WARM WATER FISH: THE PERCH, PIKE, AND BASS FAMILIES

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Summary

Bass, perch and pike families comprise numerous fish species common in fresh, brackish and marine waters of the Northern Hemisphere. These families, which should be classified among the coolwater fish rather than purely warmwater fish, substantially support recreational and commercial fisheries. Although most representatives are carnivorous, they occupy several trophic levels in aquatic food webs, as planktivores, omnivores and piscivores. Therefore they are very important members of the aquatic community and have been the subject of many studies in fish biology, community ecology, and predator-prey interactions. Fish belonging to the perch, pike and bass families can be found in many environments and show tolerance to eutrophication and acidification. In these environments they are generally considered as key organisms in maintaining the structure and function of the food web. The combined effects of spawning and nursery habitat reduction, and over-fishing by commercial and recreational fisheries have, however, affected progressively the recruitment and population dynamics of wild stocks. Many of these populations would have collapsed or become extinct without sustained programmes of enhancement by restocking. Bass, perch and pike families are group-synchronous spawners and spawn once a year in the spring, depending on latitude. The annual rhythm is controlled by exogenous factors including temperature, photoperiod, substrate, water levels and velocity and social interactions. Fecundity is rather high in all species from these families, averaging 50,000-100,000 ova per kg of females. Larvae are zooplanktonophagous, but shift more or less rapidly to a invertivorous or piscivorous feeding habits during their first months of life. Cannibalistic trait is a common feature in species from these families. Aquaculture of these families has known variable successes and levels of development,

depending on the family. Culture of percid fishes is currently under investigation, both at the semi-intensive and highly intensive levels. Main advantages are the easy spawning in captivity, while small larvae, cannibalism and relatively poor growth in some species (perch and yellow perch) are the major bottlenecks before the emergence of a large percid fish industry. Esocids have not yet been successfully domesticated and management of their reproduction has mainly been applied to their natural habitats. However esocids have been reared in hatcheries for some considerable time mainly for producing fish to supplement or establish natural populations. Poor adaptability to captivity, dependence of fingerlings and large fish on live prey and cannibalism are currently highlighted as the major bottlenecks for the intensification of pike production, regardless of culture systems. No significant advances in the production of esocids to market size have been reported. Aquaculture of the largemouth bass, for all intents and purposes is for the purposes of recreational fishing. Largemouth bass are spawned and reared in earthen ponds then stocked at small juvenile sizes for grow out and harvest by angling. There is a limited amount of food fish production of largemouth bass but due to the «game-fish» status of the species, commercial culture is very limited. Conversely, the aquaculture industry of the North American *Morone* bass has grown 10 fold over the past 12 years with annual production nearing 5,000 mT. Most of the industry is based on hybrid production between striped bass, *M. saxatilis*, and white bass, *M. chrysops*. Most interest is either in the pure striped bass or the hybrid using the female of the striped bass. The latter primarily to take advantage of the genetic potential that can be expressed in this species. Culture requirements are very similar to the European bass species *Dicentrarchus labrax*.

1. Introduction

The bass, perch and pike families comprise numerous fish species common in fresh, brackish and marine waters of the Northern Hemisphere. These families, which should be classified among the coolwater fish rather than purely warmwater fish, substantially support recreational and commercial fisheries. Although most representatives are carnivorous, they occupy several trophic levels in aquatic food webs, as planktivores, omnivores and piscivores. Therefore they are very important members of the aquatic community and have been the subject of many studies in fish biology, community ecology, and predator-prey interactions. Compared to salmonids which are relatively restricted in their habitat range due to their limited thermal tolerance, fish belonging to the perch, pike and bass families can be found in many environments and show tolerance to eutrophication and acidification. In these environments they are generally considered as key organisms in maintaining the structure and function of the food web. However, despite a relatively high resistance to degradation in water quality, the combined effects of spawning and nursery habitat reduction, and over-fishing by commercial and recreational fisheries have progressively affected the recruitment and population dynamics of wild stocks. Many of these populations would have collapsed or become extinct without sustained programmes of enhancement by restocking.

The demand for restocking and or for human consumption has led to improved methods in aquaculture, mainly based on the application of techniques recently developed in marine farming. Development of these techniques has varied between species and between families. Although some progress have been made in the culture of pike, no

significant advances in the production of esocids to market size have been reported. On the other hand the breeding techniques and production of bass have progressed very rapidly during the last decade and an increasing amount of research has been devoted to the improvement of percid fish culture.

The purpose of this article is to outline the main biological and ecological features of some major representatives of these families and describe the recent developments in their culture.

2. The Perch Family

2.1. Biology and Fisheries of Percidae

2.1.1. Taxonomy

This family of freshwater fish comprises ten genera and about 197 species. Two subfamilies are normally recognised, the Percinae with seven genera and about 178 species and the Luciopercinae with three genera and nine species. The Percinae include three species of *Perca*: *P. fluviatilis* Linnaeus, Eurasian perch, *P. flavescens* (Mitchill), yellow perch, and *P. schrenki* Kessler, Balkhush perch. There are four species of the genus *Gymnocephalus*: *G. cernuus* (Linnaeus), ruffe; *G. schraetser* (Linnaeus), striped ruffe, *G. acerina* (G∫ldenstadt), Don ruffe, and *G. baloni* Hol≠ik and Hensel, Balon's ruffe. The genus *Percarina* is monotypic, *P. demidoffi* Nordmann, percarina. The other four genera of the Percinae subfamily are the darters: *Percina* Haldeman with 39 described species, *Ammocrypta* Jordon with six described species, *Etheostoma* Rafinesque with 124 described species and *Crystallaria*, with one described species *C. asprella* Jordan (Page personal communication). The Luciopercinae comprise three species of *Zingel*: *Z. zingel* (Linnaeus), zingel, *Z. streber* Siebold, streber and *Z. asper* (Linnaeus), apron, one species of *Romanichthys*: *R. valsanicola* Dumitresch, B″n″rescu and Stoica, asprete, and five species of *Stizostedion*: *S. lucioperca* (Linnaeus), pikeperch, *S. marina* (Cuvier), sea pikeperch, *S. volgensis* (Gmelin), Volga pikeperch, *S. canadense* (Smith), sauger, and *S. vitreum* (Mitchill), walleye.

2.1.2. Distribution

Percidae are confined to temperate and subarctic regions of North America and Eurasia although some species of the family have been introduced into the Southern Hemisphere. Percids have a long history and fossils from the Oligocene have been found in both landmasses. The darters are endemic to North America (from Arctic Canada to northern Mexico) and *Gymnocephalus*, *Percarina* (Sea of Azov and parts of the Black Sea), *Zingel* (zingel and streber in the Danube and Vardar River systems and the apron in the Rh⇔ne) and *Romanichthys* (Vilsan River, Romania) genera are endemic to Eurasia. The darters although widespread, do not occur in north-east USA, eastern Canada, streams entering the Arctic Ocean and west of the Rocky Mountains, except where they have been introduced The ruffe is widely distributed in lakes and slow moving rivers in Europe and north-west Asia and has recently been introduced to the Great Lakes of North America. Balon's and striped ruffe are found in the Danube River, the latter also occurring in the estuary entering the Black Sea. The Don ruffe

inhabits rivers emptying into the north of the Black Sea including the Don, Dniester and Dnieper. European perch are widely distributed in Eurasia and are also found, as a result of introductions, in South Africa, Australia and New Zealand. The Balkhush perch is confined to eastern Kazakh, Russia. The yellow perch, walleye and sauger are North American species. Pikeperch is found in Europe and West Asia. It has been introduced into England. The sea pikeperch inhabits the Caspian and Aral Seas and the Volga pikeperch is restricted to the main rivers in the basins of the Volga (Kama and Vyatka), Ural, Don, Dnieper, Bug, Dniester and Danube rivers.

2.1.3. Body Form

The percids have two dorsal fins which are separated or narrowly joined (broadly joined in *Zingel*). The anal fin has one or two spines. Scales are ctenoid. Large species have laterally compressed bodies and well developed swim bladders. Many of the smaller fish have depressed or terete bodies and reduced or vestigial swim bladders. The anterior-most interhaemal bone of Percinae is greatly enlarged, the lateral line does not extend onto the caudal fin and the anal spines are large and well developed. These features distinguish the subfamily from the Lucipercinae in which the interhaemal bone is not enlarged, the lateral line does extend onto the caudal fin and the anal spines are not well developed. The family exhibits a great variability in shape, size and colour which is dependent in part on its habitat. The European and yellow perch are characterised by tapering bars (seven) down the sides of their bodies. The eyes of many species are well developed indicating the importance of acute vision. In the genus *Stizostedion* the eye contains a tapetum lucidium which is a reflective layer found in the pigmented epithelium of the retina. Light is reflected back and forth between the tapetal processes with additional absorption by the rods after each reflection. This allows the fish to remain active at low light intensities. The tapetum lucidum is better developed in North American species than those from Eurasia.

2.1.4. Growth, Mortality and Longevity

Percids have been aged using a variety of calcified structures including opercula, fin rays, cleithra, otoliths and scales. There is great variability in growth, mortality and longevity between and within species. Within a species there is often sexual dimorphism, females usually grow faster and live longer than males. The maximum sizes and ages of the main economically important members are: about 500 mm, 3500 g and 21 years for European perch, 380 mm, 1000 g and 11 years for yellow perch; 1050 mm, 10700 g and 20 years for walleye; and 1200 mm, 12000 g and 20 years for pikeperch. In natural environment, optimum temperature for growth is 22.6°C for walleye, 24.7°C for yellow perch, 25.4°C for European perch and 27.0°C for pikeperch. Perch, pikeperch and walleye grow more slowly the further north they are although they tend to live longer and reach a larger ultimate size. Growth and natural mortality are positively correlated.

2.1.5. Diet

Percids are opportunistic feeders although in young and small fish prey type may be restricted by gape size. Selection is related to availability which is affected by

seasonality. At first feeding the fish will consume algae and ciliates progressing to rotifers, copepods and cladocerans. Juveniles and adults feed on a variety of pelagic and benthic invertebrates and on fish. Large species tend to be more piscivorous. Cannibalism is common in perch, pikeperch and walleye.

Perch in comparison to many fish are poor swimmers and feeding success is enhanced by shoaling behaviour although very large and older fish may become ambush predators and live in solitude. Peaks of activity throughout most of the year occur at sunrise and sunset although this will depend on the turbidity of the water. Walleye are also shoaling predators even as adult piscivores, feeding in the open water from the evening until early morning. In turbid water they will remain active throughout the day as they can detect prey at very low light intensities due to the tapetum lucidum in the eye. Pikeperch shoal as young fish but are solitary after becoming piscivorous. They feed in the open water, on the bottom and amongst vegetation. Perch food consumption is greatest in the summer while in the walleye and pikeperch it is normally in the autumn and spring respectively.

2.1.6. Reproduction

The age of maturity of percids depends on their locality, latitude and temperature. Female perch normally mature between two to four years and the males one year earlier than the females. Walleye age of maturity ranges from two years in the southern USA to 10 years in the North West Territories of Canada. Pikeperch are sexually mature from two to five years across their range. All species are difficult to sex externally except at spawning time when ova or milt are being exuded.

Perch, walleye and pikeperch are group-synchronous spawners and spawn once a year in the spring depending on latitude. The annual rhythm is controlled by exogenous factors including temperature, photoperiod, substrate, water levels and velocity and social interactions. Male perch have paired testes and undergo spermatogenesis during late summer and early autumn. In the female, the single ovary of perch is formed by the fusion of two rudiments. Walleye and pikeperch have paired ovaries. Oogenesis starts in early summer and continues until final maturation just prior to spawning. Temperature is probably the most important factor in final maturation which can be inhibited by high abnormal temperatures from late autumn. Temperature may determine the limit of percid southern distribution of self-reproducing populations. Development of the ovary takes up a considerable amount of energy (87% for European perch) stored up in the year by the soma compared to the testes (10%). Absolute fecundity is very variable. The relative fecundity of pikeperch is greater than walleye. Fecundity is strongly influenced by food supply and more eggs with a higher fat content are produced following a year of good feeding conditions compared with a poor food supply. Poor conditions may delay oocyte development in the early summer so that the next spawning season may be missed.

Spawning migrations are not normally extensive. Perch migrate night and day, walleye only at night. Spawning in perch normally involves one female and from two to five males at depths of 0.5-8.0 m. All eggs are released in a single egg strand which is attached to a suitable substrate. Males may remain at the spawning site to mate with

other females. Walleye spawn nocturnally in lakes or streams at depths between 0.1-4.6 m. Spawning groups vary between one female and one to two males to two females and up to six males. Fertilised eggs are spread over the substrate; they are adhesive and stick to rocks and gravel. There is no parental care. Pikeperch migrate to specific nursery areas in rivers or lakes with depth 0.5-1.0 and 0.5-17.0 m respectively. On the substrate of sand or stones the male builds a nest exposing roots on which the adhesive eggs later stick. The pikeperch is monogamous, the female lays all her eggs at once, at dawn, and after fertilising the eggs the male remains at the nest to guard the eggs and young fry. Viability of the spawned eggs can be very variable (e.g. 3.4 to 100% in walleye) and can be reduced by factors such as lowering of the water level or reduction in pH (often the result of acid rain).

Percid embryonic development depends on water temperature. Perch, walleye and pikeperch hatch with well developed eyes. At first they are distributed passively according to lake or stream currents. At the start of exogenous feeding most of the yolk in the yolk sac has been utilised.

2.1.7. Populations and Communities

A number of models have been developed to understand the factors influencing the population dynamics of economically important percids in particular those determining year class (cohort) strengths and thus the number of recruits. These factors have included cannibalism, predation, competition, stock size, spring (spawning) water temperature and water temperature during the first summer of growth. Some of the models have explained a considerable proportion of the variability in recruitment. For example, up to 90% of the variance in recruitment for European perch in Windermere, England, are based on density independent summer temperature and density dependent adult biomass (negative effect due to cannibalism) and predation by pike (also negative). Although European perch have been found to respond to reduction in population size by an increase in relative fecundity, no relationship has been found between the number of eggs laid by a population in a given year and the resulting year class strength. In Windermere perch a very strong year class was produced from one of the smallest spawning populations. Percid species play an essential part in the community structure of many temperate water bodies by acting as a food source for other fish (and some piscivorous invertebrates), through predation and competition and in transmitting parasites and diseases to other organisms.

2.1.8. Fisheries

Remains of percids have been found during archaeological evacuations of human habitations. European perch and pikeperch were fished along the south coast of the Baltic Sea at least 6000 years ago. Native North Americans caught percids from inland waters but it was probably not until the settlement of Europeans that fishing had any impact on the populations. European and yellow perch, pikeperch and walleye are fished extensively both commercially and for sport throughout their range. Finland has the largest commercial catch of European perch and although landings are much smaller in Switzerland, the Netherlands, Germany, Romania and Poland, they make a significant contribution. Yellow perch commercial catches are greater in Canada (74%)

than the USA. Most walleye (99%) are also commercially caught in Canada although mainly sold in the central USA. The main commercial fishing gears used for percids include gill nets, trammel nets, seines, trawls, portable traps, fyke nets, pound nets, trap nets, artificial lures and hook and line. The value of sport fishing, in particular in North America far surpasses that of commercial fishing.

The state of percid fisheries has shown considerable fluctuation with time due to a number of complex climatic, biological, social and economic factors. Intervention by humans has usually had a detrimental effect including over-fishing, unplanned introductions, eutrophication, pollution and climate warming. Many percid stocks are now depressed, collapsed or extinct and rehabilitation will take careful planning and management.

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Biographical Sketches

Patrick Kestemont graduated in Zoological Sciences from the Catholic University of Louvain (UCL), Belgium, in 1983, and got a PhD degree in Sciences at the University of Namur (FUNDP, Belgium) in 1988, with a specialisation in fundamental and applied ichthyology.

He was Associate lecturer at the National Museum of Natural History in Paris, in 1988 (Laboratory of Fundamental and Applied Ichthyology, Head: Prof. R. Billard) and Associate Research Scientist at the University Claude Bernard (Laboratory of Microbial Ecology, Head: Prof. A. Chalamet) and CEMAGREF (Laboratory of Biochemistry-Microbiology, Head: Dr B. Montuelle) in Lyon (France) in 1989. From 1989, he worked as research scientist and associate lecturer at the Unit of Freshwater Ecology (Head: Prof. J.C. Micha), in charge of the research and teaching in reproductive physiology of fish, fisheries and aquaculture. From 1999, he is Professor at the University of Namur (FUNDP-Unit of Research in Organismic Biology) in charge of research and teaching in ecophysiology, ecotoxicology, fundamental ichthyology and aquaculture. Occasionally consultant for Food and Agriculture Organisation (FAO) and Belgian Administration for Cooperation and Development (BADC), in fisheries and aquaculture. Visiting professor at the University of Gent (Belgium, 1993-now) in the MSc in aquaculture (Head: Prof. P. Sorgeloos) and at the University of Nancy (France, 2000-now). Board member of the European Aquaculture Society (EAS) from 1990 to 2000, member of the Royal Society of Zoology of Belgium, member of the editorial board of the Belgian Journal of Zoology, and expert at the National Foundation for Scientific Research (FWO) in Belgium.

In aquaculture, research topics mainly focus on reproductive physiology, animal husbandry aspects and nutritional requirements of non-salmonid freshwater fish, while research in freshwater ecology focuses on spatio-temporal distribution of river and lake fish. New research programmes deal with the impact of xenobiotics on reproductive physiology of fish.

John Craig obtained his PhD from Lancaster University and he is a Fellow of the Institute of Biology and the Linnean Society of London. He is presently Editor of the Journal of Fish Biology. He has worked as a Research Scientist at the Freshwater Biological Association's Windermere Laboratory, UK, and at the Department of Fisheries and Oceans' Freshwater Institute, Winnipeg Canada. In the last twelve years he has worked mainly, as an independent fisheries consultant, in Angola, Burundi, Egypt, India, Nepal, Tanzania, UK and Yemen. His research interests are in freshwater fish ecology in particular population dynamics and life history strategies. He has written and edited several books and published many papers in the primary literature.