

# Preface

The Percidae family of fishes is a large, diverse, and economically important group of mostly freshwater fishes that includes 11 genera and 266 known species, belonging to the order Perciformes and the class Actinopterygii, and originally inhabiting the northern hemisphere. Several species of this family play important ecological roles in the functioning of lotic and lentic aquatic ecosystems as well as providing a valuable resource for both recreational and commercial fisheries. Considering the slow but continuous decline of percid capture fisheries, some of these species have been identified from the early 1970s as valuable candidates for aquaculture, and research efforts have been intensified from the 1990s, providing a huge amount of recent scientific and technical knowledge. In the past, some authors have dedicated a significant part of their time to compile the existing data on the biology and exploitation of several representatives of this diverse fish family, while some others assembled the knowledge on the aquaculture aspects. John Thorpe published in 1977 the first *Synopsis of Biological Data on the Perch *Perca fluviatilis** (Linnaeus, 1758) and *Perca flavescens* (Mitchill, 1814) within the *Fisheries Synopsis* series produced by the Food and Agriculture Organization (FAO) of the United Nations. In 1979, Canadian fisheries biologists started to assemble the existing knowledge on walleye *Sander vitreus* biology and fisheries and produced the *Walleye Synopsis* (Colby et al., FAO Fisheries Synopsis 119). About a decade later, in 1987, John Craig published the first comprehensive monograph on percid fish biology (*The Biology of Perch and Related Fish*) and updated it in 2000 with the book *Percid Fishes: Systematics, Ecology, and Exploitation*, covering most taxonomical, ecological, and fisheries aspects of this family, but also including two new chapters, one on aquaculture (written by Patrick Kestemont and Charles Mélard) and one on North American darters (subfamily Etheostomatinae) (written by Larry Page). From an aquaculture perspective, a multi-contributor book dealing with the culture of walleye was edited by Robert Summerfelt in 1996 (*Walleye Culture Manual*), while, the same year, a special issue of the *Journal of Applied Ichthyology* (vol 12, Issue 3–4, 137–200) was published that focused on the *Recent Advances in the Aquaculture of Percid Fish* (Patrick Kestemont and Konrad Dabrowski as guest editors). More recently, the North Central Regional Aquaculture Center (NCRAC) of the USA

promoted the compilation of information gleaned from scientific and extension reports in order to produce in 2006 the *Yellow Perch *Perca flavescens* Culture Guide* (edited by Hart, Garling and Malison). The American Fisheries Society supported the publication of the revised and updated walleye synopsis (*Biology, Management, and Culture of Walleye and Sauger*, edited by Bruce Barton in 2011). These publications represent the insight of fish cultural technicians and workers working in collaboration with many scientists and engineers on just a few economically important species of this family.

*Biology and Culture of Percid Fishes: Principles and Practices* intends to provide the reader a comprehensive scientific state of the art of percid biology and culture. All biological aspects relevant to the culture of different species belonging to the Percidae family are described in detail, including a complete critical peer review of the scientific literature complemented by unpublished data from different contributors.

This book represents the collaboration of 75 authors from 15 countries. It is composed of 35 chapters distributed into eight parts, dealing with systematics, ecology, and evolution of percids (2 chapters); reproductive biology (4 chapters); early life stages (development, metabolism, and husbandry) (5 chapters); juvenile and grow-out stages (growth, metabolism, behavior, and husbandry) (8 chapters); nutrition, feeds, and feeding practices (3 chapters); genetic improvement and domestication (5 chapters); stress, immunology, diseases, and health management (4 chapters); and commercial production, quality, marketing, and economics (4 chapters).

Chapter 1 (C.A. Stepien and A.E. Haponski) provides an updated knowledge on the taxonomy, distribution, and evolution of Percidae, using the results of the latest DNA sequence technology and morphological analyses to resolve the relationships of the family Percidae and its component genera and species. Newly assembled distribution maps are presented for the taxa, and their primary distinguishing morphological and life history is summarized. In Chap. 2, Z.S. Feiner and T.O. Höök review the basic information on environmental biology of the *Perca* and *Sander* genera, on which the majority of fisheries and aquaculture practices are focused. The authors discuss how individual- and population-level vital rates, including growth, foraging, reproduction, recruitment, and mortality, are mediated by biotic and abiotic environmental variables, with the aim to identify the major environmental drivers of biological variation in percids and thereby provide information for fisheries management practices for both wild and cultured percid populations.

In Part II, Chap. 3 (P. Fontaine et al.) describes with details the reproduction of the main cultured percid species, including the morpho-anatomical, histological, and physiological changes occurring during an annual reproductive cycle and the way to obtain out-of-season gonad maturation and spawning by photothermal regime regulation. In Chap. 4, written by D. Zarski and coauthors, endocrine regulation and reproductive protocols are reviewed, focusing on the final gamete maturation, spermiation, and ovulation processes which are the steps needed to be considered for successful reproduction. Characteristics of sperm morphology, physiology, and viability in Percidae are described in Chap. 5 (H. Alavi et al.) as well as the main factors affecting semen quality. This chapter also presents the methods for

sperm short-term storage and cryopreservation. Part II is complemented by Chap. 6 (B. Schlaerlinger and D. Zarski) reviewing the current knowledge on ova characteristics and the proper embryonic development and larval metamorphosis for several percid species, allowing the identification of ova defects or developmental failures and the selection of relevant quality indicators for ova and larvae.

Part III focuses on the early life stages' development in Percidae and on the larval culture methods of *Perca* and *Sander* genera. In Chap. 7, M. Kamaszewski and T. Ostaszewska describe the development of sensory organs (olfactory placodes and epithelium, taste buds, eye and optic vesicles, inner ear, and neuromasts), starting during embryogenesis and evolving over the larval and juvenile stages, in relation with trophic and environmental preferences of the different percid species. Chapter 8 (N. Hamza et al.) examines the development and functionality of the digestive system, based on histological and enzymatic studies, focusing on the stomach, pancreatic, and intestinal digestive enzymes. The authors also show that the digestive structures and enzymes activities can be affected by the nature and the diet composition, providing some information about the nutritional requirements of percid larvae. In Chap. 9, P. Kestemont and coauthors present an overview of the different methods used to produce juveniles of the Eurasian perch and yellow perch, separating the production of fish in fertilized ponds, the fertilization in mesocosms and semi-intensive production systems, and the intensive production in tanks with supply of live prey gradually replaced by formulated feeds. For each system, the optimal husbandry conditions as well as the influence of main factors influencing the survival and growth of fish from larval to juvenile stages are described. Similarly, Chaps. 10 (S. Stenfeldt) and 11 (R.C. Summerfelt and J.A. Johnson) focus on the cultivated species of the *Sander* genus and review the intensive larviculture of pike perch (*Sander lucioperca*) and walleye, respectively. The description of husbandry aspects includes the embryonic development and egg incubation, the optimal biotic and abiotic rearing conditions, and the problems occurring in intensive larval culture system such as the non-inflation of gas bladder and occurrence of skeletal deformities.

Characteristics of cultivated percid species during grow-out stages, from juvenile to adult/market size fish, are described in Part IV. The current state of knowledge regarding fish skeletal muscle characteristics, factors affecting muscle growth, and proteomic-based research in teleost fish with emphasis on percids is reviewed in Chap. 12. The authors (K. Kwasek et al.) also compare skeletal muscle sarcoplasmic proteins/peptides between fast- and slow-growing yellow perch in order to identify the differences in expression of skeletal muscle proteins in fish exhibiting different growth capabilities and, ultimately, propose a selection tool for the production of larger percid fish. Bioenergetic aspects are examined in Chap. 13 (A. Alanärä and A. Strand) and Chap. 14 (C.P. Mandenjian). As percid fish species are relatively new in culture, there are no models available to estimate their energy requirement in intensive rearing systems, which in turn limits the opportunities to calculate the required daily feed allowance. In Chap. 13, authors put together data from the scientific literature to produce an alternative model for prediction of the daily growth and energy need of percid fish, with a special attention to Eurasian perch. This

chapter also discusses how factors such as season and culture conditions influence the bioenergetic requirements and energy expenditures. As shown in Chap. 14, modeling can be used to identify the important factors determining the growth of percids in lakes, rivers, or seas. Bioenergetic modeling can also be applied to estimate the amount of food being annually consumed by the percid population or to quantify the effect of the difference in growth between sexes on contaminant accumulation in, for instance, walleye. Behavior is described in Chap. 15 by C. Magnhagen. This author highlights the importance of fish body size on trophic behavior and social interactions, but also the influence of the environment. Improving knowledge regarding the behavior of percids in the wild is suggested for obtaining the best result in culture. Chapters 16 (T. Polizar and coauthors) and 17 (I.A. Johnson and R.C. Summerfelt) provide updated information and recommendations regarding the main husbandry aspects affecting the culture of Eurasian perch and North American walleye, respectively. For both species optimal abiotic and biotic conditions are defined according to the rearing system, from the pond to recirculating aquaculture system(s) (RAS). Main advantages and constraints of these culture systems are presented, and opportunities for future research are discussed. In Chap. 18, Briland and coauthors analyze fish and plankton ecology in production ponds to provide a better understanding of the ecological and biological factors involved in optimal pond production of percid fingerlings for stocking. Factors affecting lifetime growth patterns of percids in natural populations are reviewed by M.D. Rennie and P.A. Venturelli in Chap. 19. The authors apply a biphasic growth model to describe the lifetime growth of Eurasian perch and pike perch populations and discuss the hypotheses for proximate mechanisms of female-biased sexual size dimorphism as well as the influence of fish density, food availability, predation, parasitism, and disease within an ecological context.

Part V deals with feeding and nutrition in percids. The influence of feed composition (especially the lipid and fatty acid type and content) on brood stock performances, with consequences for survival and growth of early life stages, is described in European percid species (Chap. 20, P. Kestemont et al.) and yellow perch (Chap. 21, K. Dabrowski et al.), respectively. Although larvae of some percid species still rely on live prey, significant progress has been achieved recently with the use of formulated diets as starting feed, namely, through an enrichment in phospholipids. In Chap. 22, F. Geay and P. Kestemont review the main abiotic and biotic factors influencing the feeding activity of juveniles and adults. The nutritional requirements of percid fish have been investigated, as well as the use of alternative oil sources, suggesting a high potential of these species to biosynthesize highly unsaturated fatty acids (HUFA) when fish oil is replaced by plant oil rich in polyunsaturated fatty acids (PUFA).

Intensive percid fish culture is rather new technology, and, up to date, despite a need to improve growth performances of these species, there have been very few attempts for genetic selection or designed domestication. However, different authors have investigated the potentialities of genetic manipulation and mass selection to improve the production of percid species in culture, as shown in Part VI. C. Rougeot (Chap. 23) presents an overview of the different methods used to produce triploids

or to control the development of the phenotypic sex and the production of all-female populations, through hormonal treatment or gynogenesis. J. Held and coauthors (Chap. 24) report on the improved growth performances of interspecific hybrids (Eurasian perch and yellow perch, walleye and sauger). In Chap. 25, C.A. Stepien et al. focus on the comparative population structure and genetic diversity of yellow perch and walleye across North America, in relationship to historical patterns, habitat connectivity, dispersal ability, distributional abundances, and reproductive behavior. Such genetic characterization has been used to select yellow perch brood stock from different geographical regions of North America in order to enhance growth and evaluate the heritability of that growth (Chap. 26, F. W. Goetz et al.). The last chapter of Part VI written by R.J.W. Blonk and H. Komen (Chap. 27) describes the principles of selective breeding programs, the most commonly used selection methods and their implications for percids, as well as some insights into the optimization of breeding programs.

One general feature of the percid fishes used in aquaculture is their high sensitivity to stress under captive conditions, with negative consequences in terms of reduced immune resistance and, as a corollary, sensitivity to diseases and pathogens. The state of the art on these interrelated aspects is described in Part VII. As reported by S. Milla and coauthors in Chap. 28, accumulating evidence indicates that corticosteroids are strongly regulated in percids after exposure to stressors and play essential roles in the stress response. This chapter characterizes the corticosteroid synthesis and receptivity in percid fish, as well as their secondary and tertiary responses to stressors due to culture conditions. The possible reduction of stress sensitivity through progressive domestication is discussed in Chap. 29 by J. Douxfils et al. Comparing the responses of different captive generations of Eurasian perch to different kinds of stressors, the authors indicate that domestication positively influences fish tolerance to some stressors like chronic confinement but not to more severe ones such as hypoxia. The immune system is characterized by R. Mandiki and coauthors (Chap. 30), with a special emphasis on the immunocompetence changes in relation to environmental conditions as well as on the positive response of percid fish to some immunomodulatory compounds. In Chap. 31, H.D. Rodgers and N.B.D. Phelps describe the main infectious diseases associated with Eurasian perch and yellow perch, including viral and bacterial diseases, protozoan parasites, as well as noninfectious conditions (tail erosion, gill disease, and skeletal deformities) giving rise to significant livestock challenges and welfare problems.

The last section deals with the commercial production, quality as human food, marketing, and economics. It is by far the section for which the availability of data is the scarcest, indicating that the percid culture sector is still in its infancy as far as commercial production is concerned. Chapter 32 (S. Stenfeldt et al.) overviews the state of production in different countries, mostly European, involved in the production of Eurasian perch and pike perch. For each country, the main culture techniques are summarized, and production types are specified, according to the local or international markets. Aside from the production performances, usually expressed in terms of tonnage, the quality of the final product is now of prime importance, and

the development of the percid fish industry calls for reflection on the concept and quantitative determination of quality. Chapter 33, written by M. Thomas et al., illustrates the complex picture of quality in percid fishes, based on nutritional, technological, sensory, and sanitary components, and identifies the main biotic and abiotic factors influencing this quality. The actual market of percid fishes is not easy to evaluate because it is largely considered, up to now, as a niche market, with large variations of consumer preferences according to the different European regions. The present picture of the European market of Eurasian perch is described in Chap. 34 (D. Toner), as well as perspectives regarding its evolution concurrently with the decline of captive fisheries supply and development of aquaculture production. The last chapter of this section (J.L. Overton et al.) aims to identify the main factors of success and constraints in percid fish aquaculture, including the positive aspects such as the control of reproductive cycle and out-of-season spawning or the better knowledge of feeding and nutritional requirements, but also the limitations for further upscaling of production, such as the slow growth, the need of domestication, or the lack of veterinary knowledge of percid diseases and prevention (vaccines, probiotics).

This book and others before it demonstrate that Percid culture has a promising future. The voluminous literature reported here demonstrates the existence of a sound foundation of basic and applied science as well as over 100 years of practical experience to move Percid cultural technology forward to produce fish for enhancement stocking as well as for commercial food fish markets. Yet, there is a critical need to see the advances in scientific knowledge integrated into production practices.

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