthyofauna before the Oligocene in Asia and not until the Miocene in Siberia, Europe (possibly because of the Ouralian Sea which separated Asia and Europe during the Paleocene), and N. America. The North American Miocene fauna belongs to one phyletic group, the Phoxinine, which may have crossed the Bering Bridge during early Tertiary time. Africa was the latest land invaded by cyprinids in the Miocene about 18 million years ago.

	Sub-families	**Genera**	**Species**	**Remarks**
Eurasia (Holarctic)	7	155	1060	70 species in China
SE Asia	7	42	263	4 genera shared with India
N. America (Nearctic)	2[(1)]	53	286	14 genera have an entirely western distribution
Africa	3[(2)]	24	477	No species shared between S.E. Asia and Africa
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[(1)] Leusciscinae and Abramidinae.
[(2)] Cyprininae, Rasborinae, and Leusciscinae.

Table 1. Number of cyprinid genera and species by continents (mostly from Howes in Winfield and Nelson 1991).

Cyprinids are widely distributed in all continents except South America, the Island of Madagascar and Australasia (the common carp *Cyprinus carpio* was artificially introduced to Madagascar and Australia). The cyprinids crossed the Wallace line and reached Borneo, but did not cross the Macassar Straight. Extant species are absent from South America but the presence of cypriniformes bones and teeth of cretaceous age have been reported. The gross distribution of the main subfamilies is given in Table 2. In Europe and in the Holarctic Asia (N and E Asia) ichthyological provinces have been recognized (West Balkan and Ponto-Caspian provinces as areas of endemism). No species are shared exclusively between SE Asia and Africa. In North America cyprinids are restricted to 2 sub-families only. In Africa 14 genera are cyprinine, 8 rasborine and one leuscicine. Only 3 genera are shared with Eurasia: *Garra*, *Labeo*, and *Barbus*. The species diversity is more important in Southern Asia but the endemic sub-family is smaller due to a large number of thermophiles Barbinae.

This led some authors (dispersalists) to conclude that cyprinids probably originate in China, migrating west and south, replacing characoids and siluroids. They reached Africa, too late to get to the South American continent. In these countries where cyprinid are absent there are some zoological and ecological equivalents: characins in South America, Melanotaenidae in Australia, and New Guinea. Other authors (vicariographers) recognized repeated dichotomies and even trichotomies of sub-families, and genera as indicative of tectonic events resulting of partition of a previously widespread biota. Finally "panbiogeographers" see the limit of distribution of cyprinid groups as indicative of past large-scale "form-making" processes.

Sub-family and main lineages/genera	**Distribution**
Leusciscinae	Europe, North America, and NE (Holarctic) Asia.
	(Absent from all regions south of equator).
	Absent from central Asia (except Abramin in Siberia).
	Phoxinin are present in Eurasia and North America.
	Suggesting a trans-Atlantic link.
	Aspinin (*Pogonichthys*) are present in Eastern Asia.
	Western North America suggesting a trans-Pacific link.
Alburninae	Europe, SE Asia (North), absent from central Asia, and India.
Cultrinae	Eastern Asia (China, Taiwan, Korea), some taxa in Thailand.
Archeilognathinae	Holarctic Asia, absent from central Asia.
Gobioninae	Holarctic Asia.
Cyprininae	Europe, Western, and SE Asia, numerous in India, Indonesia, and Africa.
	Gondwanic distribution: it coincides in the case of
	Cyprinion-Onychostoma to the Asian lithographic plates.
	Quasi-absent from North Eurasia.
Rasborinae	Africa, India, SE Asia, and marginally in western Asia.
	Gondwanic distribution.

Table 2. Geographic distribution of the main cyprinid sub-families (mostly from Howes in Winfield and Nelson 1991).

3. Morphology, Classification and Systematics

A protrusive mouth, toothless jaws and palate, tooth bearing pharyngeal bones, and various bone and muscle structures in the cranium, characterize cyprinids. They exhibit a considerable morphological diversity especially in relation with feeding. This has allowed to identify several subfamilies and to propose an evolutionary scheme. The barbels are present in Cyprininae and absent in Leusciscinae. Inside Cyprininae the structure of the barbels also allows discrimination between *Tinca*/*Gobio* (only posterior barbels) and *Cyprinus*/*Barbus* (histological zonation of the barbels and maxillary barbels, which lack taste-buds but have a double nerve supply and muscular bundles). Some Cyprininae are however deprived of barbels such as *Carassius*. In some populations, posterior barbels are still formed or are on one side only, suggesting a secondary loss. This may be a result of hybridization. Several Rasborinae are also defined from the structure and innervations of barbels and rasborines lacking barbels show a thickened area below the lateral border of the palatine. From this it is clear that the presence/absence of barbels is not a reliable character.

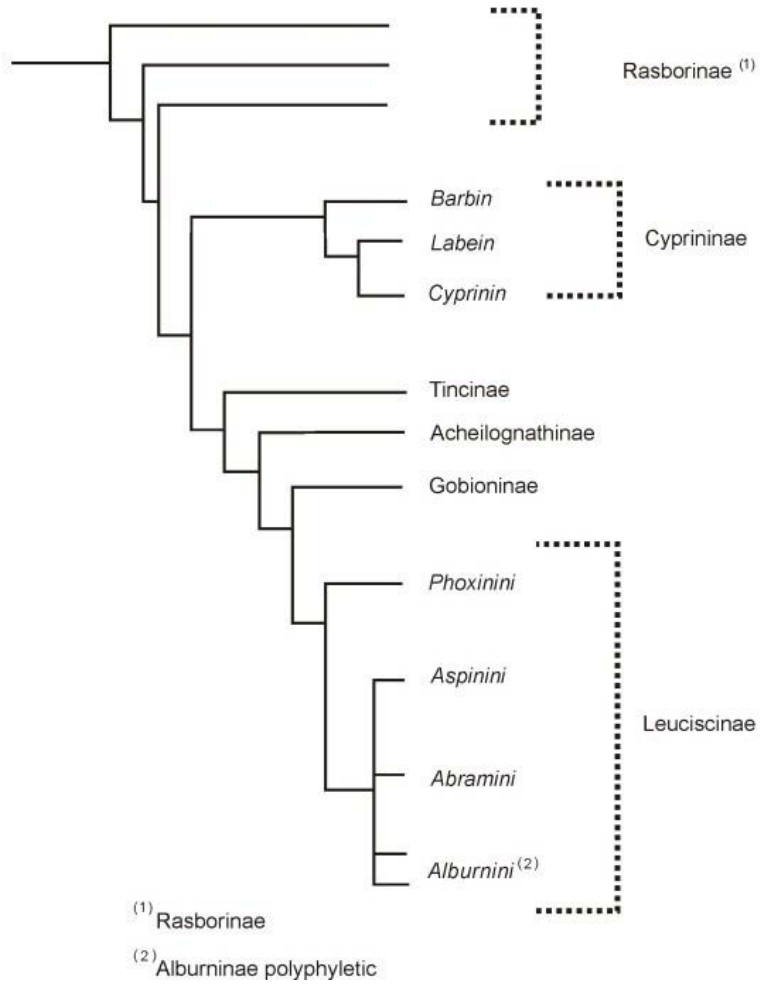

Figure 1. Consensus tree of the inter-relationship of extant cyprinid subfamilies and tribes based morphological and molecular characters analysis (cytochrome B, 16S mt, control region 18S rDNA, 28S rDNA) (A. Gilles and G. Lecointre)

The definition of other cyprinid subfamilies which lack (or sporadically possess) barbels (Leuscicinae, Archeilognathinae, Cultrinae, Alburninae, and Psylorhynchinae) is based on osteological characters, location of fins, gill rakers on gill-arch, number of scales on the lateral line, vertebral number, fin rays, gut structure, color of the peritoneum, and—to a lesser extent—external color and size. Primitive cypriniformes showed probably a reduced dentition related to bentophagous feeding with development of chemosensory structures on lips and jaws such as barbels and poor development of the vision system. A consensus tree of the classification of the various groups is proposed in Figure 1.

Most of these sub-families are not recognized as monophyletic but in those assemblages, monophyletic lineages have been identified. The large variety of characters available especially from the skeleton, which have evolved independently from each other in a mosaic pattern, will be mapped into molecular phylogenies. This will eventually lead to recognition of morphological characters defining sub-families among cyprinids.

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Biographical Sketch

Roland Billard was born in 1934 in France; he graduated from Lyon University in 1965. He received his Doctorate d'Etat at the Paris P&M. Curie University. He has worked as Assistant and Director of research at the National Institute of Agronomic Research (INRA) and was Director of the Fish Physiology Laboratory in this institute from 1970 to 1984. Since 1986 he is Professor at the Museum National d'Histoire Naturelle in Paris and Director of the Laboratory of General and Applied Ichthyology. His main research interest is fish reproduction, spermatogenesis (structural and quantitative aspects, endocrine regulation), and physiology of spermatozoa with application to the control of reproduction and spawning, gamete preservation, and artificial insemination. He also showed interest on the production systems in aquaculture. He has published more than 300 scientific articles and 200 technical papers and published or edited a dozen books. He is a member of the French Academy of Agriculture, foreign member of the Romanian Academy of Agriculture, and a member of the Academia Georgofilli (Italy).