Chapter 7

Domestication of the Eurasian Perch (*Perca fluviatilis*)

Pascal Fontaine and Fabrice Teletchea

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.85132

Abstract

The farming of percids (Eurasian perch *Perca fluviatilis*, pikeperch *Sander lucioperca*) has progressively become a diversification path of European inland aquaculture in the past 25 years. This required the domestication of wild or pseudowild (coming from polyculture ponds) populations. Considering the history of Eurasian perch, this domestication can be subdivided into four main successive parts: (1) a short initial prospective period (bibliographical analysis, market analysis, etc.), (2) a first experimental period to acquire basic data that notably resulted in the choice of the rearing system and commercial feeds, (3) a second experimental period allowing to get an in-depth knowledge on each of the main phase of the life cycle of this species (control of the life cycle in rearing conditions), and (4) a third experimental period, still ongoing, of optimization of rearing practices. This chapter allows understanding the domestication framework of this species and better understanding the role of different actors in the decision-making. In the future, the farming of this species is likely to rely on a larger diversity of rearing systems; a key issue is to study the interactions between species-rearing system. How different domestication trajectories or paths (intratrajectories variability) will affect global performances of Eurasian perch remains an open question.

Keywords: Eurasian perch, domestication, aquaculture, chronology, major steps, rearing system

1. Introduction

Fish farming is an animal production sector that followed, in the past years, various dynamic paths according to the region considered. For instance, between 1995 and 2015, this sector displayed a strong increase at global scale with a production rising from 14.9 to 51.3 Mt. (+242%), whereas only a slight increase was observed within the European Union countries: from 490,000 to 660,000 tons (+34%). At national level, fish production has decreased from 65,500 tons in 1995 to 44,500 tons in 2005 (−32%) in France, despite its expansion in other countries like Norway. This fact illustrates that the development of this sector depends strongly on territorial contexts. Despite projections indicating the strong increase of aquaculture at global scale up to 2050, much higher than any other animal production sectors, except for poultry production [1, 2], some territories are facing several obstacles. These obstacles include, among others, (i) competition with other economic sectors (fisheries, tourism, agriculture, production of potable water, etc.), for access to land and water resources, (ii) an economical context of free exchange that often results in strong competition with imported products coming from countries with much lower production costs, (iii) policies (environmental and social protection, food safety, etc.) most often perceived as very binding, and (iv) a degraded image of rearing systems and farming products for which sustainability is frequently questioned by societies in developed countries, particularly concerning quality of products, respect of animal welfare, and environmental impacts. All these issues could hamper the development of aquaculture in some developed countries, such as France. In this context, it is hard to conceive that fish farming could increase significantly in those regions. Nevertheless, these territories are heterogeneous and often display a strong historical, cultural (e.g., culinary traditions), and landscape (mountainous or coastal regions, ponds, wetlands, etc.) diversity that results in numerous microterritories with their specific consumption of fish or more exactly very typical products or dishes. This is particularly true for Europe and France. For instance, one might cite the consumption of smoked eel in the Netherlands [3], frying of cyprinids (roach, rudd) in the Valley of Moselle (Luxemburg), tench in the region of Extremadura in Spain, fried carps in the Sundgau in Alsace in France, meager in the southeast French Mediterranean Sea, or Eurasian perch in the countries around the Alps. These small markets rely on a close link between local populations, the history of the territory, and the presence of a specific landscape (e.g., country of ponds) or particular ecosystems (lakes) and the animal species inhabiting these regions. This tight link between consumers and species is obviously the case for the market of Eurasian perch in the Alps region, where consumers often require the presence of the fish skin to clearly observe the alternation of dark and light bands, typical of this species [4]. These are key advantages for this territory that could allow the development of a diversified and resilient aquaculture based on the diversification of the production and the domestication of new fish species, corresponding to a development model that we can call "mosaic aquaculture." This is in this global context associated with this vision that the domestication of Eurasian perch started in the early 1990s, 25 years ago. The understanding of the initial motivations and the process of domestication realized over this period require first considering the specificities of inland European aquaculture and associated territories.

In Europe (European Union), inland aquaculture only represents 25.3% of the total production [5]. Two main distinct economic sectors exist, salmoniculture (farming of salmonids, chiefly monoculture of rainbow trout (*Oncorhynchus mykiss*) in running waters and pond culture, corresponding to polyculture in ponds with the dominant species being common carp (*Cyprinus carpio)*. Thus, logically, the two most consumed fish species in Europe are rainbow trout (second) and common carp (fifth), mainly in Central and Eastern Europe for the latter. The domestication of Eurasian perch started in France with the will to diversify inland aquaculture while respecting the other economic sectors already developed, particularly pond aquaculture. Interestingly, it is important to specify that in France, pond aquaculture is mainly for the restocking market in link with angling activities: fish are sold alive to river managers (associations of anglers) or private ponds. These markets are both more lucrative and less demanding in terms of personnel and investment. A very small percentage of this aquaculture production is destined to the markets for human consumption.

2. Why choosing Eurasian perch?

The initial choice of Eurasian perch resulted from several points that were taken into account locally, like at the Lorraine territory scale in France. First, at national level, there was at that time the mutual motivation by several stakeholders (producers, policymakers, and developing agencies) to promote and diversify freshwater aquaculture with different incentives, even though the human consumption market was targeted (**Table 1**). In Lorraine, this dynamism first resulted in one part in the structuring of the inter-profession with the establishment of the Inland Aquaculture Lorraine Sector (Filière Lorraine d'Aquaculture Continentale) in 1987 and on the other part the inception of a new specific university diploma in inland aquaculture, the "Ingénieur-Technologue" DI-T [6–8]. Besides, carnivorous fishes, such as Eurasian perch, pikeperch *Sander lucioperca*, or pike *Esox Lucius*, are and remain both the most appreciated species by anglers and consumers who know them, particularly in Western Europe (except salmonids). Third, a survey realized at the European scale revealed that in some territories (Eastern France, Switzerland, and Northern Italia), this species was widely consumed in various forms (whole fish, fillets, etc.) and at different sizes (**Table 2**) [9], and they exist a niche market relatively large such as in Switzerland where it was estimated at about 4000 tons of fillets per year with a supply essentially ensured by fisheries from large lakes in Central and Northern Europe and Russia [10–11]. Fourth, the production of Eurasian perch in polyculture ponds remains challenging to control, which is less the case for other carnivorous species. So much that in certain French regions (Centre), this species was considered as undesirable by fish farmers because of dwarfing problems often linked to the overabundance of young individuals [11].

Summing up, the domestication of Eurasian perch appeared as a good compromise for several reasons: (1) a diversification of aquaculture production targeting the human consumption market by valuing a native species known by consumers and benefiting from a good image

Species	Territories	Initial will	Current production in France
Black bass *Micropterus salmoides*	South-West	Angling, human consumption	Negligible
Siberian sturgeon *Acipenser baeri*	Aquitaine	To preserve another sturgeon species (*A. sturio*)	17 farms, third global producer of caviar
Eurasian perch *Perca fluviatilis*	Lorraine, Rhône-Alpes	Human consumption	100 tons, three perch farms
Wels *Silurus glanis*	Centre, Languedoc	Human consumption	Negligible

Table 1. Trials of diversification and domestication of new fish species in inland aquaculture in metropolitan France during the last decades of the twentieth century.

Countries	Production/exploited ecosystems	Valorization
Germany	Fisheries (large lakes, rivers, Baltic Sea)	Angling, exportation, weak human consumption
Austria	Fisheries (Constance Lake)	Exportation, human consumption
Belgium	Fisheries in rivers, polyculture in ponds	Angling
Bulgaria	Fisheries in rivers or in reservoirs	Angling, human consumption
Denmark	Fisheries in lakes or estuaries	Angling, exportation
Finland	Fisheries in Baltic Sea and inland waters	Angling, strong human consumption
France	Fisheries in lakes and rivers	Angling, strong human consumption (East)
Great Britain	Fisheries in lakes and rivers	Angling
Hungary	Fisheries in lakes and rivers	Angling
Ireland	Lough Neagh	Exportation
Luxemburg	Fisheries in rivers	Angling, weakly consumed
Norway	Fisheries in inland waters of East, South, and North-East	Angling, exportation, human consumption
Netherlands	Fisheries in IJsselmeer lakes and inland waters	Angling, weak human consumption
Baltic countries	Fisheries in lakes	Exportation
Poland	Fisheries in inland waters (Swinoujscie region)	Angling, exportation
Czech Republic and Slovakia	Fisheries in the Danube River and other rivers	Angling, human consumption
Romania	Fisheries in ponds, in the Danube River, Razelm Lake	Angling, human consumption
Serbia and Macedonia	Fisheries in the Danube River and lakes (Dojran Lake)	Human consumption
Sweden	Fisheries in the Baltic Sea	Angling, exportation, human consumption
Switzerland	Fisheries in lake	Angling, strong human consumption

Table 2. Interest for Eurasian perch according to European countries, survey realized in 1993 [9].

and an established market niche and (2) the development of a new activity that did not harm other traditional activities of the sector (no competition). Initially, this project of diversification aimed at developing a complementary activity for pond fish farmers. Besides, linking to the survey realized [9], a possible competition with capture fisheries coming from Eastern and Central Europe as well as Scandinavia was highlighted; yet, surveyed persons stated that the capture levels were highly variable from one year to another, product quality (filleting yield) also strongly varied (effect of reproductive cycle), and supply period of market was stopped during the spawning season in spring. Consequently, all these facts confirmed the possibilities to develop an aquaculture of Eurasian perch targeting a regular production of fresh fillets with a constant and high quality.

3. Acquiring knowledge on the biology of *P. fluviatilis* and *P. flavescens*

A the end of the 1980s and beginning of the 1990s, an in-depth analysis of the available literature on the biology of Eurasian perch and a North American close species, the yellow perch *P. flavescens*, was performed to better evaluate potentialities of this species. We first analyzed general articles as well as book chapters [12–22]. Then, we considered more specific studies focusing on the characteristics of populations inhabiting particular aquatic areas [13–27]. In the meantime, because some farming trials were already performed on yellow perch in the United States (large lake areas), a similar approach was realized aiming at establishing a synthesis of knowledge acquired on the zootechny of this sister species [28–38]. At this period, yellow perch was considered as the reference to promote the farming of Eurasian perch. This choice was reinforced by the fact that questioning about the rearing systems (ponds or recirculated systems) was similar. Based on these bibliographical analyses, preliminary thoughts resulted in the emergence of farming possibilities in Europe [39], and perciculture (i.e., farming of perch) was proposed as a possible way to diversity inland aquaculture in Europe [40].

3.1. Study of the life cycle of perch in natural conditions, first zootechnical trials, and choice of the rearing system

During the 1990s, researches were undertaken to first better know the life cycle of the species in local aquatic ecosystems, mainly in the Mirgenbach reservoir and Lindre ponds (Moselle, France), and second to determine the potential of this species at different stages (larval rearing, on-growing). The choice of the Mirgenbach was linked to the fact that this reservoir presents heated waters due to the nuclear power plant of Cattenom and could potentially present thermic conditions more favorable for the growth of perch, in the perspective of a future economic development. These field studies allowed describing the feeding regime, growth (relation size-weight), composition of the main tissues (muscles, gonads, liver, viscera), as well as the reproductive cycle [27, 41–44]. These data constituted the frame of reference and brought the basis for future experimentations, such as the control of the reproductive cycle. In parallel to these descriptive studies, first trials of acclimatization were realized using perch sampled at different development stages in natural conditions (e.g., egg ribbons mainly from the Leman Lake, INRA Thonon-les-Bains, Haute-Savoie, France), polyculture ponds (young perch of 4–20 g for Lorraine fish farm ponds), or rivers (eggs ribbons from Meuse). The acclimatization of young perch, either juveniles or sexually mature individuals, with diverse features from one year to another, was closely linked to the will to value stocks of fish often very abundant during fall and spring pond fisheries and displaying a low market value. Based on the works performed on the yellow perch [32, 34, 36], several weaning protocols were tested using feeds or diverse raw materials (beef liver, frozen plankton, dried or hydrated formulated feeds) [45]. Because of (i) very high mortality rate (40–60% in 2 months) linked to food refusal, development of pathologies caused by *Aeromonas hydrophila* and cannibalism, (ii) high variability of qualities of the different batches of fishes received (juveniles or mature fishes, sizes, more or less lean fish, etc.), and (iii) difficulty of weaning protocols, this way of developing perciculture was rapidly stopped. Nevertheless, it was maintained during few years to produce the biological material to realize growth trials and produce breeders [46]. This work allowed conducting a thinking on the choice of the rearing system, which was the most adapted to perciculture. If the production of juveniles could be realized in small ponds following extensive or semi-intensive methods [47], the on-growing phase was rapidly focused on rearing systems in controlled conditions, which allow higher production levels and a rationalization of rearing conditions to guarantee a reproducibility of performances and the development of the sector. Thus, on-growing trials were performed in floating cages (Lindre ponds, Lake of Féronval) and in recirculated aquaculture system (RAS) in Belgium and France. In this comparative approach of the possible potentialities by different rearing systems, it was demonstrated that similar specific growth rates were obtained in cages and RAS, but survival rates, feed conversion rates, and the homogeneity of individual weights were better in RAS [45, 48, 49]. It also appeared that perches farmed in cages had started a reproductive cycle: females and males captured in September (40–70 g) displayed gonadosomatic indexes of 2.4 and 7.1%, respectively, whereas they were constant and low in RAS (<0.5, sexual resting) [45, 48]. Yet, the development of gonads at such a low weight, lower than the market weight targeted (80–120 g), constituted a problem for maintaining optimal growth performances. These zootechnical trials also demonstrated that this species was very sensitive to pathogens, among which are parasites such as *Heteropolaria sp*., a protozoaire [50, 51], or bacteria, such as *Aeromonas sobria* [52]. This sensitivity of this species led to the shutdown of the project of the enterprise Perlac SA located in the Lake Neuchâtel in Switzerland. The sensitivity of this species to external parasites, such as *Dactylogyrus* or *Costias*, was confirmed during the first rearing trials performed by the society Lucas Perches created in 2001 in France [53]. At this period, this society used the water from a small river “La petite seille” to decrease the water temperature coming from a geothermal forage used by the society. At last, a strong individual growth heterogeneity was observed during trials [50]. All these experiences realized in Belgium, France, and Switzerland resulted in the choice of RAS as the most adapted rearing system for the development of perciculture [54, 55]. This choice was confirmed by technical choices operated by the first perch farms, Percitech in Switzerland (society created in 1994) and Lucas Perches in France (created in 2002) (**Figure 1**). Since then, researches exclusively focus on this rearing system using diets for trout or sea bass mainly.

3.2. Control of the life cycle of Eurasian perch for the development of perciculture in RAS

Once the rearing system selected (intensive monoculture in RAS for the production of fillet for human consumption), diverse researches were performed in order to control the life cycle of the species in indoor conditions. They include the control of the reproductive cycle, the development of larval rearing protocols, the determination of nutritional needs, the optimization of growth performances, the control of quality of products, and first trials of genetic improvement. These researches were funded by both national (mainly in Belgium and France) and international, chiefly thanks to the European Union (FAIR-CT96-1572 1996-1998, FAIR-CT98-9241 1998-1999, Σ! 2321 ACRAPEP/ANVAR A0011134L 2001-2004, COOP-CT-2004-512629-PERCATECH 2004-2006) programs.

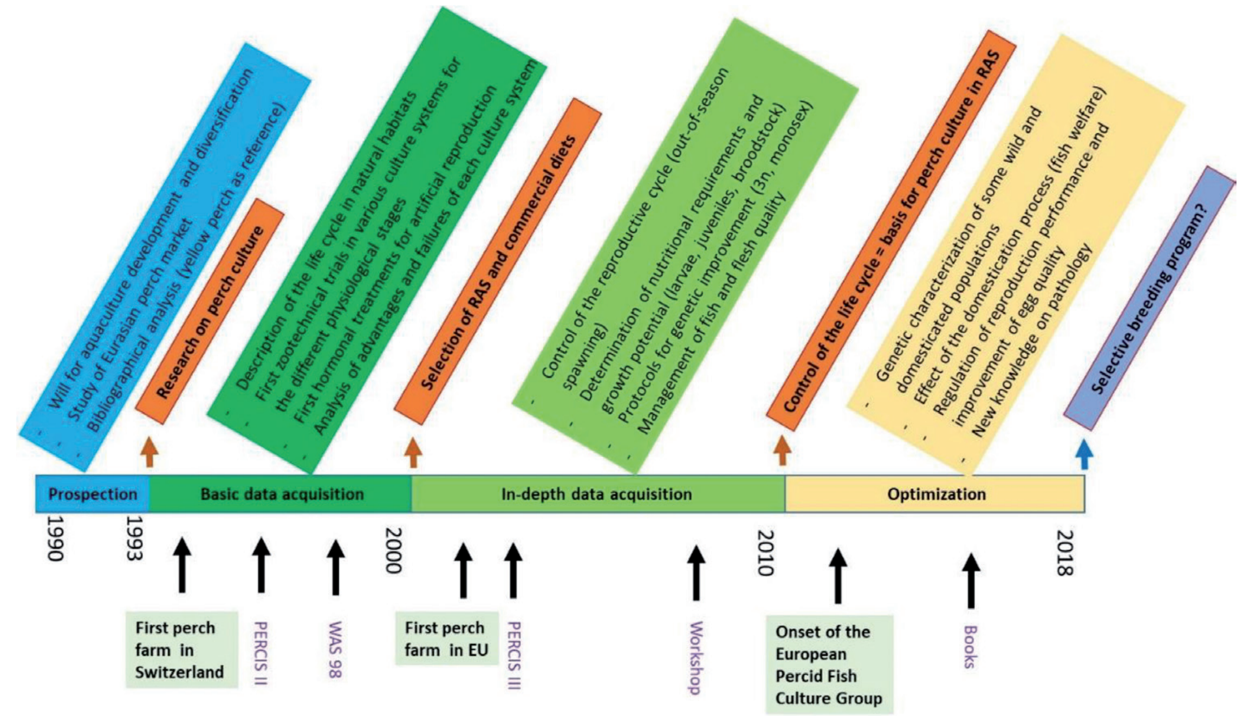

Figure 1. Timeline displaying the key phases of the domestication of Eurasian perch with from one hand the main knowledge acquired and the decisive decision taken (above the bar) and from the other hand the major events that occurred (below the bar) over the period 1990–2018.

3.3. Control of the reproduction

Even though the market for the perch fillet remains seasonal in the traditional consumption market (March–October), the development of an intensive monoculture in RAS required a complete control of the reproductive cycle in order to obtain out-of-season spawning and not only rely on the single annual reproduction occurring in spring [41–43, 56]. A first research axis focused on the environmental control of the reproductive cycle. A preliminary test demonstrated the possibility of controlling the reproductive cycle by manipulating both water temperature and duration of photoperiod [57]. Thereafter, these researches allowed disentangling the respective roles of water temperature variations and duration of photophase by distinguishing the different phases of a reproductive cycle: induction, vitellogenesis, and final steps of the cycle [58–66]. All these works allowed developing a reliable protocol for the induction of out-of-season spawning close to 100% [67]. This program is now routinely applied in farm conditions; it allowed the realization of 2–12 reproductive cycles per year with different batches of breeders managed in delayed conditions. If the temperature variations and the duration of photoperiod drive the timing of the successive steps of the reproductive cycle (determining factors), other factors can modulate the quality of reproductive performances observed. For example, the feeding strategy is very important, and thus the nutritional needs of breeders were specified [68, 69]. In fact, numerous rearing factors, including environmental, nutritional, and populational, can act on breeders and influence their reproductive performances; multifactorial approaches must be used to optimize rearing conditions and secure performances [70, 71].

Complementary to the control of reproductive cycle for the induction of out-of-season spawning, additional protocols based on hormonal injection were developed to synchronize spawning during the reproductive season [72–77]. They were based on previous works performed on the yellow perch [78–80]. The application of hormonal injections is now facilitated by the use of a classification method of oocyte stage maturation in preovulatory period [81]. At last, reliable protocols for collecting gametes (spermatozoa, oocytes) and artificial reproduction are also now available [82].

3.4. Larval rearing

Initially, trials of larval rearing were performed with spawning collected in various aquatic areas. Like for on-growing trials, several ways were initially prospected to promote the production of weaned juveniles: (1) an extensive production in small ponds with an *ex situ* weaning in tanks, (2) a semi-intensive production in mesocosms, and (3) an intensive production in RAS [83]. Even though few fish farms used the methods of mesocosms to produce the juveniles, particularly in Ireland, this is the intensive rearing in RAS that is mainly used nowadays. The first works aimed at optimizing the abiotic environment of farming (light intensity, duration of photophase, color of tank walls) and feeding protocols [84–87]. Initially, particular attention was paid to the use or not and the choice of live prey for larval rearing. The first protocols that have been developed used rotifers [88] or nauplii of *Artemia* spp. of various sizes [84, 87, 89–91]. The feeding transition (weaning = change from a feeding based on live prey to a commercial formulated diet) was soon questioned [92]. Very rapidly, major issues appeared: first, a high growth heterogeneity with a strong intra-cohort cannibalism rate [93–95] and second, the onset of developmental anomalies (malformations of skeleton and lordosis) with notably low inflation rate of the swim bladder [96–98].

The very strong impact of cannibalism within the first weeks of rearing was rapidly confirmed during the first commercial production [53]. Up to now, the strategy adopted by fish farmers to reduce cannibalism relies on frequent sorting (each week or 2 weeks) to maintain homogeneous batches during the nursery period and early weeks of on-growing. At that level, the results obtained by Mandiki et al. [99] suggested that they are natural populations less aggressive than others are, when they are placed in rearing conditions. Consequently it could be interesting to evaluate the intraspecific variability of wild populations (search for more docile populations). Concerning the problems of the inflation of the swim bladder and developmental anomalies often linked to the first point, they are mainly related to larval rearing conditions [100]. An improvement of rearing conditions associated with a high level of prophylaxis allowed increasing inflation rates and reduced malformation rates. In order to avoid the on-growing of individuals without swim bladder, protocols of sorting, based on practices realized in marine fish farming, were developed [101, 102]. Today, perch farms with well-conceived and seriously managed hatchery-nursery produce regular batches of 0.5 up to 1 million of weaned juveniles. However, developmental anomalies remain regularly observed in farms [103]. It is important to specify that the publication of a developmental table for the embryo-larvae corresponding to a normal development constitutes a major tool to identify the causes of common developmental anomalies) [104].

3.5. On-growing, nutritional needs

Once fry were available, trials on pre-on-growing and on-growing were realized in order to determine from one part the optimal conditions of growth and on the other part the potential of this species. It was first demonstrated that this species has a diurnal feeding activity [105]; the application of photoperiod with a long photophase stimulates growth and inhibits gonadal development [106]. First rearing trials had also demonstrated the gregarious behavior of this species (schooling behavior) and its ability to feed on pellets [46]. At this period, feeds for rainbow trout or sea bass were distributed to perch; feed conversion rates of 1.0–1.5 were registered according to the ration rate applied [49, 106–108]. High survival rates were also obtained (>80%).

Once these favorable prerequisites were established (gregarious behavior, sufficient survival, acceptability of artificial feeds, correct alimentary conversion rate, etc.), more dedicated researches were realized on the effects of both major abiotic and biotic factors on growth. Thus, it was demonstrated that the optimal temperature for growth was 22–24°C [107]. Thereafter, complementary works allowed specifying the effects of the rearing environment (tank wall color, light intensity, manipulations) on the ingested feed and growth [109–110]. The effects of rearing conditions on the physiological state of fish were also studied; perch appeared as very sensitive to both poor conditions and manipulations [111, 112]. At the feeding level, ration table for maintenance and optimal and maximal growth according to physiological stages were determined [107, 108, 113, 114]. Then, nutritional needs were progressively determined to promote the emergence of a feed for percids once the volume of production would be large enough. Thus, the nutritional requirements in proteins, lipids, and some additives, such as oxidative as ethoxyquin, were specified [89, 115–118]. These studies allowed defining that a feed for perch should contain 43–50% of proteins, 13–18% of lipids, and 10–15% of glucids [119].

3.6. Quality of products

The domestication of species for the human consumption market requires knowing and controlling the quality of products (whole fish, fillet). Thus, very early, once the first zootechnical trials were completed, the chemical composition of the tissue of perch, and notably muscle, was analyzed [41, 120]. One major goal was the production of constant quality fillet to consumers, similar to the wild fillet coming from the lake. Researches were started from one part to understand the natural variability of organoleptic properties of the perch fillet according to the origin of captures and, on the other part, to identify the determinants of this quality. Importantly, the quality of a product is a vague and complex notion that depends on nutritional, technological, sensorial, and sanitary features. Thus, features of perch coming from different regions (Geneva Lake, Rhine estuary) were compared among themselves and to perch obtained from RAS [121, 122]. It was found that first the quality of products was highly variable according to the natural environment studied and second that farming factors (feeds, rearing densities, etc.) strongly impacted the properties of farmed perch [123, 124]. In fact, the control of the quality of products (flesh or whole fish), over the course of domestication, is multifactorial [125, 126].

3.7. Manipulation of sex and ploidy: genetic management of domesticated populations

The Eurasian perch displays a sexual dimorphism of growth in favor of females [107, 108]; thus, the production of monosex female populations has rapidly appeared as a solution to reduce growth heterogeneity and increase growth performances. Hence, protocols (hormonal treatment with 17α-methyltestosterone) were developed for the production of homogametic males or neomales (XX) [127], with a sperm quality similar to heterogametic males [128]. Once produced and mature, those neomales were breeded with normal females (XX) allowing the production of 100% females, for which growth improvements were observed after 7 months of rearing in RAS at 23°C [129]. In a complementary study, trials of production of 100% female populations were also realized by gynogenesis using spermatozoa inactivated by UV radiation [130]. However, due to the low survival rates as well as insufficient growth performances, this method is rarely used [129].

A second path, triploidization, was also studied in order to produce sterile animals. This path also appeared as very important because Eurasian perch is a species that can start a reproductive cycle before reaching market size. It is possible to capture in natural habitats (ponds) sexually mature females and males as such low weights as 10–20 g, even lower for males. As for other species reared in fish farming (salmonids), protocols based on thermal or pressure chocks were also developed to produce triploid perch [131].

With the development of perch farms (7–8 farms localized in Germany, France, Ireland, and Switzerland) and the increase of production in RAS (estimated between 500 and 800 tons per year), first thinking on the necessity to develop selective breeding programs emerged, mainly to improve growth performances and decrease production costs. Yet, up to now, no true selective breeding programs exist, even though basic genetic knowledge was acquired to develop them. Studies have notably allowed to characterize the genetic variability of wild perch, very often used as founding populations of current farmed stocks [132–133] and stocks of domesticated breeders currently present in perch farms [134]. These studies have demonstrated that the available stocks of domesticated perch in farms were (i) sufficiently genetically variable to allow developing selective genetic programs (lack of consanguinity) and (ii) often genetically distant from the origin populations (Alpine lakes) presumably assumed by fish farmers.

4. Dissemination and knowledge transfer

The domestication of a species requires the onset of periods of exchanges between all stakeholders of the sector (**Figure 1**), notably to allow transfer of expertise and co-elaboration of projects based on the identification of priorities and major bottlenecks. Concerning Eurasian perch, very rapidly, the few research laboratories implied in this species cooperated and organized scientific seminars at different scales to allow sharing new knowledge. The meetings organized at the transatlantic level (Canada, USA, and Europe) aimed first at sharing works performed on Eurasian and yellow perch. Some of these events (Namur, 2008; Nancy, 2014) had for main objective exchanges between the socioeconomic stakeholders of the sector (fish

http://dx.doi.org/10.5772/intechopen.85132

farmers, designer of fish farms, traders in aquatic products, etc.). Progressively, knowledge was compiled in more and more comprehensive book [135, 136]. Obviously, this diffusion of knowledge and co-construction also occurred at local, regional, and national scales. In France, for instance, an informal group of exchanges, entitled "National group of pond carnivorous fish," often met in the beginning of the 1990s to discuss experience on various species (Wels, pikeperch, black-bass, and perch) that were the subject of diversification [137–140]. At the regional level, in Lorraine, the " Filière Lorraine d'Aquaculture Continentale (FLAC)" supports diverse zootechnical trials and, therefore, actively contributes to the emergence of perch farms on this territory. Later a similar initiative was taken in other regions from other countries, like in Ireland [141].

5. Conclusion

The domestication of Eurasian perch was initially based on local issues (niche market, development of activities and jobs in rural environments). This domestication occurred in a few main steps: (1) socioeconomic analysis of the market, (2) first zootechnical trials and choice of the major rearing system (RAS), and (3) acquisition of in-depth knowledge on the successive stages of the production cycle (control of the reproductive cycle and reproduction, control of the larval rearing, on-growing, and quality of products) (**Figure 1**). It is important to highlight that the first two steps strongly considered the knowledge previously acquired on a close species, the yellow perch. Today, the Eurasian perch is considered at the level 4 of domestication, which means that the entire life cycle is closed in captivity without any wild inputs but no selective breeding programs is applied [142].

Even though the first experimental trials were initiated at the beginning of the 1990s, the first perch farm (SARL Lucas Perches) created within the European Union was located in 2002 as a pilot enterprise. Importantly in Switzerland, a perch farm, Percitech, was created much earlier in 1994. About 20 years later, numerous projects were launched, some with very high expectations (e.g., FjordFresh Holding S/A in Estonia), in numerous European countries; 10 of these enterprises truly developed a commercial activity. Today, most perch farms pursue their activities; only few, mainly in Ireland (country where perch is not consumed), have stopped their activity. The investors that initially believed in this species were not issued from the aquaculture sector and discovered it. Sometimes, it corresponds to industrials that succeeded in other sectors and wants to diversify their activities. This initial distance from the aquaculture sector constitutes one of the reasons of the slow development of perciculture. Learning requires time. Without doubt, the domestication of Eurasian perch was and remained a particular human adventure, where the link between the species and humans is visible at different levels and various forms.

In terms of perspective, one can expect that this young sector will pursue its development first based on current farms, whose economic viability remains to be demonstrated and second in link with the emergence of new projects and expansion of the market toward new consumers. This new development could imply the production of both pikeperch and perch within the same farms. To support this development, it is imperative to reduce production costs, high in RAS, and secure current stocks. The decrease of cost production will require in priority the onset of selective breeding programs and genetic improvements, a standardization and rationalization of rearing protocols (e.g., percid feeds, ration tables, etc.) and a reduction of investment levels for the development of new perch farms. For some, the development of a monoculture of perch in ponds could be the solution because it will allow a strong decrease in production cost. On the security side, it is important to (i) better know pathologies associated with this species, notably virus, among which some might represent a major risk for percids [143] and (ii) specify the effects of the domestication process on rearing performances of this species. As any other domesticated species, biological responses and performances of perch are modified by the domesticating environment specific to the rearing system chosen and associated rearing practices. Thus, preliminary results indicated that reproductive performances [144, 145] and its sensitivity to stress and immune system [146–150] depend on farm conditions. In the future, the domesticating context (**Figure 2**) could strongly vary according to local environment, which could lead fish farmer to choose different rearing systems and to target different markets. Once this main choice realized (context and domesticating direction fixed), secondary choices will define the trajectory of domestication that will result in physiological stage capture in nature, of the dynamic of transition (progressive or sharp) and cultural practices used, practices that could evolve over time with different dynamics. This complexity is reinforced by the fact that a population engaged in a specific domesticating context could change into another context because of a modification in the project, as was the case for perch reared in polyculture ponds, then weaned, and grown in cages or RAS (**Figure 2**). This diversity of directions and domesticating trajectories should lead to different evolutions (behavior, stress physiology, reproduction, etc.) variable from a context to another. These evolutions could even lead fish farmers to reconsider the initial choice of founding populations, given the enormous genetic diversity available in wild populations [4].

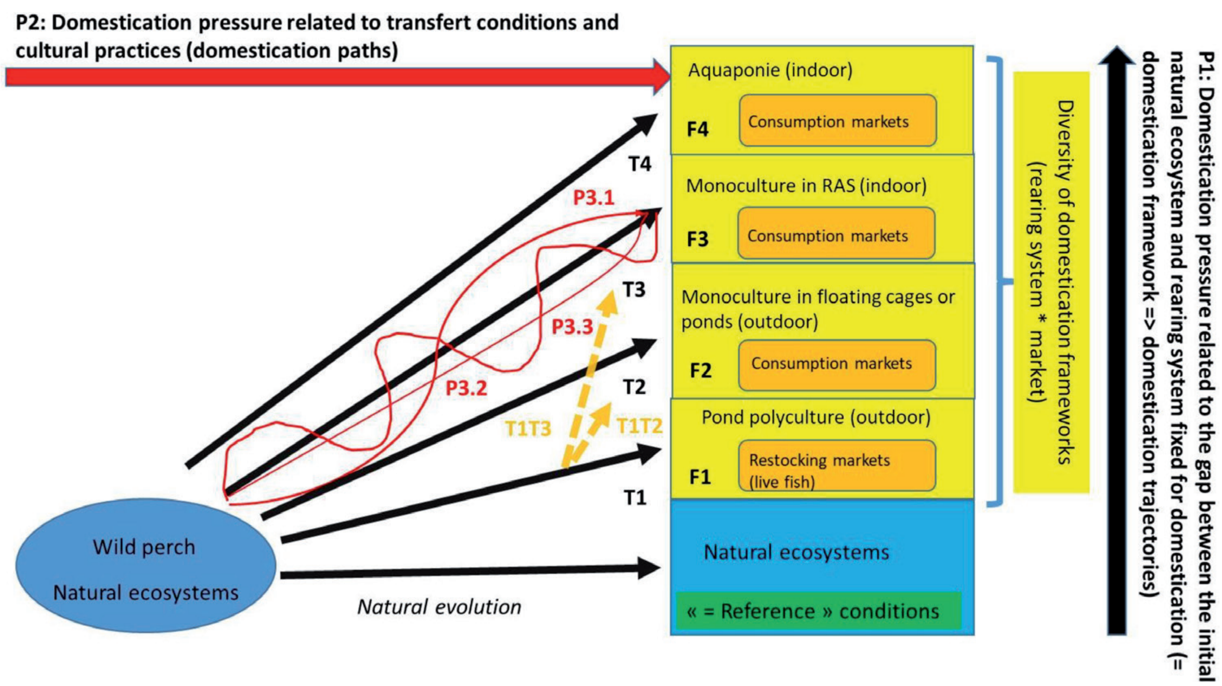

Figure 2. Diagram explaining the different domestication frameworks and pressures encountered by Eurasian perch during current farming trials (F: Framework, T: Trajectory, P: Path).

http://dx.doi.org/10.5772/intechopen.85132

Author details

Pascal Fontaine* and Fabrice Teletchea

*Address all correspondence to: p.fontaine@univ-lorraine.fr

University of Lorraine, Nancy, France

References

[1] MacLeod M, Gerber P, Mottet A, Tempio G, Falcucci A, Opio C, et al. Greenhouse gas emissions from pig and chicken supply chains—A global life cycle assessment. In: Food and Agriculture Organization of the United Nations. Rome: FAO; 2013. p. 196

[2] FAO. La situation mondiale des pêches et de l'aquaculture 2018. Atteindre les objectifs de développement durable. Rome. 2018. p. 254

[3] FranceAgriMer. Etude d'initiatives françaises potentielles dans la filière européenne de l'anguille. VIA AQUA, Les études de FranceAgriMer. 2014. p. 15

[4] Stepien CA, Taxonomy HAE. Chap. 1. Distribution, and evolution of the percidae. In: Kestemont P, Dabrowski K, Summerfelt RC, editors. Biology and Culture of Percid Fishes—Principles and Practices. Dordrecht, The Netherlands: Springer; 2015. pp. 3-60

[5] Hough C editor. European Aquaculture Technology and Innovation Platform. A Review of the EATiP Strategic Research and Innovation Agenda. 2017. p. 29

[6] Condé B, Terver D. Filière Lorraine d'Aquaculture Continentale—Compte-rendu des journées du 5 juin et 16 septembre 1987. Supplément à la Revue française d'Aquariologie. 1998;**1**:39

[7] Fontaine P. Une région dans la cour des grands de l'aquaculture continentale. A l'est, du nouveau. Aqua Revue. 1993;**49**:25-28

[8] Terver D, Condé B, Fontaine P, Georges A. Aquariologie et aquaculture continentale à l'Aquarium tropical de Nancy. Objectifs culturels, pédagogiques et scientifiques: Bilan et perspectives. 2ème partie: Aquaculture. Supplément à la Revue française d'Aquariologie. 1993;**1**:8

[9] Tamazouzt L, Dubois JP, Fontaine P. Productions et marchés de la perche commune (*Perca fluviatilis*) en Europe. La Pisciculture Française. 1993;**114**:4-8

[10] Donzé F, Gradoux F. Frais du lac? L'illustré. 1998;**32**:24-27

[11] Fontaine P. Avancée récente des connaissances en perciculture. Aquafilia. 2004;**1**:5-8

[12] Turner CL. The seasonal cycle in the spermary of the perch. Journal of Morphology. 1919;**32**:681-711

[13] Le Cren ED. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluvitilis*). Journal of Animal Ecology. 1951;**20**:201-219

[14] Le Cren ED. Observations on the growth of perch (*Perca fluviatilis* L.) over twenty-two years with special reference to the effects of temperature and change in population density. Journal of Animal Ecology. 1958;**27**:287-233

[15] Mansuetti AJ. Early development of yellow perch, *Perca flavescens*. Chesapeake Science. 1964;**5**:46-66

[16] Jezierska B. The effect of various type of food on the growth and chemical composition of the body of perch (*Perca fluviatilis*) in laboratory conditions. Polish Archives Hydrobiology. 1974;**21**:467-479

[17] Collette BB, Ali MA, Hokanson KEF, Nagiec SA, Smirnov SA, Thorpe JE, et al. Biology of the percids. Journal of the Fisheries Research Board of Canada. 1977;**34**:1890-1899

[18] Thorpe JE. Synopsis of biological data on the perch *Perca fluviatilis* L. 1758 and *Perca flavescens* Mitchell 1814. FAO Fisheries Synopsis. 1977;**113**:139

[19] Hoestalndt M. Recherches biologiques sur la perche, *Perca fluviatilis* L., en France. Rapport Conseil Supérieur de la Pêche. 1979. p. 105

[20] Zelenkov VM. Early gametogenesis and sex differentiation in the perch, *Perca fluviatilis*. Journal of Ichthyology. 1981;**12**:124-130

[21] Craig JF. The Biology of Perch and Related Fish. Portland, Oregon: Timber Press; 1987. 333 p

[22] consumption KPF. Growth and recruitment in perch (*Perca fluviatilis* L.). [PhD thesis]. Sweden: University of Uppsala; 1987. p. 130

[23] Malservisi A, Magnin E. Changements cycliques annuels se produisant dans les ovaires de *Perca fluviatilis flavescens* (Mitchill) de la région de Montréal. Naturaliste Canadien. 1968;**95**:929-945

[24] Makarova NP. Seasonal changes in some of the physiological characteristics of the perch (*Perca fluviatilis*) of Ivan'kova reservoir. Journal of Ichthyology. 1973;**13**:742-752

[25] Craig JF. The body composition and of adult perch, *Perca fluviatilis* in Windermere. Journal of Animal Ecology. 1977;**46**:617-632

[26] Tanasichuk RW, Mackay WC. Quantitative and qualitative characteristics of somatic and gonadal growth of yellow perch *Perca flavescens*, from lac Ste Anne, Alberta. Canadian Journal of Aquatic Sciences. 1989;**46**:889-894

[27] Flesch A. Biologie de la perche (*Perca fluviatilis*) dans le réservoir du Mirgenbach (Cattenom, Moselle) [PhD thesis]. Université de Metz, France. 1994. p. 241

[28] Hale JG, Carlson AR. Culture of yellow perch in the laboratory. Progressive Fish Culturist. 1972;**34**:195-198

[29] Huh HT. Bioenergetics of food conversion and growth of yellow perch (*Perca flavescens*) and walleye (*Stizostedion vitreum vitreum*) using formulated diets [PhD thesis]. University of Wisconsin, USA. 1975. p. 196

[30] Hokanson KEF. Optimum culture requirements of the early life phases of the yellow perch. In: Soderberg RW editor. Perch Fingerling Production for Aquaculture. Wisconsin, USA: University of Wisconsin; 1978. pp. 24-40. Sea Grant Advisory Report #421 (p. 77)

[31] Kayes TB. Reproductive biology and artificial propagation methods for adult perch. In: Soderberg RW, editor. Perch Fingerling Production for Aquaculture. University of Wisconsin; 1978. pp. 6-23. Sea Grant Advisory Report # 421; p. 77

[32] Schott EF, Kayes TB, Calbert HE. Comparative growth of male versus female yellow perch fingerlings under controlled environmental conditions. American Fisheries Society Special Publications. 1978;**11**:181-186

[33] West G, Leonard J. Culture of yellow perch with emphasis on the development of eggs and fry. American Fisheries Society Special Publications. 1978;**11**:172-176

[34] Best CD. Initiation of artificial feeding and the control of sex differentiation in yellow perch, *Perca flavescens* [PhD thesis]. Madison, Wisconsin, USA: University of Wisconsin; 1981. p. 121

[35] Manci WE, Malison JA, Kayes TB, Kuszynski TE. Harvesting photopositive juvenile fish from a pond sing a lift net and light. Aquaculture. 1983;**34**:157-164

[36] Heidinger RC, Kayes TB. Yellow perch. In: Stickney RR, editor. Culture of Nonsalmonid Freshwater Species. Boca Raton, FL: CRC Press; 1986. pp. 103-113

[37] Hinshaw M. Factors affecting survival and growth of larval and early juvenile perch (*Perca flavescens*, Mitchill) [PhD thesis]. University of North Carolina State, USA. 1986. 80 p

[38] Malison JA, Held JA. Effects of fish size at harvest, initial stocking density and lighting conditions on the habituation of pond reared yellow perch (*Perca flavescens*) to intensive culture condition. Aquaculture. 1992;**104**:67-78

[39] Goubier V, Marchandise B. Etude de la faisabilité d'une pisciculture de perche. Rapp. Inst. Rég. Recher. Aqua. 1990. p. 70

[40] Fontaine P, Tamazouzt L, Terver D, Georges A. Actual state of production of perch: Problems and prospects. I—Mass rearing potentialities of the common perch under controlled conditions. In: Kestemont P, Billard R, editors. Aquaculture of Freshwater Species (Except Salmonid). Oostende, Belgium: European Aquaculture Society. 1993;**20**:46-48

[41] Sulistyo I. Contribution à l'étude et à la maîtrise du cycle de reproduction de la perche eurasienne *Perca fluviatilis* L [PhD thesis]. University Henri Poincaré, Nancy, France. 1998. p. 144

[42] Sulistyo I, Rinchard J, Fontaine P, Gardeur J-N, Capdeville B, Kestemont P. Reproductive cycle and plasma levels of sex steroids in female European perch *Perca fluviatilis*. Aquatic Living Resources. 1998;**11**:101-110

[43] Sulistyo I, Fontaine P, Rinchard J, Gardeur J-N, Migaud H, Capdeville B, et al. Reproductive cycle and plasma levels of sex steroids in male European perch *Perca fluviatilis*. Aquatic Living Resources. 1998;**13**:80-106

[44] Migaud H, Mandiki R, Gardeur J-N, Fostier A, Kestemont P, Fontaine P. Synthesis of sex steroids in final oocyte maturation and induced ovulation in female European perch, *Perca fluviatilis*. Aquatic Living Resources. 2003;**16**:380-388

[45] Tamazouzt L. L'alimentation artificielle de la perche *Perca fluviatilis* en milieux confinés (eau recyclée, cage flottante): Incidence sur la survie, la croissance et la composition corporelle. Thèse Université Henri Poincaré, Nancy, France. 1995. p. 126

[46] Fontaine P, Vlavonou R, Tamazouzt L, Terver D, Masson G. Essai d'élevage de perches sevrées en eau recyclée: Résultats préliminaires. Cahiers d'Ethologie Appliquée. 1994;**13**: 411-420

[47] Mélard C, Philippart JC. Essai d'élevage semi-intensif en bassins d'alevinage de perche fluviatile (*Perca fluviatilis* L.) obtenus par reproduction artificielle. Cahiers d'Ethologie Appliquée. 1984;**4**:59-66

[48] Fontaine P, Tamazouzt L, Capdeville B. Growth of the Eurasian perch *Perca fluviatilis* L. reared in floating cages and in water recirculated system: First results. Journal of Applied Ichthyology. 1996;**12**:181-184

[49] Tamazouzt L, Dubois JP, Fontaine P, Capdeville B, Terver D. Zootechnical performances and body composition of *Perca fluviatilis* fed pelleted diet in a floating cage: Effect of daily ration. Annales Zoologici Fennici. 1996;**33**:635-641

[50] Mélard C, Baras E, Kestemont P. Preliminary results of Eurasian perch (*Perca fluviatilis*) intensive rearing trials: effect of temperature and size grading on growth. Bulletin Français de la Pêche et de la Pisciculture. 1995;**336**:19-27

[51] Grignard JC, Mélard C, Baras E, Poirier A, Philippart JC, Bussers JC. Occurrence and impact of *Heteropolaria* sp. (Protozoa, Ciliophora) on intensively cultured perch (*Perca fluviatilis*). Annales Zoologici Fennici. 1996;**33**:653-657

[52] Chappuis V. Un élevage voué à l'échec? Terres & Nature. 2008;**5**:5

[53] Fontaine P, Ritter B. Premiers résultats en perciculture hors-sol chez Lucas Perches. Aquafilia. 2004;**2**:10-14

[54] Mélard C, Kestemont P. Diversification de la pisciculture en Région Wallonne: mise au point de l'élevage intensif de cyprinidés et percidés. Rapport de recherches à la Région Wallonne. Namur: Université de Liège, Facultés Universitaires Notre-Dame de la Paix; 1995. p. 58

[55] Fontaine P, Sulistyo I, Capdeville B, Kestemont P. Avancées récentes concernant la biologie et le contrôle de la reproduction de la perche eurasienne *Perca fluviatilis*. La Piscicuture Française. 1998;**133**:27-33

[56] Teletchea F, Fostier A, Kamler E, Gardeur J-N, Le Bail P-Y, Jalabert B, et al. Comparative analysis of reproductive traits in 65 freshwater fish species: Application to the domestication of new fish species. Reviews in Fish Biology and Fisheries. 2009;**19**:403-430

[57] Tamazouzt L, Fontaine P, Terver D. Décalage de la période de reproduction de la perche (*Perca fluviatilis*) en eau recyclée. Ichtyophysiologica Acta. 1994;**7**:29-40

[58] Migaud H, Fontaine P, Sulistyo I, Kestemont P, Gardeur J-N. Induction of out-of-season spawning in Eurasian perch *Perca fluviatilis*: Effects of cooling and chilling periods on female gametogenesis and spawning. Aquaculture. 2002;**205**:253-267

[59] Migaud H, Gardeur J-N, Kestemont P, Fontaine P. Off-season spawning of Eurasian perch *Perca fluviatilis*. Aquaculture International. 2004;**12**:87-102

[60] Migaud H, Fontaine P, Kestemont P, Wang N, Brun-Bellut J. Influence of photoperiod on the onset of gonadogenesis in Eurasian perch *Perca fluviatilis*. Aquaculture. 2004;**241**: 561-574

[61] Migaud H, Wang N, Gardeur J-N, Fontaine P. Influence of photoperiod on reproductive performances in Eurasian perch *Perca fluviatilis*. Aquaculture. 2006;**252**:385-393

[62] Fontaine P, Pereira C, Wang N, Marie M. Influence of pre-inductive photoperiod variations on Eurasian perch *Perca fluviatilis* broodstock response to an inductive photothermal program. Aquaculture. 2006;**255**:410-416

[63] Wang N, Gardeur J-N, Henrotte E, Marie M, Kestemont P, Fontaine P. Determinism of the induction of the reproductive cycle in female Eurasian perch, *Perca fluviatilis*: Effects of environmental cues and modulating factors. Aquaculture. 2006;**261**:706-714

[64] Wang N, Teletchea F, Kestemont P, Milla S, Fontaine P. Photothermal control of the reproductive cycle in temperate fishes. Reviews in Aquaculture. 2010;**2**:209-222

[65] Abdulfatah A, Fontaine P, Kestemont P, Gardeur J-N, Marie M. Effects of photothermal kinetic and amplitude of photoperiod decrease on the induction of the reproduction cycle in female Eurasian perch *Perca fluviatilis*. Aquaculture. 2011;**322-323**:169-176

[66] Abdulfatah A, Fontaine P, Kestemont P, Milla S, Marie M. Effects of the thermal threshold and the timing of temperature reduction on the initiation of reproduction cycle in female of Eurasian perch *Perca fluviatilis*. Aquaculture. 2013;**376-379**:90-96

[67] Fontaine P, Wang N, Hermelink B. Chapter 3. Broodstock management and control of the reproductive cycle. In: Kestemont P, Dabrowski K, Summerfelt RC, editors. Biology and Culture of Percid Fishes: Principles and Practices. Dordrecht, The Netherlands: Springer; 2015. pp. 103-122

[68] Henrotte E, Mandiki R, Prudencio A, Vandecan M, Mélard C, Kestemont P. Egg and larval quality, and egg fatty acid composition of Eurasian perch breeders (*Perca fluviatilis*) fed different dietary DHA/EPA/AA ratios. Aquaculture Research. 2010;**41**:51-63

[69] Henrotte E, Kaspar V, Rodina M, Psenicka M, Linhart O, Kestemont P. Dietary n-3/n-6 ratio affects the biochemical composition of Eurasian perch (*Perca fluviatilis*) semen but not indicators of sperm quality. Aquaculture Research. 2010;**41**:31-38

[70] Wang N. Déterminisme multifactoriel de la qualité du cycle de reproduction chez la perche commune *Perca fluviatilis*. Approche multifactorielle. Thèse de l'Université Henri Poincaré. Nancy. 2006;**1**:140 p

[71] Castets M-D. Fonction de reproduction et régulation de la qualité chez la perche commune, *Perca fluviatilis* [thèse de l'I.N.P.L]. Nancy. 2011. p. 301

[72] Kucharczyk D, Kujawa R, Mamcarz A, Skrzypczak A, Wyszomirska E. Induced spawning in perch, *Perca fluviatilis* L. using carp pituitary extract and HCG. Aquaculture Research. 1996;**27**:847-852

[73] Kucharczyk D, Kujawa R, Mamcarz A, Skrzypczak A, Wyszomirska E. Induced spawning in perch, *Perca fluviatilis* L. using FSH + LH with pimozide or metoclopramide. Aquaculture Research. 1998;**29**:131-136

[74] Kucharczyk D, Szczerbowski A, Luczynski MJ, Kujawa R, Mamcarz A, Wyszomirska E, et al. Artificial spawning of Eurasian perch, *Perca fluviatilis* L. using ovopel. Archives of Polish Fisheries. 2001;**9**:39-49

[75] Kouril J, Linhart O, Relot P. Induced spawning of perch by means of a GnRH analogue. Aquaculture International. 1997;**5**:375-377

[76] Rónyai A, Lengyel SA. Effects of hormonal treatments on induced tank spawning of Eurasian perch (*Perca fluviatilis* L.). Aquaculture International. 2010;**41**:345-347

[77] Targońska K, Szczerbowski A, Zarski D, Luczynski MJ, Szkudlarek M, Gomulka P, et al. Comparison of different spawning agents in artificial out-of-season spawning of Eurasian perch, *Perca fluviatilis* L. Aquaculture Research. 2014;**45**:765-767

[78] Goetz FW, Theofan G. In vitro stimulation of germinal vesicle breakdown and ovulation of yellow perch (*Perca flavescens*) oocytes. Effects of 17a-hydroxy-20ß-dihyroxyprogesterone and prostaglandins. General and Comparative Endocrinology. 1979;**37**:273-285

[79] Goetz FW, Duman P, Berndtson A, Janowsky EG. The role of prostaglandins in the control of ovulation in yellow perch, *Perca flavescens*. Fish Physiology and Biochemistry. 1989;**7**:163-168

[80] Dabrowski K, Ciereszko A, Ramseyer L, Culver D, Kestemont P. Effects of hormonal treatment on induced spermiation and ovulation in the yellow perch (*Perca flavescens*). Aquaculture. 1994;**120**:171-180

[81] Żarski D, Bokor Z, Kotrik L, Urbányi B, Horváth A, Targońska K, et al. A new classification of a preovulatory oocyte maturation stage suitable for the synchronization of ovulation in controlled reproduction of Eurasian perch, *Perca fuviatilis* L. Reproductive Biology. 2011;(3):194-209

[82] Żarski D, Horváth A, Kotrik L, Targońska K, Palińska K, Krejszeff S, et al. Effect of different activating solutions on the fertilization ability of Eurasian perch, *Perca fuviatilis* L., eggs. Journal of Applied Ichthyology. 2012;**28**:967-972

[83] Kestemont P, Mélard C, Held JA, Dabrowski K. Chapter 9. Culture methods of Eurasian perch and yellow perch early life stages. In: Kestemont P, Dabrowski K, Summerfelt RC, editors. Biology and Culture of Percid Fishes: Principles and Practices. Dordrecht, The Netherlands: Springer; 2015. pp. 265-293

[84] Fiogbé ED. Contribution à l'étude des besoins nutritionnels chez les larves et juvéniles de la perche fluviatile (*Perca fluviatilis* L.) [thèse de doctorat]. Facultés Universitaires Notre-Dame de la Paix, Namur, Belgique. 1996. p. 334

[85] Tamazouzt L, Leray C, Escaffre AM, Terver D. Effects of particle size on *Perca fluviatilis* larval growth. Aquatic Sciences. 1998;**60**:89-98

[86] Tamazouzt L, Chatain B, Fontaine P. Tank wall colour and light level affect growth and survival of perch larvae (*Perca fluviatilis* L.). Aquaculture. 2000;**182**:85-90

[87] Jourdan S. Influence de facteurs abiotiques, la photopériode et l'intensité lumineuse, sur la survie et la croissance de larves, post-larves et juvéniles de perche *Perca fluviatilis* L [thèse de l'I. N.P.L.]. Nancy. 1999. 147 p

[88] Awaiss A, Kestemont P, Micha JC. Nutritional suitability of the rotifer *Brachionus calyciflorus* Pallas for rearing freshwater fish larvae. Journal of Applied Ichthyology. 1992;**8**:263-270

[89] Kestemont P, Mélard C, Fiogbé ED, Vlavonou R, Masson G. Nutritional and animal husbandry aspects of rearing early life stages of Eurasian perch *Perca fluviatilis*. Journal of Applied Ichthyology. 1996;**12**:157-165

[90] Vlavonou RS. Elevage expérimental de la perche *Perca fluviatilis* L.: Développement larvaire et croissance [thèse de doctorat]. Université de Metz, France. 1996. p. 48

[91] Vlavonou RS, Masson G, Moretteau JC. Growth of *Perca fluviatilis* larvae fed with *Artemia* spp. *Nauplii* and the effects of initial starvation. Journal of Applied Ichthyology. 1999;**15**:29-33

[92] Kestemont P, Fiogbé ED, Parfait O, Micha JC, Mélard C. Relationship between weaning size, growth, survival and cannibalism in the common perch larvae, *Perca fluviatilis*: Preliminary data. In: Lavens P, Jaseprs E, Roelants I (eds), Larvi'95, Fish and Shellfish Larviculture Symposium. Eur. Aquacult. Soc. Spe. Pub. 24, Ghent, Belgium, 1995. pp 285-288

[93] Mélard C, Baras E, Mary L, Kestemont P. Relationship between stocking density, growth, cannibalism and survival rate in intensively cultured larvae and juveniles of perch (*Perca fluviatilis*). Annales Zoologici Fennici. 1996;**33**:643-651

[94] Baras E, Kestemont P, Mélard C. Effect of stocking density on the dynamics of cannibalism in sibling larvae of *Perca fluviatilis* under controlled conditions. Aquaculture. 2003;**219**:241-255

[95] Kestemont P, Jourdan S, Houbart M, Mélard C, Paspatis M, Fontaine P, et al. Size heterogeneity, cannibalism and competition in cultured predatory fish larvae: Biotic and abiotic influences. Aquaculture. 2003;**227**:333-356

[96] Ribi G. Perch larvae (*Perca fluviatilis* L.) survived better in dilute sea water. Aquatic Sciences. 1992;**54**:85-90

[97] Bein R, Ribi G. Effects of larval density and salinity on the development of perch larvae (*Perca fluviatilis*). Aquatic Sciences. 1994;**56**:97-105

[98] Egloff M. Failure of swimbladder inflation of perch, *Perca fluviatilis* L., found in natural populations. Aquatic Sciences. 1996;**58**:15-23

[99] Mandiki RSNM, Blanchard G, Mélard C, Koskela J, Kucharczyk D, Fontaine P, et al. Effect of geographic origin on growth and food intake in Eurasian perch (*Perca fluviatilis* L.) juveniles under intensive culture conditions. Aquaculture. 2004;**229**:117-128

[100] Szczerbowski A, Luczynski MJ, Kucharczyk D. The effect of surface water spray on swimbladder inflation, survival and growth of perch (*Perca fluviatilis* L.) larvae reared under controlled conditions. In: Grizel H, Kestemont P, editors. Aquaculture and Water: Fish Culture, Shell Fish Culture and Water Usage. Aquaculture Europe'98, Bordeaux, France. European Aquaculture Society Special Publications 26. 1998. pp. 261-262

[101] Jacquemond F. Sorting Eurasian perch fingerlings (*Perca fluviatilis* L.) with and without functional swim bladder using tricaine methane sulfonate. Aquaculture. 2004;**231**:249-262

[102] Jacquemond F. Separated breeding of perch fingerlings (*Perca fluviatilis* L.) with and without initial inflated swim bladder: Comparison of swim bladder development, skeleton conformation and growth performances. Aquaculture. 2004;**239**:261-273

[103] Alix M, Zarski D, Chardard D, Fontaine P, Schaerlinger B. A detailed investigation of deformities in newly hatched embryos revealed variations among Eurasian perch populations reared in pond or RAS conditions. Journal of Zoology. 2017;**302**:126-137

[104] Alix M, Chardard D, Ledoré Y, Fontaine P, Schaerlinger B. An alternative developmental table to describe non-model fish species embryogenesis: Application to the description of the Eurasian perch (*Perca fluviatilis* L. 1758) development. EvoDevo. 2015;**6**(1):39

[105] Anthouard M, Fontaine P. L'auto-alimentation chez la perche (*Perca fluviatilis*): Adaptation à cette modalité de nourrissage et mise en évidence du rythme nycthéméral de la prise alimentaire. Ichtyophysiologica Acta. 1998;**21**:1-13

[106] Jourdan S, Fontaine P, Boujard T, Vandeloise E, Gardeur JN, Anthouard M, et al. Influence of daylength on growth, heterogeneity, gonad development, sexual steroid and thyroid levels, and N and P retention and waste in *Perca fluviatilis*. Aquaculture. 2000;**186**:253-265

[107] Mélard C, Kestemont P, Grignard JC. Intensive culture of juvenile and adult Eurasian perch (*Perca fluviatilis*): Effect of major biotic and abiotic factors on growth. Journal of Applied Ichthyology. 1996;**12**:175-180

[108] Fontaine P, Gardeur J-N, Kestemont P, Georges A. Influence of feeding level on growth, intraspecific weight variability and sexual growth dimorphism of Eurasian perch *Perca fluviatilis* L. reared in a recirculation system. Aquaculture. 1997;**157**:1-9

[109] Strand Å, Alanårå A, Staffan F, Magnhagen C. Effects of tank colour and light intensity on feed intake, growth rate and energy expenditure of juvenile Eurasian perch, *Perca fluviatilis* L. Aquaculture. 2007;**272**:312-318

[110] Strand Å, Magnhagen C, Alanårå A. Effects of repeated disturbances on feed intake, growth rates and energy expenditures of juvenile perch, *Perca fluviatilis*. Aquaculture. 2007;**265**:163-168

[111] Acerete L, Balasch JC, Espinosa E, Josa A, Tort L. Physiological responses in Eurasian perch (*Perca fluviatilis*, L.) subjected to stress by transport and handling. Aquaculture. 2004;**237**:167-178

[112] Jentoft S, Aastveit AH, Torjesen PA, Andersen Ø. Effects of stress on growth, cortisol and glucose levels in non-domesticated Eurasian perch (*Perca fluviatilis*) and domesticated

rainbow trout (*Oncorhynchus mykiss*). Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology. 2005;**141**:353-358

[113] Juell JE, Lekang OI. The effect of feed supply rate on growth of juvenile perch (*Perca fluviatilis*). Aquaculture Research. 2001;**32**:459-464

[114] Fiogbé ED, Kestemont P. Optimum daily ration for Eurasian perch *Perca fluviatilis* L. reared at its optimum growing temperature. Aquaculture. 2003;**216**:243-252

[115] Fiogbé ED, Kestemont P, Mélard C, Micha J. The effects of dietary crude protein on growth of the Eurasian perch *Perca fluviatilis*. Aquaculture. 1996;**144**:239-249

[116] Kestemont P, Vandeloise E, Mélard C, Fontaine P, Brown P. Growth and nutritionnal status of Eurasian perch *Perca fluviatilis* fed graded levels of dietary lipids with and without added ethoxyquin. Aquaculture. 2001;**203**:85-99

[117] Xu X, Fontaine P, Mélard C, Kestemont P. Effects of dietary fat levels on growth, feed efficiency and biochemical compositions of Eurasian perch *Perca fluviatilis*. Aquaculture International. 2001;**9**:437-449

[118] Blanchard G, Makombu JG, Kestemont P. Influence of different dietary 18:3n-3/18:2n-6 ratio on growth performance, fatty acid composition and hepatic ultrastructure in Eurasian perch, *Perca fluviatilis*. Aquaculture. 2008;**284**:144-150

[119] Geay F, Kestemont P. Chapter 22. Feeding and nutrition of percid fishes during ongrowing stages. In: Kestemont P, Dabrowski K, Summerfelt RC, editors. Biology and Culture of Percid Fishes: Principles and Practices. Dordrecht, The Netherlands: Springer; 2015. pp. 587-622

[120] Lucas S. Variations de la composition chimique des tissus de la perche eurasienne élevée en circuit fermé. In: DEA Sciences Agonomiques. Nancy: INPL; 1997. 40 p

[121] Mairesse G, Thomas M, Gardeur J-N, Brun-Bellut J. Appearance and technological characteristics in wild and reared Eurasian perch, *Perca fluviatilis* (L.). Aquaculture. 2005;**246**:295-311

[122] Mairesse G, Thomas M, Gardeur J-N, Brun-Bellut J. Effects of geographic source, rearing system, and season on the nutritional quality of wild and farmed *Perca fluviatilis*. Lipids. 2006;**41**:221-229

[123] Mathis N, Feidt C, Brun-Bellut J. Influence of protein/energy ratio on carcass quality during the growing period of Eurasian perch (*Perca fluviatilis*). Aquaculture. 2003;**217**:453-464

[124] Mairesse G, Thomas M, Gardeur J-N, Brun-Bellut J. Effects of dietary factors, stocking biomass and domestication on the nutritional and technological quality of the Eurasian perch *Perca fluviatilis*. Aquaculture. 2007;**262**:86-94

[125] Gardeur JN, Mathis N, Kobilinsky A, Brun-Bellut J. Simultaneous effects of nutritional and environmental factors on growth and flesh quality of *Perca fluviatilis* using a fractional factorial design study. Aquaculture. 2007;**273**:50-63

[126] Thomas M, Mairesse G, Gardeur J-N, Brun-Bellut J. Chapter 33. Concept and determination of quality in percid fishes. In: Kestemont P, Dabrowski K, Summerfelt RC,

editors. Biology and Culture of Percid Fishes: Principles and Practices. Dordrecht, The Netherlands: Springer; 2015. pp. 843-864

[127] Rougeot C, Jacobs B, Kestemont P, Mélard C. Sex control and sex determinism study in Eurasian perch, *Perca fluviatilis*. Aquatic Living Resources. 2002;**16**:90-94

[128] Rougeot C, Nicayenzi F, Mandiki SNM, Rurangwa E, Kestemont P, Mélard C. Comparative study of the reproductive characteristics of XY males and hormonally sex-reversed XX male Eurasian perch, *Perca fluviatilis*. Theriogenology. 2004;**62**:790-800

[129] Rougeot C. Chapter 23. Sex and ploidy manipulation in percid fishes. In: Kestemont P, Dabrowski K, Summerfelt RC, editors. Biology and Culture of Percid Fishes: Principles and Practices. Dordrecht, The Netherlands: Springer; 2015. pp 625-634

[130] Rougeot C, Virumumbalu Ngingo J, Gillet J, Vanderplasschen A, Mélard C. Gynogenesis induction and sex determinism study in Eurasian perch, *Perca fluviatilis*, by use of hormonally sex-reversed male breeders. Aquaculture. 2005;**243**:411-415

[131] Rougeot C, Minet L, Prignon C, Vanderplasschen A, Detry B, Pastoret P-P, et al. Induce triploidy by heat shock in Eurasian perch, *Perca fluviatilis*, by use of hormonally sex-reversed male breeders. Aquaculture. 2003;**211**:81-89

[132] Ben Khadher S. Etude de la variabilité génétique de populations sauvages et captives de la perche eurasienne *Perca fluviatilis*, espèce en cours de domestication. Doctorat Université de Lorraine, 2015. p. 232

[133] Ben Khadher S, Agnèse J-F, Milla S, Teletchea F, Fontaine P. Patterns of genetic structure of Eurasian perch (*Perca fluviatilis* L.) in Lake Geneva at the end of the spawning season. Journal of Great Lakes Research. 2015;**41**:846-852

[134] Ben Khadher S, Fontaine P, Milla S, Agnèse J-F, Teletchea F. Genetic characterization and relatedness of wild and farmed Eurasian perch (*Perca fluviatilis*): Possible implications for aquaculture practices. Aquaculture Report. 2016;**3**:136-146

[135] Kestemont P, Mélard C. Chap. 11 - Aquaculture. In: Craig JF, editor. Percid Fishes. Systematics, Ecology and Exploitation. Oxford: Blackwell Science; 2000. pp. 191-224

[136] Kestemont P, Dabrowski K, Summerfelt RC. Biology and Culture of Percid Fishes: Principles and Practices. Vol. 901. Dordrecht, The Netherlands: Springer; 2015

[137] Fontaine P. Les marchés de la perche. Journées Techniques Black Bass, Perche, Sandre. Poisy-Chavanod, France. 1996

[138] Fontaine P. Le grossissement de la perche. Journées Techniques Black Bass, Perche, Sandre. Poisy-Chavanod, France. 1996

[139] Fontaine P. Production et marché de la perche: Bilan et perspectives. Journées Aquacoles Nationales. Nancy, France. 1997

[140] Fontaine P. Grossissement de la perche en circuit fermé. Journées Aquacoles Nationales. Nancy, France. 1997

[141] Toner D, Rougeot C. Aquaculture explained special publication—Farming of Eurasian perch. Vol. 1. Juvenile Production. Bord Lascaigh Mhara. Irish Sea Fisheries Board; 2008. 80 p

[142] Teletchea F, Fontaine P. Levels of domestication in fish: Implications for the sustainable future of aquaculture. Fish and Fisheries. 2014;**15**:181-195

[143] Bigarré L, Plassiart G, de Boisséson C, Pallandre L, Pozet F, Ledoré Y, et al. Molecular investigations of outbreaks of perch Perhabdovirus affections in pikeperch. Diseases of Aquatic Organisms. 2017;**127**:19-27

[144] Kristan J, Stejskal V, Policar T. Comparison of reproduction characteristics and broodstock mortality in farmed and wild Eurasian perch (*Perca fluviatilis* L.) females during spawning season under controlled conditions. Turkish Journal of Fisheries and Aquatic Sciences. 2012;**12**:191-197

[145] Khendek A, Alix M, Viot S, Ledoré Y, Rousseau C, Mandiki R, et al. How does a domestication process modulate oogenesis and reproduction performance in Eurasian perch? Aquaculture. 2017;**473**:206-214

[146] Douxfils J, Mandiki SNM, Marotte G, Wang N, Silvestre F, Milla S, et al. Does domestication process affect stress response in juvenile Eurasian perch *Perca fluviatilis*? Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology. 2011;**159**:92-99

[147] Douxfils J, Mathieu C, Mandiki SNM, Milla S, Henrotte E, Wang N, et al. Physiological and proteomic evidences that domestication process differentially modulates the immune status of juvenile Eurasian perch (*Perca fluviatilis*) under chronic confinement stress. Fish and Shellfish Immunology. 2011;**31**:1113-1121

[148] Douxfils J, Desprez M, Mandiki SNM, Milla S, Henrotte E, Mathieu C, et al. Physiological and proteomic responses to single and repeated hypoxia in juvenile Eurasian perch under domestication—Clues to physiological acclimation and humoral immune modulations. Fish and Shellfish Immunology. 2012;**33**:1112-1122

[149] Douxfils J, Lambert S, Mathieu C, Milla S, Mandiki SNM, Henrotte E, et al. Influence of domestication process on immune response to repeated emersion stressors in juvenile Eurasian perch (*Perca fluviatilis* L.). Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology. 2014;**173**:52-60

[150] Douxfils J, Mandiki SNM, Mathieu C, Milla S, Kestemont P. Chapter 29. Domestication and responses to stress. In: Kestemont P, Dabrowski K, Summerfelt RC, editors. Biology and Culture of Percid Fishes: Principles and Practices. Dordrecht, The Netherlands: Springer; 2015. pp. 743-760