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BETTER MANAGEMENT PRACTICES FOR CARP PRODUCTION IN CENTRAL AND EASTERN EUROPE, THE CAUCASUS AND CENTRAL ASIA

Better Management Practices for Carp Production in Central and Eastern Europe, the Caucasus And Central Asia

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PREPARATION OF THIS DOCUMENT

The Central Asian aquaculture sector was hit hard by the collapse of the former Union of Soviet Socialist Republics (USSR). The sector's output decreased significantly after the independence of the Central Asian economies. However, the sector has shown clear signs of recovery in the last few years. Production is increasing and governments are giving more attention to fisheries and aquaculture as they recognize the benefits of the sector.

In the framework of the FAO Turkey Partnership Programme (FTPP), the Turkish Government, through its Ministry of Food, Agriculture and Livestock (MFAL), provides assistance to several countries of the subregion, namely, Azerbaijan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkey, Turkmenistan and Uzbekistan, for which the FAO Sub-regional Office for Central Asia (SEC) is responsible.

The development goal of the regional programme is to increase the performance of the Central Asian fisheries and aquaculture sector in terms of its capacity to generate food, employment and income, and in terms of economic viability, environmental compatibility and social acceptability. This programme has been sustained under the project GCP/RER/031/TUR. One of the important initiatives of the project is the preparation of better management practices (BMPs) for sustainable management of fisheries and aquaculture.

After the Second World War most of the countries of Central and Eastern Europe (CEE)[1] also belonged to the political and economic partnership of the USSR. Therefore, in all CEE and Caucasus and Central Asia (CCA) countries the same or at least very similar principles, approaches and technologies were practiced, including fish culture in general and carp production in particular. During the decades of socialist political and economic partnership fish farm managers, specialists and scientists exchanged views, ideas and learned from each other. Therefore, the current carp production techniques and technologies in CEE and Caucasus[2] and Central Asia[3] (CCA) developed together, hence are very similar.

Because of the above reasons, the original title and planned contents of the present document were extended to embrace the entire region where carp is cultured according to the same principles. Consequently, this document will support the sustainable management of the vast 400.000 hectares of fish pond resources of CEE and CCA.

The present publication is thought to gradually contribute to the dissemination of best practices for the use of the Eastern Europe, Caucasus and Central Asia

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1 Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Republic of Moldova, Montenegro, Poland, Romania, the Russian Federation, Serbia , Slovakia, Slovenia and Ukraine

2 Armenia, Azerbaijan and Georgia.

3 Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.

countries as well as the relevant fisheries management organizations, including the newly formed Central Asian and Caucasus Regional Fisheries and Aquaculture Commission. These BMPs are expected to be practically useful for people involved in aquaculture, particularly the owners of carp hatcheries and farms and employees of these establishments.

ABSTRACT

Common carp is the most widely cultured Cyprinid. It is indigenous to Eurasia, but has been introduced practically everywhere outside its native geographical and climatic range.

For centuries, common carp was the main species of the fish ponds of Europe and Central Asia. Today, it remains the best choice for utilizing fish pond resources under the temperate climate of Central and Eastern Europe, the Caucasus and Central Asia. In the countries of these regions, carp is produced in polyculture where the application of better management practices (BMPs) could significantly contribute to the physical and financial development of its producers and the health of the environment.

This guide describes and explains the key biological, technical, economic, social and environmental aspects of BMPs of carp production. The topics have been chosen because there are many benefits to the aquaculture sector and to its stakeholders in adopting BMPs. Reduced public cost of managing the sector, higher production efficiency, better access to markets, increased profitability, and improved image and reputation of the fish farms and their representation are among them.

The establishment and maintenance of efficient fish farm facilities and infrastructure and the optimum utilization of feeds and other production inputs require skilled and knowledgeable farm managers and workers. These create the preconditions for a successful and sustainable carp aquaculture.

This document deals with the related BMPs of advanced fry and grow-out production of carps in general and of common carp in particular. These are presented together with the related activities in a systematic, concise and easy-to-read format.

Natural culture of carp and the biological control of water weeds with carps are special polyculture production systems. Their BMPs are also discussed.

Although at present the production of common carp is feasible only in pond polyculture, this document also presents useful and practical information about monoculture and intensive culture of carp in tanks and cages.

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ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
BMP	Better Management Practice
CCA	Caucasus and Central Asia
CEE	Central and Eastern Europe
CIS	Commonwealth of Independent States
D°	Day degree
FAO	Food and Agriculture Organization of the United Nations
FIRA	Fisheries and Aquaculture Service
FTPP	FAO-Turkey Partnership Programme
GEF	Global Environment Facility
H°	Hour degree
ha	hectar
kcal	kilocalorie
kg	kilogram
KHV	Koi herpesvirus
MFAL	Ministry of Food, Agriculture and Livestock
mg	milligram
min	minimum
ml	millilitre
NACA	Network of Aquaculture Centres in Asia-Pasific
no	number
Qty	quantity
SEC	Sub regional Office for Central Asia
UNDP	United Nations Development Programme
USA	United States of America
USSR	Union of Soviet Socialist Republics

1. INTRODUCTION

1.1 Justification and background of better management practices (BMPs) of carp culture in CEE and CCA

Before the huge changes in the politics and economies in the regions countries of Central and Eastern Europe (CEE)[1], the Caucasus[2] and Central Asia[3] (CCA), carp culture in ponds was the most widely practiced fish culture technique. Between 1950 and 1990, the characteristics of this several centuries-old technique changed considerably in these countries. Chinese major carps[4] were introduced and intensive carp polyculture technologies were developed and practiced.

Until 1990, three- and five-year central plans characterized and determined the economy of CEE and CCA countries in which intensity took priority over profitability in fish production. Although intensive carp culture in ponds yielded impressive volumes of physical product, the economic performance of the farms began to be questioned as soon as the countries shifted to a market economy.

One of the characteristics of the three- and five-year economic plans was that prices of inputs and outputs were centrally determined and fixed, and any quantity of fish produced was readily absorbed by the markets.

Countries started changing towards the market economy from the late 1980s and the early 1990s. The transition included the privatization of fish farms. During this period, fish farms lacked financial resources for capital investments and operating costs. Financial constraint was compounded by the absence of technical information that would have helped owners and technical staff to find the most suitable and applicable technologies. This was because the technologies that could produce the most profit under the changed economic conditions were missing.

Before the 1990s government managed capture fishery in natural waters and water reservoirs through regulation. In many of these waterbodies, the role and proportion of carps were significant. These were restocked with fish produced in the fish farms. After the 1990s, enforcement of such government regulations weakened or even disappeared. What followed was a long and steady decline in the production in both capture fisheries and aquaculture, shown in Tables 1 and 2. Causes for the collapse included among others:

- institutional and political factors (e.g. the lack of governmental and non-governmental structures to promote the use of irrigation systems for fish production, the absence of legislation to ensure the rights of private fish farmers to guaranteed water supply, limited interest from the governments

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1 Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Republic of Moldova, Montenegro, Poland, Romania, the Russian Federation, Serbia, Slovakia, Slovenia and Ukraine

2 Armenia, Azerbaijan and Georgia

3 Kazakhstan, Tajikistan, Kyrgyzstan, Uzbekistan and Turkmenistan

4 Silver carp, bighead carp, grass carp and black carp

in fisheries in the years after independence, absent or bad management of waterbodies, and conflicts between government institutions about their duties, rights and responsibilities with regards to the inland aquatic resources),

- economic factors (e.g. a lack of government financing and private investments in the industry and absence of specialized credit lines for aquaculture and culture based fishery enterprises, reduction in investment in research and production facilities to insignificant levels, decreased subsidies and efforts made to maintain hatcheries in good conditions and lack of investment in modern processing and marketing facilities and equipment),
- social factors (e.g. poverty increase in rural areas led to increased poaching, return of fishery and aquaculture specialists to their home countries outside the region, poorly planned and premature privatization of the industry combined with widespread corruption in the handover process), and
- technical factors (e.g. lack of academic and vocational education in fisheries and aquaculture resulting in limited numbers of skilled aquaculture and fisheries workers, closure of facilitating industries, such as feed production and insufficient access to good quality fry and lack of quality feed).
- While recognizing the collapse of the sector, it should be noted that currently most of the catches go unrecorded (generally because of lack of information and statistics capacity) and IUU[5] fishing is widespread in inland waters of many CEE and CCA countries. This is because appropriate policy, legal and institutional frameworks are generally lacking, outdated or are not being properly enforced or implemented.

TABLE 1

Average aquaculture production of carps in Central and Eastern Europe, in the Commonwealth of Independent States and in selected neighbouring countries between 1988 and 2008

Country	Average of periods					
	1988 – 1989	1989 - 1990	1990 - 1991	1991 - 1992	1992 - 2000	2000 – 2008
	Tonnes					
Albania	429	402	235	126	45	46
Belarus	16 976	17 214	15 681	11 080	5 186	4 794
Bosnia and Herzegovina						2 257
Bulgaria	10 324	8 655	7 131	7 255	4 791	1 909
Croatia				2 722	3 053	2 575
Czech Republic					15 326	18 521
Czechoslovakia	17 881	18 611	18 887	19 581	2 280	

5 Illegal, unreported and unregulated (IUU).

Country	Average of periods					
	1988 – 1989	1989 - 1990	1990 - 1991	1991 - 1992	1992 - 2000	2000 – 2008
	Tonnes					
Estonia	206	395	403	327	70	53
Hungary	18 700	18 534	15 579	14 052	9 925	11 347
Latvia	4 598	4262	2268	1 460	439	497
Lithuania	4 098	4569	4 681	4 325	2 065	2 317
Macedonia (Former Yugoslavia Republic)				121	341	233
Republic of Moldova	6 951	6 949	6133	4 030	1 447	3 325
Poland	21 924	22 062	23 700	25 350	21 137	20 249
Romania	48 416	40 505	31 785	26 765	14 978	8 400
Serbia						1 813
Serbia and Montenegro				1 150	3 200	2 040
Slovakia					426	266
Slovenia				52	187	231
Ukraine	95 028	87 574	66 781	56 243	37 664	25 803
Socialist Federal Republic of Yugoslavia	10 000	10 872	8 872	3 000		
Total of CEE countries	**255 530**	**240 601**	**202 132**	**177 636**	**122 560**	**106 673**
Armenia	4 280	4 423	3 444	2 229	861	716
Azerbaijan	1 633	1 419	1 681	1 905	603	52
Georgia	780	564	1 625	1 821	250	52
Kazakhstan	7 878	9 134	11 304	8 255	1 693	614
Kyrgyzstan	1 062	1 038	928	749	195	55
Tajikistan	3 246	3 435	3 646	2 782	667	69
Turkmenistan	2 422	2 437	2 329	2 099	1 058	28
Uzbekistan	20 723	21 468	23 122	21 524	10 407	3 791
Total of Commonwealth of Independent States countries	**42 024**	**43 916**	**48 077**	**41 363**	**15 735**	**5 376**
Grand total of CEE and Commonwealth of Independent States countries	**297 553**	**284 517**	**250 209**	**218 999**	**138 295**	**112 049**
China	3 842 098	3 959 410	4 131 432	4 493 703	8 504 369	12 554 962
Iraq	4 000	2 300	1 675	3 250	3 642	8 276
Islamic Rep. of Iran	25 250	25 627	22 951	20 324	25 180	65 259
Russian Federation	147 748	210 927	179 762	104 631	65 165	85 207
Turkey	1 617	1 085	767	341	643	643

Source: FAO, Department of Fishery and Aquaculture, online query of global aquaculture production, 2011.

TABLE 2

Changes of aquaculture production of carps in Central and Eastern Europe, the Commonwealth of Independent States and in selected neighbouring countries between 1988 and 2008

Country	Period					
	1988 – 1989	1989 - 1990	1990 - 1991	1991 - 1992	1992 - 2000	2000 - 2008
	%					
Albania	100	94	55	29	10	11
Belarus	100	101	92	65	31	28
Bulgaria	100	84	69	70	46	18
Czechoslovakia	100	104	106	110	13	-
Estonia	100	192	196	159	34	26
Hungary	100	99	83	75	53	61
Latvia	100	93	49	32	10	11
Lithuania	100	111	114	106	50	57
Republic of Moldova	100	100	88	58	21	48
Poland	100	101	108	116	96	92
Romania	100	84	66	55	31	17
Ukraine	100	92	70	59	40	27
Yugoslavia SFR	100	109	89	30	-	-
Total of CEE countries	**100**	**94**	**79**	**70**	**48**	**42**
Armenia	100	103	80	52	20	17
Azerbaijan	100	87	103	117	37	3
Georgia	100	72	208	233	32	7
Kazakhstan	100	116	143	105	21	8
Kyrgyzstan	100	98	87	71	18	5
Tajikistan	100	106	112	86	21	2
Turkmenistan	100	101	96	87	44	1
Uzbekistan	100	104	112	104	50	18
Total of Commonwealth of Independent States Countries	**100**	**105**	**114**	**98**	**37**	**13**
Grand total of CCA and Commonwealth of Independent States countries	**100**	**96**	**84**	**74**	**46**	**38**
China	100	103	108	117	221	327
Iraq	100	58	42	81	91	207
Islamic Republic of Iran	100	101	91	80	100	258
Russian Federation	100	143	122	71	44	58
Turkey	100	67	47	21	40	40

Opportunities for the sector in general and for producers of carps in particular are good: consumer demand for fisheries and aquaculture products is increasing with increasing incomes. Generally, consumption as well as production of fish in the 1980s was tenfold of today's. This shows the potentials. As demand for affordable fish is large, fish pond owners and their managers can be certain that finding the right approach to sustainable production of carps will improve profitability in the coming decades.

1.2 Why BMPs for carp culture is needed[6]

"Better management practices" abbreviated as "BMPs" is used in several ways and in various contexts. Its most obvious meaning is that it is the best-known way to undertake any activity at a given time. In this sense, it refers to the practice or practices of producers who are performing better than the average (see Figure 1).

BMP also refers to a set of guidelines that is developed on population-based risk factor studies, in consultation with the practitioners and relevant stakeholders and on the evaluation of current practices. Adoption of BMPs is expected to lead to an overall improvement bring benefits such as:

- optimizing the utilization of resources, facilitating sustainability and increasing profit,
- improving growth performance,
- minimizing disease occurrence,
- improving environmental conditions by reducing impacts on the environment, and
- attaining food quality standards and improving marketability of the product.

It is important to note that BMPs is a set of management guidelines instead of standards. Adoption of the guidelines is relatively easy to achieve without increased costs. "Better" also implies that BMPs is always evolving, open and improving as the culture practices also improve (see Figure 1).

Although most BMPs have an overall similarity in guidelines and in objectives, there are significant variations between commodities and locations.

Land, water, broodfish, fish seed, feed and labour are very important inputs for aquaculture. Using these resources correctly and efficiently guarantees optimum production. Pond polyculture of large cyprinids (common carp and Chinese major carps) with predator fishes is very common in the countries of CEE and CCA. Both regions have more than 400 000[7] ha of fish farms and small water reservoirs, but most of these huge resources are underused.

Generally, fish farmers continue with production of carp in polyculture but in a different way from what was practiced until the period of 1990-1991. During that time intensive and semi-intensive pond culture was widespread. Today, however,

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6 This chapter followed the logic and adopted the main views and points of the relevant chapter of the document; Development of Better Management Practices for Catfish Aquaculture in the Mekong Delta, Vietnam (001/07VIE).

7 It is about a total of 350 000 ha in Central Eastern Europe countries and is approximately 50 000 ha in the countries of the Caucasus and Central Asia.

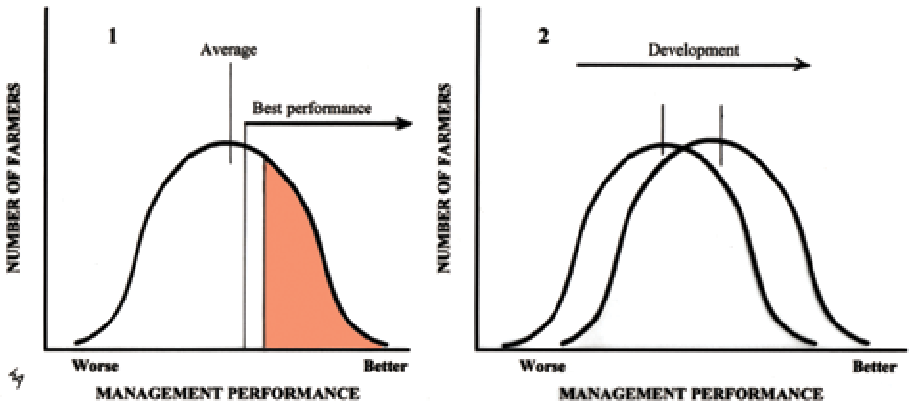
most farmers practice the extensive production methods. In fact, extensive pond polyculture is the cheapest way of carp production. In this case, the growth of fish is based on the natural fish food that grows in ponds. Even though farmers use manure and fertilizers, they are still far from the optimum regarding the correct identification and proper utilization of physical, financial and human resources. Though fish farmers produce and sell fish and they could generate profit, many of them need to improve their management practices in order to obtain better, safer and more profitable results.

Producing and consuming fish is one of the cheapest ways to provide protein to people. However, using land and water resources effectively is also very important. BMPs of different aquatic species have been contributed to farmers' success in places where they have been used (see Box 1).

Similar results are expected from this BMPs of carp culture. If practiced in CEE and CCA countries, they will help fish farmers to follow the necessary steps and achieve improvements and benefits.

FIGURE 1

Schematic variation curve of worse, better and best management performance



1) The bell curve illustrates the variation of farmers' management performance. There most of the farmers are around the average, but the number of those whose practice approaches towards worse and better is continuously reducing. Best producers are those whose performance is well above the average and comply with predefined criterions.

2) Farmers with best performance ensure and dictate the development and sophistication of management practices. Therefore, the knowledge and introduction of better management practices will support the development of the actual management performance of farmers.

Source: Tucker and Hargreaves, 2008.

BOX 1

Benefits of BMPs in aquatic farming systems

It is clear that adoption of BMPs has brought about very significant beneficial impacts to different aquatic farming systems.

In the early 2000s, India started to use BMPs of shrimp production. Today it is one of the major shrimp producers in the world. In this instance, not only could the farmers adopt better the BMPs but their collective action through being organized into societies improved yields, minimized disease occurrences, and resulted in increased profits among benefits. Being organized improved their economy of scale. Similarly, Indonesia and Bangladesh are following the same steps and achieving similar success because of their improved production practices. Egypt is one of the most important tilapia producers and it reached that level because of using BMPs of tilapia.

In countries where production of catfish is widespread, BMPs helps farmers in their decisions.

1.3 Objectives and scope

The objectives of the document are to support the carp farmers with applicable concepts and solutions. This concise introduction to BMPs aims to improve the overall knowledge of fish farmers, who grow carps in CEE and CCA. Hence, it is envisaged that this publication will serve as an effective tool of carp farmers and will support them in finding feasible options, answering questions and solving problems. Therefore, if fish farmers acquire familiarity with the subject and they can improve their production on a more sustainable and profitable way, the objectives will be fully achieved.

Common carp (*Cyprinus carpio*) can be cultured in ponds, tanks or cages. Pond culture is practically the only way it is being farmed in the two regions. The contribution of tank and cage culture of carp to the overall production is so small that it is not being captured in statistics. Therefore, this document is dedicated to BMPs of carp production in ponds, while the most important aspects of producing carps in tanks and cages are discussed in an attachment to this document (see Appendix 5).

Preconditions of successful carp production are both the good quality and the usability of farm facilities. This is why a chapter is dedicated to BMPs of construction, rehabilitation and maintenance of the different direct and indirect production facilities which is presented in Figure 2.

FIGURE 2
Elements of BMPs of production facilities of carp culture in ponds

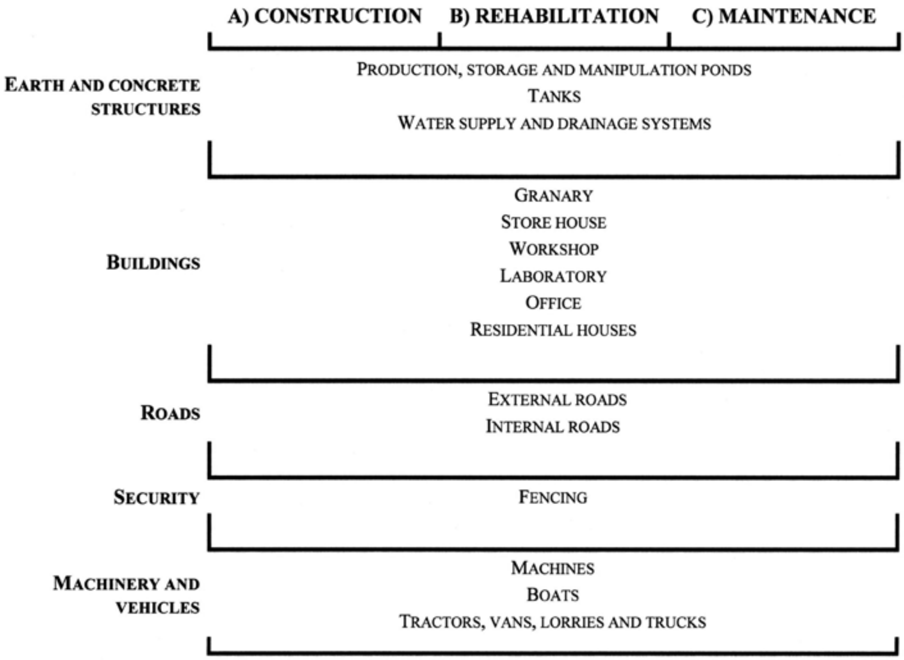


Illustration courtesy of Andras Woynarovich

When required farm facilities are ready, fish farmers may concentrate on production and related activities. The elements of BMP, presented in Figure 3, help to understand how the different tasks, activities and related socio-economic issues follow and link to each other. Consequently it will guarantee easy understanding of the information and proper adoption of the recommendations presented in the following chapters.

It is emphasized that this document is neither a scientific study nor a manual of instruction. It is a set of BMPs of carp production compiled for fish farmers who would like to improve management practices and obtain more profitable results in a sustainable way. Though the coming chapters contain many key information, solutions and data, the readers may need to check further useful details. For this reason, references are made not only in the chapter of the used references but also in Appendix 8 where thematically listed relevant FAO documents can be found.

FIGURE 3

Elements of BMPs of carp production in ponds

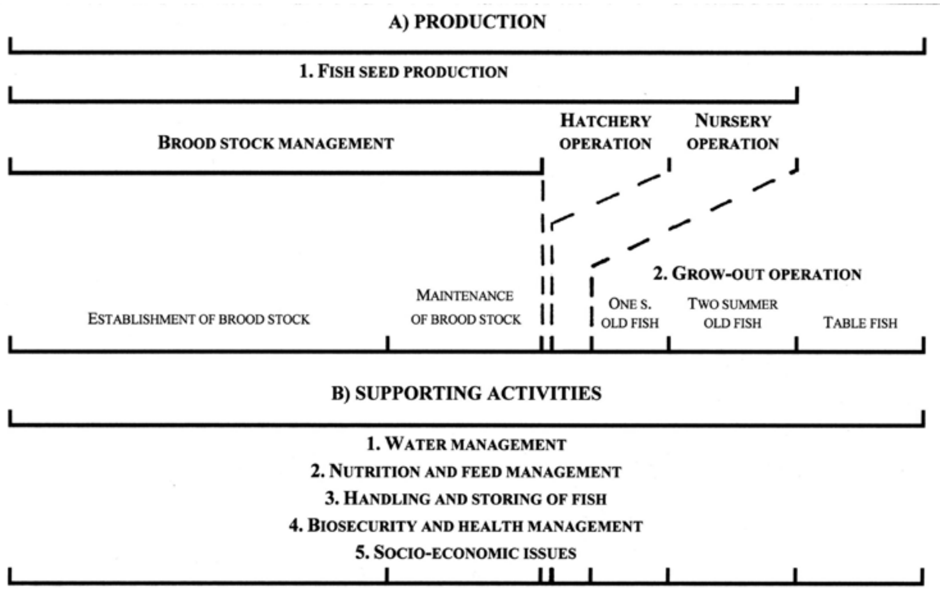


Illustration courtesy of Andras Woynarovich

2. FARM FACILITIES, MACHINERY AND VEHICLES

There is a certain production infrastructure and production environment that should be created and maintained to achieve reliable long-term physical and financial results in fish production. The farm infrastructure includes facilities (ponds, tanks, buildings, roads and fencing), machinery (pumps, aerators, grinders, feed mixer), and vehicles (boats, tractors, vans, lorries and/or trucks). This chapter describes the following activities:

- construction of new fish farm facilities,
- rehabilitation and maintenance of old and existing fish farm facilities, and
- rehabilitation and maintenance of machinery and vehicles.

2.1 Construction of new fish farm facilities

At design and construction of new fish farm facilities some important feasibility criteria should be considered as presented in Appendix 7. At design and construction of new facilities the BMP principles are:

- new facilities should be built in accordance with acceptable engineering and construction practices and under the guidance of experienced engineers and contractors,
- many potential problems can be avoided by employing contractors who have previous experience in construction fish ponds, water supply and drainage structures and farm buildings, and
- a well-designed farm will minimize potential long-term problems.
- For future development, the potential enlargement of a new fish farm needs to be considered. The size of the farm depends on the size of land, the amount and quality of available water and the management capacity for the farm. Water supply should be reliable and pipes and canals large enough to fill up ponds. If possible, both water supply and drainage of ponds should be done by gravity.

Water, road and electricity (if possible) should be within reach of a farm site before starting construction. Usually electricity is the principal energy of a fish farm. Therefore, it is better to select a site where it is easy and affordable to connect the farm to the national electricity grid.

Professional engineering design needs detailed topography of the site, as well as analyses of water and soil quality.

Farm facilities for carp production include ponds, earth and concrete tanks and farm buildings such as granary, stores, workshops and offices. Fish hatchery and housing for staff are optional, but staff accommodations are helpful for their well-being as well as farm security.

Ponds and outdoor tanks

Most important parts of a carp fish farm are the production and storage/wintering ponds and outdoor tanks to keep fish before their stocking, transport or sale.

Fish hatchery

It is optional to establish and operate a fish hatchery. During the decision-making and planning stages, the following factors should be considered:

- capital investment cost (building, water system, devices, equipment and tools),
- size of pond area occupied by brood fish,
- cost of feed and other production materials, and
- cost of labour.

Farm buildings

A simple feed store with processing machines is an organic part of a new fish farm (see Figure 32 in Chapter 5). This and a small but well-equipped mechanical workshop will ensure proper maintenance of equipment, machinery and vehicles.

A modern fish farm should accommodate a small laboratory where simple tests and hydrobiological investigations can be performed with the objectives described in Chapters 3 and 7. It is advantageous to locate the administrative unit of a new farm in a building from which the ponds can be viewed and easily reached.

Roads

Good tarmac and well-maintained dust roads within the farm will make it easier and quicker to transport production materials and fish.

2.1.1 Site selection

When planning a new fish farm, the prospective site should be examined in a systematic way, taking into consideration the quantitative and qualitative characteristics of the site and the availability, volume and quality of water.

Suitability of the site is important because it fundamentally determines the feasibility of viable fish production. The location and available resources should meet all the requirements. BMP principles of site selection are:

- site location and its climate should be suitable for carp culture,
- adequate area for construction of the initial farm and its future expansion,
- good quality and sufficient quantity of available water throughout the year is essential,
- topography and soil should be suitable for constructing ponds, buildings, and access roads, site should be fully drainable,

- site should not be on a flood and pollution prone area and should not occupy a natural water course,
- good, all-weather access to the farm through a well maintained road is important to ensure efficient delivery of supplies and ability to reach markets as required,
- should not be too remote, as cost effective availability of utility services such as electricity, phone etc. is important, and
- geographical location should facilitate easy access to services and markets.

Serious consideration should also be given to provide on-farm accommodation in order to ensure security and rapid response to critical situations. Key staff can live on the farm or stay there in shifts.

Soil quality

Different soil characters deeply affect the quality of pond construction and influence fish production results. Therefore, soil quality should be carefully tested. Soil for pond construction should be impermeable and strong enough to build dykes. Loam is the best soil for dyke construction. If sandy loam soil is used for dykes, the dyke crown should be widened and the gradient of the slope decreased.

Chemical properties of soil, especially too low or too high pH or too high concentration of salts will also influence fish production. If, for example, the iron content in the water is too high, ferric hydroxide will form colloid in water and will deposit on the pond bottom. This rusty sediment may hinder the respiration of fish and the development of fish eggs and fry.

Topography of site

Fish farms can be constructed on flat, gently sloping or on hilly sites. On flat or gently sloping areas, contour ponds are built while barrage ponds are usually constructed on hilly sites. Both types of pond, as well as their combinations, are suitable for carp culture.

2.1.2 Water source

The most important requirement in fish culture is water supply. Therefore both quality and quantity of the available water should be checked as summarized below.

TABLE 3

Qualitative parameters of the technological water

Quality/parameters	Minimum	Optimal/ desired range	Maximum	Lethal
Temperature (C°)	4	20–25	30	35–35.8
Turbidity (mg/l)		<25		
pH	6.5	7–8	8.5	<4.7 – >10.8
Salinity (‰)		0.5 – 1.5	5.0000	
Relative conductivity (at 20 °C) μS/cm		800	1 600	
Dissolved oxygen (mg/l)	4	>6		
Hardness (ppm)	100	120 – 180	300	
Ammonium ion (mg/l) (pH dependent)		<1.0000	2.5000	see Table 6
Free ammonia (mg/l)			0.0200	
Nitrite ion (mg/l)		<0.1000	0.3000	
Nitrate ion (mg/l)		<20	40	
Hydrogen sulphide (mg/l)			0.0020	
Orthophosphate ion (mg/l)		0.3000	2.0000	
Arsenic (mg/l)		0.0500	0.1000	
Zinc (mg/l)		0.2000	0.7000	1.0000
Mercury (mg/l)		0.0005	0.0010	
Cadmium (mg/l)		0.0030	0.0040	0.0050
Chrome – total (mg/l)		0.0100	0.0200	0.1000
Nickel (mg/l)		0.0200	0.1000	
Lead (mg/l)		0.0100	0.0500	0.1000
Iron (mg/l)		<0.5000	0.9000	
Copper (mg/l)		0.2000	0.0220	1.0000
Cyanide (mg/l)		0.0100	0.1000	
Total suspended material (mg/l)		1 000	1 500	
Crude oil (mg/l)				0.6000
Petroleum (mg/l)				0.3000
Diesel (mg/l)				0.0400
Petrol (mg/l)				0.0050

Source: Papp and Fűrész, 2003.

Quality of water

In general, any surface or underground water free of poisonous substances and/or pollution is good for carp culture. To be sure that the water is suitable for carp culture its quality must be checked in a laboratory. Qualitative criterions of water are listed in Table 3.

The wastewater from some food processing mills such as slaughterhouses, breweries and bean curd works is rich in organic materials. These may be beneficial to fish farming through fermentation, sedimentation or controlled introduction to fish ponds.

Underground water often contain gases and minerals that might be harmful to fish. Artesian water is too cool and its oxygen content may be low. Therefore, it should be stored in a tank or pond before it is used in a fish hatchery. Waters of mining origin may be too acidic to culture fish.

Quantity of water

At site selection seasonal availability of water in the required quantity is a prime criterion. Therefore, collection and analyses of relevant information, such as hydrology and precipitation are important. Plan of the yearly used water is the precondition of selecting a site for carp culture. Accordingly, the following aspects should be considered:

- quantity of water needed to fill up the different ponds before the production seasons. It is usually at least 1.2–1.5 times more than the actual volume of the pond, and
- quantity of water needed during the production seasons to replace seepage and evaporation of pond water.

If a farm is constructed along a lake, river or reservoir, the highest and lowest water levels measured in the last 25 years has to be checked. The site should be selected only if the area was free of floods and droughts within the last 25 years. If, for some reason a flood affecting area is planned to be selected, flood prevention should be done.

2.1.3 Pond construction

Ponds should be planned and constructed with environmental considerations. Relevant BMP principles are:

- Pond should not be constructed in the vicinity of large trees. They will shed the water surface and their roots may cause seepage. Their leaves will fall into the water from where they have to be removed.
- A fish pond broad from the east to the west will receive more solar irradiance.
- Size and depth of pond should serve well the actual production. In case of hilly areas, the topography of the site is what determines the size of new ponds. In case of flat sites, it is easier to plan and construct fish ponds of uniform size.
- Nursery ponds should be less than a few hectares. Their optimal size varies between 0.05 and 5 ha and they should not be deeper than 1.0–1.2 metres on average.
- Grow-out ponds should be both large (5–50 ha) and also deep (1.5–2.5 metres).
- If possible, the shape and size of the similar type of ponds should be uniform.

- Both water supply and drainage structures should be large enough to fill up and drain ponds within the required time listed in Table A14. In case of barrage ponds, located in a row and drain into each other, the design and construction of overflow is important. This will ensure passing through heavy rains. All overflows should be screened to prevent escape of fish from the pond.
- Dikes should be build layer by layer, and each new level must be well compacted and worked together with the below one.
- Before the construction of a fish pond starts, fertile top soil full of roots should be removed and the remaining soil below should be well compacted. It is often recommended to replace the removed top soil evenly along the pond bottom. This layer should also be compacted.

Earthen ponds should be constructed on land that has proper soil texture and low organic content to minimize seepage. Poorly designed and constructed ponds will need more maintenance hence will decrease farm profitability. Pond construction considerations are:

- If possible, ponds should be rectangular in shape to facilitate harvesting and to reduce construction costs.
- Average pond depth should be as specified for nursery and grow-out ponds.
- Pond bottom should be flat and gently sloping (3‰–5‰) towards the deeper end. A slight slope from dyke foot to the central area helps drainage and harvest operation. This will allow proper drainage and drying pond bottom after harvest.
- Inlets and outlets should be installed. For each pond these should be located at opposite ends of the pond. This allows sufficient retention of fresh water and also facilitates mixing during water change.
- Slope of dykes should be determined by a specialized civil engineer as it depends on the soil from which the dykes are built. Embankments steeper than soil allows erode quickly and hence increase maintenance costs.
- Pond dykes should be high enough to hold water and resist wind and waves.
- Slopes of dykes should be enforced against erosion with planted grass. Grass grown on the dykes can be fed to fish. Gravel on the crown of dykes will allow easy movement, even on rainy days.
- Construction should be carried out during “dry” season to minimize sediment runoff.
- Care should be taken to avoid polluting adjacent waters with silt. Temporary silt fences can be installed during construction to slow down and catch potential suspended sediments. Materials such as woven plastic or fabric, or hay bales can be used for this purpose.

Water intake and drainage system

This system is to maintain water level and change water in ponds. This is why an independent water intake and drainage system should be constructed. This system also includes inlet and outlet canals and its bypass channels, such as aqueducts, culverts, stilling basins, slice gates etc.

2.2 Rehabilitation of fish farm facilities, machinery and vehicles

During decades of use both the physical state and the quality of fish ponds decay. It is especially true if maintenance of ponds and other farm facilities was neglected, or if during the transition period of early 1990s ponds remained unused. Most frequent problems of old and unused ponds are:

- dykes, water supply and drainage structures are damaged,
- reed and sedge, or even bush, covers most of the pond area,
- thick silt/sludge which accumulated on the pond bottom during the decades,
- water seeps away from ponds,
- farm roads are damaged,
- farm buildings often are deserted and decayed,
- fencing is destroyed, or entirely missing, and
- machinery and vehicles are broken.

FIGURE 4
Different types of drainage structures used in fish ponds

Monks made out of iron sheets and pipes (above). Traditional monk (below left) and open monk (below right) made out of concrete. Open monks facilitate to trap the fish during drainage of the pond.

Those monks are the suitable ones, which are equipped with three parallel grooves on both internal sides. This will allow quick and proper control and management of pond water. Grooves should be parallel and their internal surface smooth to hold water properly if planks are placed into them. Monks with only one set of grooves, as shown above right, do not allow pond draining from the bottom. Through such monks water drains only from the surface.

Photos courtesy of Andras Woynarovich.

2.2.1 Rehabilitation of dykes and water management structures

In order to improve the production efficiency and productivity of ponds, their physical state and qualities should be improved through rehabilitation and renovation.

During the years, the sections of dykes exposed to waves will decay. If damage is small, it is enough to enforce the dike with a wicker-work or corrugated iron sheets, as demonstrated in Figure 5. It is not cheap, but polyethylene nets are strong, hence they can be used well to protect dyke against erosion.

If dikes collapse, the damaged parts should be repaired with a bulldozer. During a well-planned day, a lot can be done with a hired machine.

Dykes are often damaged on their crowns, due to heavy movements of vehicles and lack of maintenance of the road built on their top. Passing and compacting the damaged sections with a grader then covering them, with stone chips will improve durability of the dyke.

FIGURE 5
Different ways to enforce dyke against erosion

Stone and reed will prevent erosion of dyke.

Such support of dyke should be repaired yearly.

Photos courtesy of Andras Woynarovich.

FIGURE 6
Typical damage of a dyke to be repaired with bulldozer

Photos courtesy of Andras Woynarovich.

FIGURE 7
Typical sight of fish pond to be rehabilitated

Photos courtesy of Andras Woynarovich.

A widely experienced problem is that the water supply canal and/or connecting pipes are broken and water outlets are damaged so much that they can hardly be used. In case of such problems emerge the structure should be repaired in order to avoid bigger problems later.

It is advantageous if ponds have uniform size and shape. In case of rehabilitation of ponds, especially of nursery and storage ponds, such aspects should be considered.

2.2.2 Removing vegetation from unused ponds

On the bottom of unused ponds tick vegetation may develop. If the pond bottom is mainly dry this will be bush, while where pond bottom remains wet reed and sedge will develop. First step in these cases is to drain the pond in order to dry its bottom. After drying vegetation (including roots) can and should be removed. A plough, harrow or harrow disk serve well this purpose.

FIGURE 8

Typical view of unused fish ponds

Photos courtesy of Andras Woynarovich.

2.2.3 Removing sludge from pond bottom

One of the direct effects of fish production is that silt/sludge deposits intensively on the pond bottom. Ideal situation is when silt/sludge is less than 15 cm on the pond bottom. In ponds that are continuously used silt should be removed. It can be done with the dry and wet methods.

Dry method is when the pond bottom is dried and the dry silt/sludge is removed. It can be done manually or with a machine. Scooping all of the unwanted silt is definitely a laborious method. The pond silt should not be deposited on the pond dyke, because when it rains the silt will be drained into the pond and damage the pond structure and water quality.

Wet method is when a sucking dredger is used. This is a much more popular method, as it is convenient and feasible for almost every pond-keeper. This option is especially recommended when the sludge is very deep (0.5–0.8 m). Such operation is always less expensive than the construction of a new fish pond. In addition, dry fertile pond silt and/or sludge may be used for crop and grass production.

A widely followed practice is when the sludge is stirred in the pond during drainage. For this purpose carp is fed at the outlet where they dig the pond bottom for feeds. As feeding is done in the internal harvesting pit where sludge usually deposits, considerable quantities will drain out of the pond. In this case silt and/or sludge traps should be used as recommended earlier.

2.2.4 Seepage control of fish ponds

In case of seepage, investigation should be made to find its reason before taking any corresponding measures. If the pond bottom or dyke contains a lot of sand or grit soil, pond leakage is predictable. New ponds often leak, but this reduces by time. Evenly spreading clay soil on the pond bottom can also help, as well as about 10 m^3/ha of cow dung spread on the pond bottom several times.

If the leakage is due to poor construction of dykes, they should be compacted. The same applies for the pond bottom. If it still leaks, spreading heavy clay soil or reconstructing of the dyke properly are the only options.

2.2.5 Improvement of pond soil quality

Acid soils are common in many parts of the world. This type of soil can be regulated with limestone ($CaCO_3$), quicklime (CaO) or slaked lime ($Ca(OH)_2$). However, the feasibility of this method depends on local conditions. Practical experience showed that soils of pH 5 require approximately 2 tons/ha of limestone while those with pH 4 require 4–6 tons/ha.

Newly-dug fish ponds may contain too much heavy metal which harms fish growth and often causes body-curved disease of fry. Therefore, in the first two years it is better to produce two-year-old and table fish. If ponds are planned being used to rear fry, the water of pond should be changed before stocking fry, so as to wash away the excessive elements which are harmful to fry.

BOX 2

Provision of services in pond and road rehabilitation and maintenance

Investing in suitable machinery such as bulldozer, graders, scrapers and dredgers in order to repair or rehabilitate only own fish ponds and roads is not feasible even if the size of fish farm is big.

If such machinery is use not only by the owner but they are also rented in the frame of affordable services for other neighbouring farms both parties will benefit. In addition to improved pond and road conditions, the service provider will obtain better and quicker return of the investment, while those who hire the services will be able to rehabilitate and maintain their ponds and roads.

In case of acute problems government supported specialised cooperation can be a feasible solution (see details in Chapter 8).

2.2.6 Rehabilitation of farm roads and buildings

Even a simple calculation can compare the benefits of keeping farm roads in good conditions. Good quality roads facilitate quick and timely movement of staff, material and fish. On the contrary, poor quality roads slow down or even may stop movements. Therefore, rehabilitation of fully damaged farm roads is essential. Steps of rehabilitation dust roads of farms are:

- levelling the surface of road with a grader or a scraper,
- Covering the surface of road with stone chips, and
- Compacting the surface of road.

Often farm buildings are also in decaying state. These should also be renovated and used for the purpose they were originally built for.

2.2.7 Fencing

Fencing of a fish farm is a rather expensive investment. Still, such investment will return well through increased safety and reduced pouching. Though price of mechanical fence is high, hedges created out of bushes and shrubs will serve well the purpose.

2.2.8 Rehabilitation of machinery and vehicles

There are many power machines (tractors and bulldozers), boat engines and vehicles on the fish farms of many CEE and CCA countries which were manufactured still before 1990s. By today most of them are in poor or off-road conditions. On the other hand there is a huge demand for works such as rehabilitation and maintenance of fish ponds and proper and timely transport of inputs and fish. Their reconditioning could help to satisfy this demand.

There is a wide range of good examples of BMPs in many countries including western countries, where programme and projects are initiated and implemented. These government or producers' associations supported regional or local initiatives, together with banks and private sector, can efficiently recondition old motors, machinery and vehicles.

2.3 Maintenance of fish farm facilities, machinery and vehicles

Proper maintenance of fish farm facilities, machinery and vehicles must be part of the daily routine.

2.3.1 Maintenance of ponds and tanks

Prevention in the form of immediate repairs is the best remedy against costly maintenance works. It is especially true if water supply and drainage structure or dykes are damaged. Related BMP principles are:

- a fish pond or tank, regardless of its material (soil or concrete), should be kept dry, whenever they are not used,
- the major period of pond maintenance, including the water management structures, is when they are dry. This is the time when feeding and drainage canals, pipes, monks and dykes should be inspected and systematically repaired, and
- tanks, especially outdoor concrete tanks, should also be inspected from time to time to detect and repair cracks that may grow longer and larger later. The same applies for all of the concrete structures of the fish farm.

2.3.2 Maintenance of roads and buildings

Dust roads usually become damaged after heavy rains or during thawing in spring. During these periods, the surface of roads loosens, which worsens if water remains in the furrows left by the wheels of vehicles. Such water pools on the road will enlarge and deepen unless they are properly drained and levelled.

Tarmac and paved roads can be damaged because of heavy traffic, rains and ice. These destroy both the surface and the foundation of roads. The changes as a road decays are almost invisible at the beginning, but larger cracks will appear rather soon, especially after winter. This is why it is so important to discover the problems in time and repair them when they are still small. Maintenance of tarmac and paved roads includes the maintenance of the drainage canals on their side. This ensures that water will not remain to loosen and freeze the surface and foundation of the road.

Maintenance of proper physical conditions of buildings is also important. Here also starting cracks should be checked on the foundation, walls and roofs and be repaired immediately.

2.3.3 Maintenance of machinery and vehicles

Maintenance is the only way to keep machines, boat engines and vehicles on the road in a reliable working condition. For this reason they should be inspected each time, before they are used according to their factory specification. If a problem is detected, it should be repaired immediately before it is worse.

Having a small but well equipped workshop together with a store with substantial spare parts is one of the preconditions of keeping machinery and vehicles in good reliable working condition.

3. CARP CULTURE

Carp production in the countries of CEE and CCA is associated with carp polyculture in ponds. This also includes a wide range of different steps and related activities, which all depend on and link to each other. As Figure 3 in Chapter 1 shows, carp culture consists of broodstock management and hatchery, nursery and grow-out operations. Consequently, related BMPs are discussed in this sequence.

3.1. Broodstock management

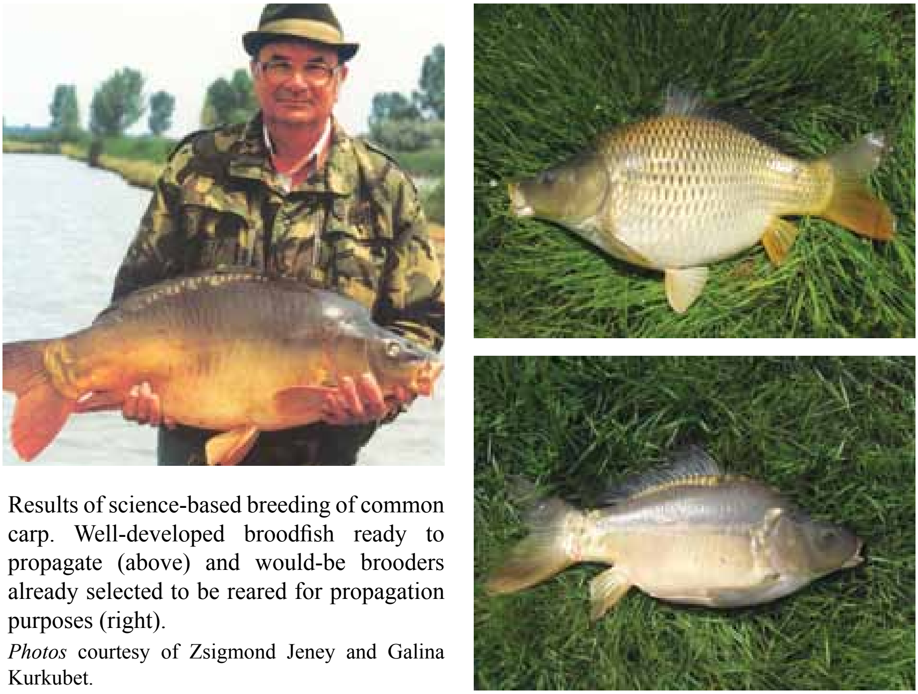
Quality fish seed is the basis of successful carp culture and it depends on the broodstock. Creating and maintaining broodstock in a controlled pond environment with no reliance on wild populations of unknown and unpredictable performance will ensure production of quality progeny in the form of good quality eggs, feeding larvae and advanced fry in the desired quantities.

3.1.1 Establishment of broodstock

Establishment of broodstock is the first step if a fish farm plans to produce feeding larvae. Each such farm has to establish its own broodstock by selecting and rearing the best-performing females and males with known genetic background.

FIGURE 9

Common carp broodfish



Results of science-based breeding of common carp. Well-developed broodfish ready to propagate (above) and would-be brooders already selected to be reared for propagation purposes (right).

Photos courtesy of Zsigmond Jeney and Galina Kurkubet.

When deciding the size of carp broodstock, planned quantities of produced larvae have to be determined on the basis of the guiding figures presented in Tables A12 and A13. Although the reproductive potential of carps is huge, it is advisable to keep 25–50 percent more brood fish than the quantity which is planned to be propagated yearly. This facilitates adjusting to the actual demand, as well as ensures to use only the best females and males.

Rearing of broodfish

Rearing of 4–6 kg large sexually well developed and matured brood fish starts with separating suitable would-be brood fish when they become about 1.5 kg. It is important that only young well performing perfect specimens should be selected for this purpose. Although finding and picking out the largest specimens from a given population is tempting, it is not recommended. Healthy fish, perfect in shape and appearance with an average weight of the population is the best choice for rearing brood fish.

Works of rearing would-be brooders includes their time to time selection and overall management. Selection of future brooders should be based on the following phenotypic characteristics:

- shape of body,
- even and regular distribution of scales,
- healthy look and appearance with desired hereditary characteristics, and
- lack of wounds, deformation or parasites.

Ponds where future brood fish are reared should be large enough to ensure the natural conditions for the growing fish. This is because the objective is to have males and females which are not too large, but their eggs and sperm producing capacities are good. For the management of future brooders BMP principles are the following:

- In order to protect them from poaching the broodstock ponds should be in the centre of the farm.
- Broodstock ponds built on productive soil should be smaller but deeper than production ponds. Optimum size is around 1–2 ha, where about 150–200/ha 1.5 kg big common carp (~ 30%), silver carp (~ 30%) and grass carp (~ 30%) and some other species (~ 10%) such as tench and predator fishes can be reared in polyculture without feeding carp. At this fish density only manuring and feeding of grass carp is needed. At low stocking density enough natural food remains for the developing fish. Preparation and manuring of a brood fish rearing pond is done in the same way as the production ponds of two-summer-old and table fish (Horváth, Tamás and Tölg, 1984).

3.1.2 Maintenance of broodstock

Broodstock should be treated with special care in order to obtain the best possible quality progeny. Maintenance of broodstock is a year-round operation which consists of pre- and post propagation phases.

The post propagation maintenance period of broodstock starts when males and females from the hatchery are stocked and kept until the following year, when they are separated again for propagation. Brood fish can be stocked into the ponds of two-summer-old fish (about 10–20 carp brooder/ha) if they are harvested in autumn or the following spring. In case there is no such pond, a separate pond should be used. The guiding rules of stocking are:

- Number of stocked brooders of common carp and Chinese major carps may vary between 300 and 500 per hectare in case there is water supply to change water. Otherwise the number of stocked brooders should not be more than 200–250 fish/ha. Stocking 0.1–0.3 kg large European catfish (200–300 fish/ha) will keep the pond clean from wild spawning (Horváth, Tamás and Tölg, 1984).
- After breeding, energy and protein-rich (25–30 percent) feeds are important for yolk production in the newly developing eggs.
- Manuring and fertilization of pond will provide for natural food while feeds at a rate of 1–3 percent of BW[8] per/day will ensure appropriate supplementary feeding of carp.

Pre-propagation period starts in the spring when the work with carp brooders are:

- Checking the physical and sexual state of breeders, and at the same time separating the matured ones[9] by sex. This is done when water temperature reaches 8–12 °C. When checking, milt will appear on slight pressure on the abdomen of males and females will have large medium soft bellies because of the well-developed ovaries. Sexually uncertain breeders should be stocked with males. Not matured fish should be returned to rearing ponds.
- In spring it is essential to stock males and females in separate ponds. For this, wintering ponds serve well, where brood fish can be kept in high density if water is continuously changed.
- Spawners should be fed in the spring with feeds high in animal protein and rich in vitamins to secure strong, healthy and well-performing brooders for propagation. Two weeks before propagation season, daily feeding should be reduced to one percent of body weight.

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8 BW is the abbreviation of body weight.

9 It is if future and actual stocks of brooders are reared together in same ponds.

3.2 Hatchery operations

Propagation is one of the most difficult periods in the life of brooders and one of the most important technological phases of carp culture. Provision of the best possible infrastructure, the best trained staff and professional management are essential in order to produce high-quality progeny.

In CEE and CCA, carp hatcheries can be used for propagation of many different fish species from early spring to early summer. The season starts with pike and continues with pikeperch, carp, tench, European catfish, and finish with Chinese major carps. Carp propagation takes place once a year, during late spring (around May). The period lasts about 4–6 weeks. Hatchery operation related works include induced ovulation, fertilization of eggs, incubation of eggs and rearing hatched larvae.

BOX 3

Criterions of a good carp hatchery

Carp hatcheries are universal and can be used for producing feeding larvae of many different freshwater fish species. A carp hatchery should be simple but equipped with a suitable water supply system and devices.

The water system must be reliable to deliver enough water of the required quality (free of pollutants, colloids, mud, silt, floating particles and plankton crustaceans). The best is if water arrives to the hatchery from an elevated water source by gravity.

Water supply from a very extensively stocked, not manured and fertilized pond or water reservoir may be good. Water from a production pond carries risks, hence it is not recommended, unless the arriving water is properly filtered.

If underground water is used, it has to be kept before use in a smaller pond or larger cistern to make it live and rich in oxygen.

Control of water temperature is essential only in large carp hatcheries. In smaller ones temperature control is not so important. Uncontrolled water temperature does not allow early start of carp propagation (maximum 1 week earlier), and it may also slow down the development of eggs and hatched larvae on colder nights and days. However, the undisputable advantage is that such hatchery has a lower cost of investment and operation.

The devices of a fish hatchery are:

- tanks to keep brood fish during hormone treatment,
- jars for the incubation of eggs,
- jars for rearing hatched larvae, and
- troughs or small tanks to rear fish fry.

3.2.1 Induced ovulation and fertilization of eggs

Induced ovulation consists of a complex set of tasks. These are:

- selection of suitable females and males for propagation and putting them into the hatchery,
- inducing ovulation with hormone treatment.
- Stripping eggs and milt, and
- fertilization and treatment of eggs before incubation.

BOX 4

Comparative notes on induced spawning and ovulation of common carp

There is a well developed technology for induced spawning of carp. It is when females and males are stocked into special shallow ponds to produce fry. In order to ensure and synchronise spawning, females are treated with carp pituitary. After stocking, females and males spawn. Released and fertilized eggs and hatched larvae remain in the pond until they are big enough (at lest 1–2 gr.) to be harvested and stocked for further rearing.

Induced ovulation of carp described in Chapter 3.2.1 is done under controlled hatchery conditions.

When comparing of the two methods, the produced number of one-summer-old fish per one kg BW of female shows huge differences. The efficiency of induced spawning is only 5 percent while the result of induced ovulation and its subsequent operations is about 20 percent. If the number of produced advanced fry is calculated the advantage is even more pronounced.

Source: Antalfi and Tölg, 1971

Selection of broodfish for propagation

It is a simple procedure which should be done swiftly as described in Figure 10. Those brooders which are checked but not selected should be gently released back to the pond.

Inducing ovulation and fertilization of eggs

Induced ovulation of common carp is the technique when hormone is administered into ripe female and male fish in order to induce the final maturation and ovulation of eggs in females and release the sperm in males. For this purpose dry carp pituitary (hypophysis) glands or different hormone products[10] are used. BMP principles of induced ovulation are:

- During hormone treatment males and females are kept in tanks separately, where each fish should receive about 4–6 l/min. water.
- It is essential to keep females and males undisturbed between hormone treatments and ovulation. Only a quiet surroundings, and a safe supply of at least 20 °C (optimum: 22–24 °C) warm water with high oxygen content (5–6 mg/l) will ensure good results. Covering tanks with a dense net will provide shelter and will prevent fish for jumping.
- Males are injected only once with about 2 mg hypophysis[11] per kg BW suspended in fish physiological solution[12]. This injection is administered when males are transferred to the hatchery.
- Females receive about 3.5–4.5 mg hypophysis per kg BW in two doses. About 10 percent of the calculated total dose is given as a preliminary (preparatory, priming) dose at their transfer to the hatchery.

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10 Producers have their own brands which are traded under different names.

11 Application of synthetic hormones traded by different producers is an alternative way.

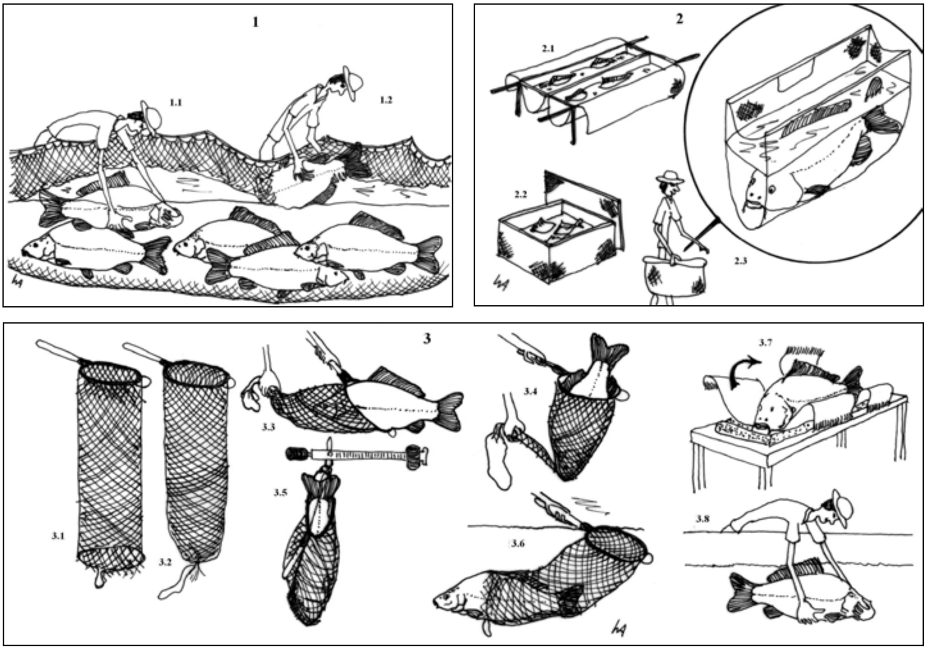
12 It is 0.7% iodide free NaCl solution.

Before the first dose is administered females should be weighed and marked with a tag in the sequence showed in Figure 10. Tag is usually a piece of coloured tread fixed on the dorsal fin. Each colour indicates a different weight (for example: 4 kg → blue, 5 kg → yellow, etc). This will facilitate exact calculations of the decisive doses.

The second, decisive dose is due 10–12 hours after the first one during late evening hours, so the ovulation occurs next morning.

FIGURE 10

Selection, transfer and weighing of brooders



(1) – Belly of brooders should be checked gently with hand without lifting them out of the water (1.1). Those which are good should be lifted out of the water and examined gently (1.2).

(2) - Brooders should be moved in a plastic bag or in a suitable container made of canvas (2.1 and 2.3) or fibreglass (2.2).

(3) - Both-end-open scoop net has a string with which it can be temporarily closed (3.1 and 3.2). This scoop net is used for capturing (3.3 and 3.4) and weighing (3.5) brooders before the preparatory doses of hormone are injected. After injection males are released (3.6). Females are tagged before first injection (3.7). After injection, fish should be placed gently into the tank by hand (3.8).

Source: A. Woynarovich and E. Woynarovich, 1998.

- Before the second dose the genital opening of females should be closed with a suture (see Figure 11). Use of "shallow anesthetisation"[13] during the closing of genital opening and administration of second dose will reduce stress of fish.

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13 Many products are suitable for this purpose. For example, the solution of MS 222 (tricaine methane-sulphonate) at a dilution of 1:10 000 (10 gr/100 litre water) or clove oil (at the concentration of 3 ml/100 litre) is also applicable.

- Ovulation can be expected within 240–260 hour-degrees[14] (H°) after the second injection (see Figure 12).
- Stripping of females and males should also be done in anesthetised condition.
- Collecting eggs and milt need to be done in absolutely dry condition. Weighing of stripped eggs on a letter or kitchen balance will help calculating the exact number of produced eggs and hatched and feeding larvae.
- Milt of two males, about a total of 10 ml, should be used for fertilizing 1 kg of dry eggs.
- When dry eggs and milt are properly but gently mixed, eggs should be fertilized with the solution of 4 gr/litre iodide free NaCl and 3 gr/litre pure carbamide.

After about 10 minutes continuous stirring, a new solution (4 gr./l NaCl and 16 gr./l carbamide) should be used. When fertilized swelling eggs are fully washed with this second solution, eggs will not need continuous only occasional stirring (Woynarovich, 1962 and 1979). When reaching the final size of swelled eggs (about 1 hour) they should be washed with tannin solution (0.9 gr./l) or with pottery or porcelain clay (kaolin).

Induced ovulation and fertilization of eggs of Chinese major carps should be done in the same way as common carp, with only few differences. These are:

- Pectoral fins of males have a rough touch when they are ready for propagation. This helps their selection.
- Females should be weighed more precisely (with ½ kg preciseness) than carp females.
- Females receive a slightly higher dose of pituitary (about 5 mg/kg bodyweight) and their genital opening should not be closed after the second dose.
- Brood fish may be kept in covered happas within their tanks. This will prevent fish jumping and being stressed.
- Solutions are not used during fertilization of eggs. Use of normal hatchery water is enough.
- Eggs should be deposited into the incubation jars about 5 minutes after fertilization. This is to allow the fragile eggs to swell to full size in the jars.

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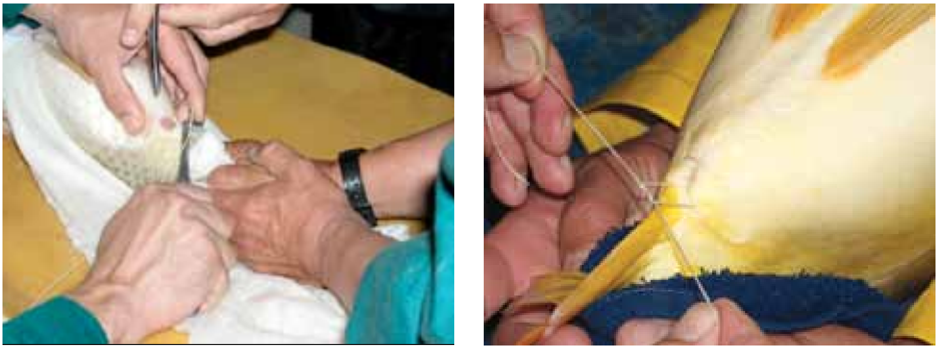
14 It is the hourly sum-up of the water temperature between decisive dose and ovulation.

FIGURE 11

Tasks at the second hormone treatment of common carp



Closing the genial opening of carp. It should be done in "N" form with a banded chirurgical needle and with soft but strong string (above).

Hormone injection should be administered into the stomach cavity near to the pelvic fin (below).

Photos courtesy of Andras Péteri and Zsigmond Jeney.

3.2.2 Incubation of eggs and rearing of hatched larvae

Incubation of eggs is a simple process when fish embryos in the fertilized eggs develop in a continuous current of water. For carp eggs 8–10 litre large, so-called Zuger jars are used, while the incubation of eggs of Chinese major carps is done in larger (60–200 litre) incubation devices (see Figures 13, 14 and 16). After hatching, larvae of carps remain in the larvae-rearing devices for an additional 3–4 days (see Table A12). Related BMP principles are:

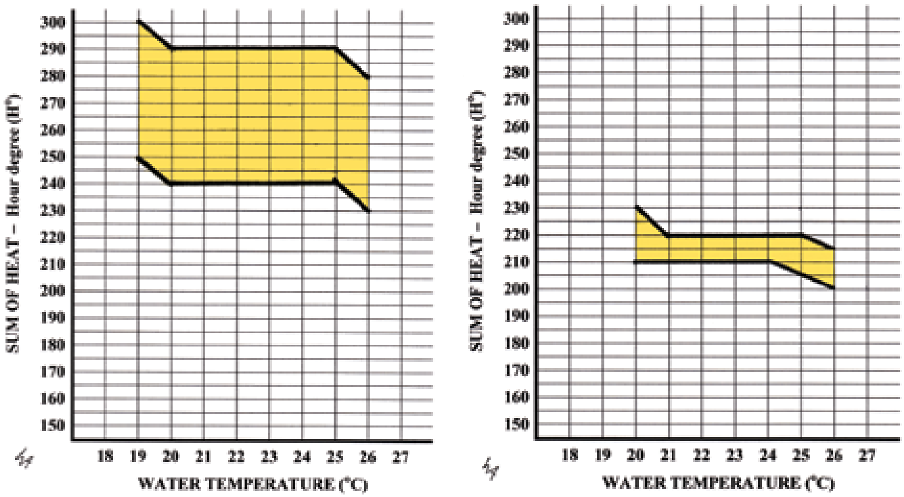
- About 1.0–1.5 litre of swollen carp eggs is to be placed in a 7–9 litre large Zuger jar. During the first 10 hours, eggs should move very slowly. They need approximately only 0.6–0.8 litre/min. water flow. Later, movement of eggs should be increased. This will need about 1.0–1.2 litre/min water. By the time of hatching, the weight of the eggs will increase. To have the same rolling movement of eggs in the incubator, the water flow should be adjusted (increased). Right before hatching, eggs should move very intensively. This time, water flow in the Zuger jars will be as much as 1.5–2.0 litre/min.
- Regular inspection of developing eggs is important. This includes checking and adjusting water flow, removing (siphoning) unfertile

or dead eggs, and applying effective and approved fungicide if fungal disease occurs.

- For carp embryo, it takes 60–70 day degree (D°)[15] to fully develop and hatch.
- Hatched larvae should be transferred into large larvae rearing jars (50–200 litre) in a density of about 2 000–2 500 larvae/litre.
- Larvae gulp and fill their swimming bladders with air and start active horizontal swimming at the same time. It is also when larvae start external feeding even if their yolk sacks are not fully consumed. At this stage of development, feeding larvae with the yolk of hard-boiled eggs should start in the rearing jars. To create the desired fine suspension, boiled egg should be washed into the jar through a very fine sieve (about 80–100 micron mesh size). Though this type of feed is not a proper one, it teaches larvae to feed independently. After the digestive tracks of larvae remain yellow they are to be transferred into nursery ponds.
- Removal of larvae from the hatchery jars should be done through a siphon, shown in Figure 15.

FIGURE 12

Sum of heat necessary for ovulation of common carp and Chinese major carps



Common carp Silver carp

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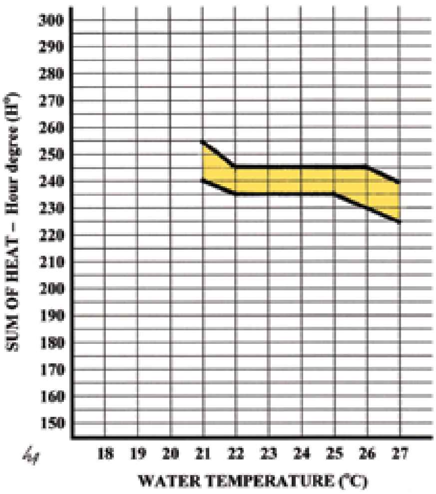
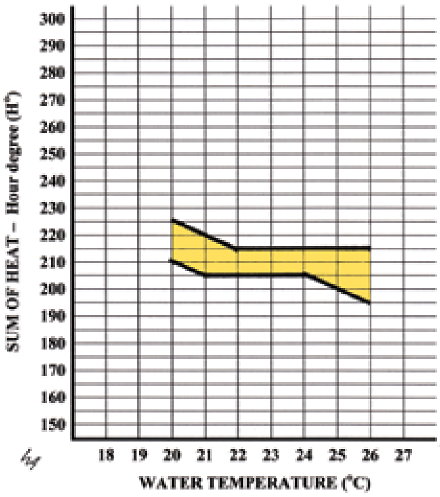
15 It is the summed up value of the daily average water temperature.

FIGURE 12

Sum of heat necessary for ovulation of common carp and Chinese major carps



Common carp



Silver carp

In case of Chinese major carps procedure of incubation of eggs and rearing of hatched larvae is the same. The only difference is that the fertilized eggs should be placed directly into the 50, 60 or 200 litre large jars. There they remain until they are stocked into nursery ponds. Hatchery operations related figures of Chinese carps are summarised in Table A12.

FIGURE 13

Zuger jars used for incubation of eggs of common carp

Photos courtesy of Andras Péteri and Zsigmond Jeney

FIGURE 14

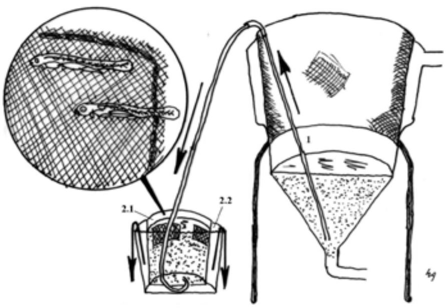
Jars used for incubation of eggs of Chinese major carps and rearing hatched larvae of all carps

Both 60 and 200 litre large jars are equally suitable for incubation of eggs and rearing of hatched larvae (see Figure 16). Shapes of the jars ensure proper circulation of water. Sieve of these jars is removable in order to clean and dry them properly.

Photos courtesy of Andras Péteri and Andras Woynarovich

FIGURE 15

Technique and equipment of removing fish larvae from hatchery jars



The length of the stiff pipe of the siphon should be as long as the depth of the larvae rearing jar (1). For this reason each type of jar should have a matching siphon.

The bucket (2.1) into the larvae are siphoned should have sieves (mesh size about 250–300 microns) on its upper part through which water will overflows. To reduce pressure on these sieves this bucket should be placed into a wider one (2.2). This ensures that fish larvae remain concentrated in the bucket.

A removable sieve in a bucket also serves the purpose.

Source A. Woynarovich and E. Woynarovich, 1998.

Making the necessary notes and calculations of hatchery operations is not only useful but is also an integral part of calculation results. Form presented in Figure 17 shows which data and information should be noted and figures calculated. Figures which support such calculations are presented in Table A12.

3.3 Nursery operations

BOX 5

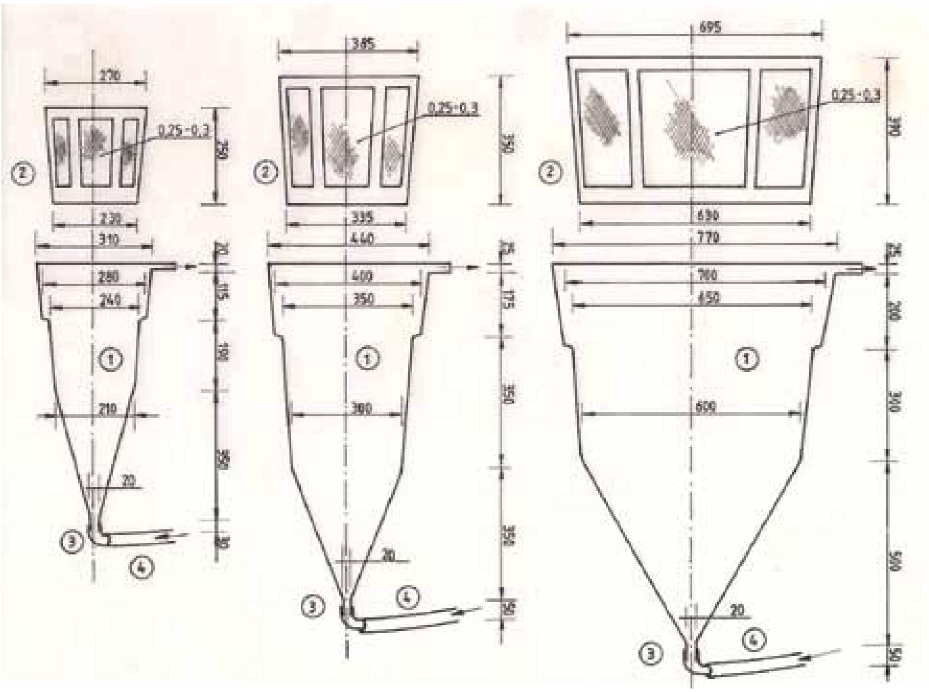
Frequent problem at rearing advanced fry

Advanced fry should be harvested in time. Fish farmers who wait with the harvest because they expect further growth overlook the fact that advanced fry in a densely populated pond cannot grow over a certain size, unless they are reduced in number. While farmers wait for further growth, the condition of fish declines, which often results in losses.

The objective of nursery operations is to produce about 1 month old 2–4 cm (0.2–1.5 gr.) large advanced fry. In nursery ponds, zooplankton is the main source of essentials proteins in the diet of developing fry. Therefore, establishment of a dense zooplankton population is the key to success. In addition to the food, feeding good-quality supplementary feeds will result in high survival rate and strong advanced fry. Nursery operations include pond preparations, stocking, feeding and harvesting.

FIGURE 16

Dimensions of standard fibreglass incubation and larvae rearing jars



Hatchery jars of 20, 60 and 200 litres volume. Their rearing capacities are about 50 000, 150 000 and 500 000 feeding larvae. They have a body (1) and a large removable sieve (2). Water enters at the bottom through a banded pipe (3) which slows down speed and reduces the strength of arriving water. (The dimensions are in millimetres.)

Source: A. Woynarovich and E. Woynarovich, 1998.

3.3.1 Pond preparation

At preparation of nursery ponds there are some important BMP principles to be known and observed. These are:

- pond bottom must be kept dry during winters and cleaned and tilled before use,
- before immediate use pond bottom and underwater slopes of dykes should be disinfected with lime in quantity suggested in Table A19,
- productivity of water should be increased with manure and fertilizers in quantities recommended in Table A17,
- water of the nursery ponds must be filtered through a dense sieve which has a mesh size of at least 1 mm the way presented in Figure 29 in Chapter 4, and
- nursery ponds should be filled with water, then manured/fertilized the same day as the larvae are hatched.

If "sudden filling" is done from a water source with minimum plankton crustaceans (Cladocerans and Copepods) the first members of the zooplankton will be Rotifers, which are also the first food of carp larvae. Desired biomass of Rotifers is about 5–10 ml/100 l (Horváth, Tamás and Tölg, 1984).

If water is populated with Cyclops (Copepods), permitted and tested selective insecticide[16] should be used in a very low concentration (0.5–1 mg/litre). Application of such chemical should be done immediately after the flooding, manuring and fertilization of the pond.

Using bangles of straw fixed to sticks around in the pond will increase the quantity of zooplankton and will also provide shelter for the developing fry.

3.3.2 Stocking and feeding

Stocking density of properly prepared nursing pond varies between 1 and 2 million feeding larvae/ha. BMP principles of stocking of larvae and feeding of developing fry are:

- Usually, smaller quantities of larvae are transferred from the hatchery to the pond in plastic bags, as demonstrated in Figure 18. In large fish farms, where several millions of larvae are transferred at the same time, a fish transporting container and oxygen should be used (see Figure 37 in Chapter 6 and Table A25). From such devices fish larvae are siphoned into the pond.

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[16] Chemicals that contain either organophosporic acid ester or trichlorfon are usually suitable for this purpose. Because rotifers are from another taxonomic group, they are not sensitive to these insecticides (Horváth, Tamás and Coche, 1985). Before using a new brand of insecticide, laboratory and field tests should prove its suitability. The list of chemical products permitted or banned varies from country to country. Therefore, use of some, otherwise suitable insecticides, may be banned in one country but permitted in another one (Woynarovich, Moth-Poulsen and Péteri, 2010).

- When stocking, special attention should be paid to equalizing the temperature of the transporting water to the pond water.
- Larvae should be released gently in equally distributed batches along the wind-protected sides of the pond.
- Feeding of good quality feed with suitable consistency and size should start on the day of stocking. Feed should contain 40–50 percent protein. Size of feed particles should be increased gradually from 0.2–0.3 mm at the start to about 1 mm by the end of the nursery period. About 1–1.5 kg of artificial feed per 100 thousand larvae, per day, in two portions is the best way of feeding. If there is no suitable special feed, a simple mixture presented in Table A20 is suitable. Overfeeding should be avoided.
- Regular monitoring of water quality and daily follow-up of the growth of developing fry is essential. This includes checking of physical state, condition of health and the presence of parasites on and in fish (see details in Chapter 7).

FIGURE 17

Form to follow up and evaluate the work in the hatchery

FORM OF FISH LARVAE PRODUCTION	
Company:	Species:
Fish Farm:	

TRANSFER OF BROODERS	Females			Males		
	Date	# of Fish	Pond N°	Date	# of Fish	Pond N°
Captured						
Stocked						

PARAMETERS OF BROODERS		HYPOPHYSATION OF BROODERS				STRIPPING OF EGGS		INCUBATION OF EGGS			PRODUCED LARVAE		
Colour of Tag	Weight kg/fish	1st Dose mg/fish	1st Dose ml/fish	2nd Dose mg/fish	2nd Dose ml/fish	Weight gr	Qty. pc	F. %	Qty. pc	C. %	Hatched pc	M. %	Stocked pc
Females													
Σ													
10 %													
110 %													
Time/Date													
Males													
Σ													

RECORD OF HOUR DEGREE		
Hours	C°	H°
1st		
2nd		
3rd		
4th		
5th		
6th		
7th		
8th		
9th		
10th		
11th		
12th		
13th		
14th		
15th		
Σ		

Observations:

STOCKING OF LARVAE		
Date	Pond	Qty. (pc)
Total		

Size of brood fish and quantity of received eggs should be weighed preciously, while rate of fertilization (F.) and proportion of crippled larvae (C.) should be estimated. Without such estimation the exact number of produced larvae can not be calculated.

This form facilitates accurate monitoring of water temperature and calculation of hour-degrees, but it is also good to follow-up the movement of brood fish and the destination of feeding larvae produced in the hatchery.

Source: A. Woynarovich and E. Woynarovich, 1998

3.3.3 Harvesting

Nursing period ends after 3–5 weeks when advanced fry must be harvested and transferred to rearing ponds for further rearing. During harvesting there are important BMP principles to observe:

Harvest and transport of nursed fries should be done with the greatest care. Therefore, use of good quality and suitable devices, equipment and tools are important.

During harvesting pond, should be drained partially and with great care. This includes use of fine, about 1 mm mesh screens, which should be continuously inspected and cleaned. Feeding of fish should stop one day before fishing.

Before transport advanced fry should be stored in a flow-trough tank or happa in a density of about 200 000–500 000 per 5–10 m^3 for a few hours.

Number of advanced fry is counted in a simple way. Counting of advanced fry is done in small batches (about 5–10 fry/batch). This is a slow procedure (see Figure 19). It is much quicker to count advanced fry by volume. In this case a few samples are taken with a suitable plastic sieve. These samples are counted then their average is calculated. Later only the number of sieves of full advanced fry should be counted and multiplied with the calculated average.

Advanced fry should not be touched by hand. Moving them must be done only with a plastic sieve (see Figure 19).

Transfer and transport of advanced fry should be done either in plastic bags or in fish transportation tanks presented in Figure 37 of Chapter 6. Quantities of advanced fry during transport depend on time, temperature and species (see Tables A26, A27 and A28).

FIGURE 18

Steps of stocking carp larvae

Concentrated larvae are packed into plastic bags, then the bags are filled with compressed air or oxygen if the larvae are transported for a longer period (see Table A25).

Photos courtesy of András Péteri and Zsigmond Jeney.

FIGURE 19

Equipment for handling advanced fry

Photos courtesy of András Péteri.

BOX 6

Government support to broodstock management, hatchery operations and nursing of fry

Sustainable production of common carp depends largely on broodstock management and production of high quality seed. Government support should focus on developing and funding the related activities:

- National Breeding Program.
- Progeny Performance Test of different carp strains.
- Financial support for applying Quality Seed Production Schemes.

3.4 Grow-out operations

BOX 7

Duration of grow-out operations of carps in ponds

It is expected that, because of increased rotation of ponds, their utilization with two year long production cycle will be better.

Rare use of this option demonstrates that increased rotation of fish ponds does not necessarily compensate other disadvantages. Still, this production cycle may be selected if:

- growing seasons are long enough (6–8 months), and
- size of produced table fish falls into lower ranges as growing fish larger than maximum 1–1.5 kg is not expected.

Two and half year long production cycle of carps, also called summer fish production, is a much more frequently selected option. This may be practiced if:

- there is demand for table fish during summers, when it is usually missing from the market, and/or
- chronic water shortages during the second half of production season force fish farmers to harvest their fish still in the summer.

Three year long production cycle is the most widely practiced option in CEE and CCA countries.

Four year long production cycle is selected when water temperature of ponds remains around 20 °C. Therefore growth of carp is relatively slow.

According to recent trends smaller table size carps are stocked for an additional fourth year in order to produce very large specimens. If market of such large size of fish has not yet fully developed, a limited number of extra large fish can be produced within a three year long cycle. In this case a certain proportion of stocked two-summer-old fish is larger which will grow to a bigger size than the rest of the stocked fish.

Grow-out operations are those that are in action when advanced fry is reared to the actual size of table fish.

Length of table fish production varies from species to species, and is determined by the actual final size of fish demanded by consumers. In case of carps this size may vary between 0.3 and 3 kg.

Under general climatic conditions of CEE and CCA regions the time period, in which carp is reared to table fish, may very between two and three years. As carp is reared in ponds, the culture technique should always be polyculture which ensures the best possible utilization of fish pond resources.

Both duration and structure of polyculture show how flexible the pond production cycle of table fish carp can be. Out of the choices summarised in Box 7, the three year long production cycle is when the size and the number of fish are well proportioned and both individual growth and growth of the fish stock are optimal. In other words, the three year long production cycle is which ensures the utilization of pond resources in the best possible way in the regions of CEE and CCA.

For the above reasons this chapter presents the BMPs of the three year long production cycle of carp. Its key data, such as stocking densities, harvested size and gross total weight of the different age groups, are presented in Figure 20.

Accordingly, advanced fry is stocked and one-summer-old fish is harvested in the first year. In the second year one-summer-old fish reared during the entire growing season and two-summer-old fish is harvested. The actual table fish is produced during the third year.

Before BMPs of grow-out operations are discussed it is important to highlight that pond culture of carps is based on thousand years of traditions and is one of the most flexible way of fish production. Though it can be practiced on different levels of intensity, such as extensive, semi-intensive and intensive, all of them are among BMP. This is because all three options can be technically and economically well justified. Pond culture in general, and its three different levels of intensity in particular, serve as a bridge between the fish stock management of unfed natural waters and water reservoirs and the super-intensive tank and cage culture of fish where biologically fully balanced feeds must be used (see Figure 30).

BMP of grow-out operations will focus on pond preparation, stocking, manuring, fertilization, feeding of fish, management of pond water and planning and evaluation of production.

3.4.1 Pond preparation

BOX 8

Frequent management problems at pond preparations

Pond bottom is not properly drained, dried, cleaned and repaired before inundation.

Filling up of pond is too slow.

Water is not properly screened.

Quantity of used manure, fertilizer and lime is either too little or too much.

Principles of BMPs at pond preparation are the same regardless of one-summer-old, two-summer-old or table fish are produced. These are as follows;

Keeping pond dry

In the course of harvesting ponds, water is drained. It is a general rule that ponds should remain as dry as possible until the next production season. For this reason, continuous drainage of melting snow and rain water is important. In order to ensure this, internal harvesting pits and drainage canals on the pond bottom should be cleaned and kept clean from mud.

Repair of pond

The most appropriate time to repair fish ponds when they are dry. This includes repair of dykes, pipes, monks and removal of excess mud from pond bottom.

Cleaning and cultivation of pond bottom

Removing unwanted objects and vegetation, such as dry sedge and reed, is the second step of pond preparation. Cutting for later use and carefully burning the rest of dry sedge and reed will allow better growth of the new and fresh vegetation in shallow waters. Such eradication of dry sedge and reed will stop their regrowth in deeper waters. This is especially true if large enough grass carp can graze on the freshly growing tender shoots of emerging water plants. Passing of dry pond bottom with a disk harrow will ensure healthier life of benthos.

Dry cultivation (growing of legumes, barley, ray or sorghum) of ponds built on less fertile soil is a feasibly option to increase their productivity.

Eradication of unwanted fish and disinfection of pond bottom

It may happen that live fish remain in the waters accumulated in depressions of pond bottom. These fish may be predators, or invasive and harmful for the new fish stock. Consequently, they should be removed. In the course of pond preparation, patches of water, remained in the depressions of pond bottom, should be checked and fished with hand nets. Distribution of quick lime after netting will ensure a complete eradication of unwanted fish from the water patches. This action also helps to disinfect waters remained in ponds.

Liming

Last step of pond preparation is liming, which is already partly done when water patches in the depressions of pond bottom are treated with quick lime. The rest of the recommended quantities of lime should be distributed evenly over the pond bottom. To use quick lime or milk of lime is the best solution (see Table A19).

Inundation of pond

Ponds used for growing any age group of carps are usually harvested in the autumn. This time ponds are completely drained. There are pros and cons regarding keeping ponds dry for the winter. On the one hand, if pond bottom freezes during winter, it will boost pond productivity. On the other hand in a pond already filled and stocked in the autumn, fish will start feeding immediately from the very beginning of early spring. This is why the pond left dry for winter has to be filled and stocked as early as possible, still before water temperature raises over 10 °C.

In reality, it is the actual availability of water that determines whether a fish pond can be left dry for the entire winter, or it has to be filled with water after a few weeks of autumn harvest, still in the autumn or early winter.

When filling ponds, there are recommended intervals of time within this task should be completed (see Table A14). Otherwise water conditions remain favourable for water plants and they will grow parallel with the rising water and will occupy too much space in the flooding pond.

Appropriate screening of water during inundation of ponds is the only prevention against the entering of unwanted fish. In case of one-summer-old fish production, the mesh size of screens should be smaller than when producing elder (larger) generations. Orientations about recommended mesh size of screens are listed in Table A15.

Screening of water that enters through a pipe into a pond is easy. A well-sized box with durable screens on its bottom and sides placed under the pipe will ensure proper screening of entering water. Still, regular checking and cleaning of the screening box is important (see Figure 29).

If water enters a fish pond through a monk-like structure, screening is more difficult. This is because the surface through which water enters is much smaller, unless it is enlarged with a screening box placed into the way of water flow. When using such screen, more alert and regular checking and cleaning is needed.

Manuring and fertilization

Next step after flooding a pond is manuring and fertilizing, which is essential if increased production of natural fish food is expected. During pond preparation, a larger preparatory dose should be evenly distributed over the pond water. Actual quantities vary according to the type and quality of manure and fertilizer (see Tables A16 and A17).

3.4.2 Stocking

BOX 9

Frequent management problems at stocking

Polyculture of carps is not appropriately composed. Hence natural fish food growing capacity of ponds is not fully utilized.

Number of fish is not proportional to planned and affordable level of production intensity.

Stocking is a vital part of grow-out operations and its BMPs includes both planning and execution.

Produced species and age group, as well as intensity of production, are those which determine size, number and proportion of stocked fish species.

Intensity of production

BMP of carp production in ponds include three choices of production intensity. Consequently, any phases of table size carp production can be extensive, semi-intensive and intensive (see Figure 20). These different levels of intensity allow farmers to adjust to the actual market conditions and demands.

Proportion of fish species

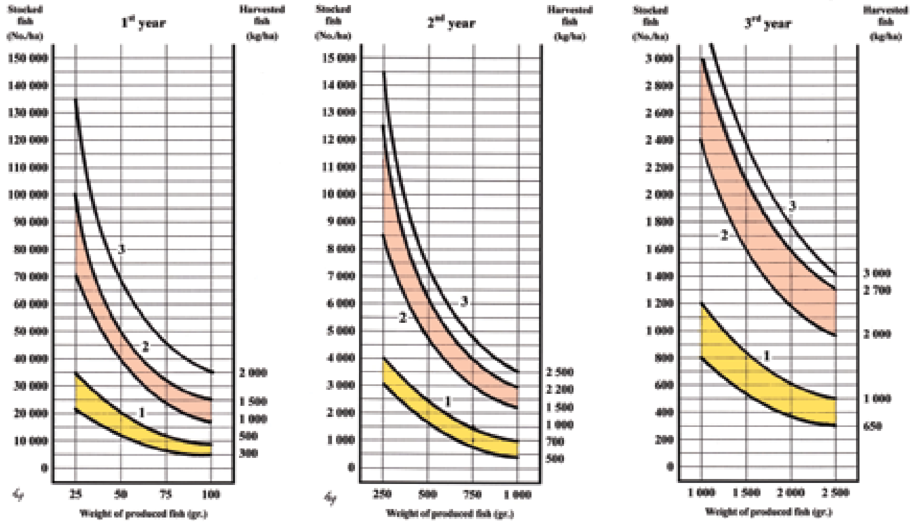
In CEE and CCE countries traditional carp culture is 90–95 percent monoculture (see Appendix 2). The remaining 5–10 percent consist of other peaceful and predator fishes listed in Appendix 1. Traditional carp culture was widely changed to polyculture after Chinese major carps were introduced during the 1960s and

1970s. Since this period, BMPs of carp is understood as the polyculture of common carp, Chinese major carps (silver and bighead carps and grass carp) and different other peaceful and predator fishes. Carp produced in polyculture will guaranty proper utilization of all biotopes of fish pond habitat.

Proportion of carp and other fish species in polyculture is a figure which changes with the intensity of production as presented in Table 4. In CEE and CCA, the most frequent predators are pike, pikeperch and catfishes.

FIGURE 20

Number of stocked fish and results of three-year-long carp production at different intensities



Gross results (kg/ha):

3) Intensive: above 2 000	3) Intensive: above 2 500	3) Intensive: above 3 000
2) Semi-intensive: 1 000–1 500	2) Semi-intensive: 1 500–2 200	2) Semi-intensive: 2 000–2 700
1) Extensive: 350–500	1) Extensive: 500–700	1) Extensive: 650–1 000

Net results (kg/ha):

3) Intensive: above 2 000	3) Intensive: above 2 250	3) Intensive: above 2 500
2) Semi-intensive: 1 000–1 500	2) Semi-intensive: 1 300–1 800	2) Semi-intensive: 1 500–2 000
1) Extensive: 300–500	1) Extensive: 400–600	1) Extensive: 500–800

1st year: production of one-summer-old fish (size of stocked fish: about 1gr., duration: 10–12 weeks and survival rate: 50–70 percent),

2nd year: production of two-summer-old fish (size of stocked fish: about 25–50 gr., duration: 22–24 weeks and survival rate: 60–80 percent),

3rd year: production of table fish (size of stocked fish: about 0.25–0.5 kg, duration: 22–24 weeks and survival rate: 80–90 percent)

Size of produced fish

Growth potential of carp is huge and it can attain the individual weight of about 0.2–0.3 kg, 1–1.2 kg and 2.5–3.5 kg by the first, second and third year, respectively.

Still, the economically feasible, individual weights of the different age groups of carp are about 0.025–0.05 kg, 0.25–0.5 kg and 1.2–1.8 kg by the end of first, second and third years; therefore these are the average weights that should be aimed for (Antalfi and Tölg, 1971, Tasnádi, 1997).

Size of stocked fish

Size of stocked carps depends on the produced age-group. Optimal is when the sizes of stocked fish for one-summer-old, two-summer-old and table fish are not smaller than about 1 gr., 25 gr. and 250 gr. respectively.

TABLE 4

Recommended proportions of carp in polyculture at different level of intensity

Species	Intensity of production		
	Extensive	Semi-intensive	Intensive
Common carp (%)	~ 30	~ 50	~ 70
Silver and bighead carp[17] (%)	~ 30	30–35	15–20
Grass carp (%)	~ 30	10–15	5–10
Predators (%)	~ 10	~ 5	~ 5
Total	100	100	100

Size of stocked fish also determines their chance of survival. Numbers and ranges presented in Figure 20 are those with which fish farmers should calculate.

Size of predators should be always smaller than the size of carps. The easiest way to ensure this is to stock a one-year younger generation, or at least much smaller specimens of predators than the stocked carps. In case of one-summer-old fish production, advanced fry of predators should be stocked either later than carps or they should be much smaller than carps.

Quantity of stocked fish

Number of stocked fish depends on the produced age-group and its planned, as well as on the intensity of production as it is presented in Figure 20.

Though proportions of predators may vary between 5 and 10 percent, the absolute quantity of them is what counts. In a pond where invasive species are abundant, the number of predators should be more than in a pond where food fish for predators is scarce. An increasingly popular technique is when small fish (easy to produce carps) are stocked purposely as food fish for predators.

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[17] Silver carp should be about 80–90 percent and bighead carp should be about 10–20 percent of the total number of filtering fish.

Quality of stocked fish

Not only the size, but also physical and health conditions are important qualities of stocked fish. Retarded, dwarf specimens or wounded and sick fish should not be stocked. Sick fish should be first cured in a separate pond before they are stocked together with healthy fish.

Execution of stocking

The task of stocking is simple. Fish should pass with the least stresses possible. Therefore, fish of all age groups must be handled with care and released gently by means of basket or sliders (see Figure 21).

Before fish is stocked temperature of both transporting water and receiving water must be checked and equalized. Difference should not be more than 1–1.5 ^{o}C. A good practice is when the transporting water is gradually changed with the water of receiving pond. Time invested in this action will return in better survival of stocked fish.

FIGURE 21

Some practical solutions for releasing live fish

Photos courtesy of György Hoitsy, Tamás Szakál and András Woynárovich

BOX 10

Frequent management problems at manuring, fertilization and liming

Manure and fertilizers are applied between long intervals, when they are usually overdosed.

Poor quality lime is used irregularly.

Manure, fertilizers and lime are not properly distributed.

Effects of manuring, fertilization and liming are followed-up irregularly or not at all.

3.4.3 Manuring and fertilization

Each pond has a certain capacity to produce fish without any human intervention. This depends on the natural fish food production capacity of ponds. Original natural fish food production capacity of ponds is determined by the quality of soil where they were built, as well as by the environment where water is received from. Ponds on fertile soil filled with water arriving from heavily fertilized lands have a much higher production capacity than ponds located on unfertile lands and supplied with empty or less suitable water. Manuring and fertilization, together with liming, are those management practices that help to increase and maintain the natural fish food production in ponds. Related BMPs include planning, execution and follow-up of manuring, fertilization and liming.

Planning and executing manuring, fertilization and liming

There are two distinct periods of time when ponds should be manured, fertilized and limed. The first one, discussed in Chapter 3.4.1, is due during pond preparation, while the second period is during the entire production season.

As presented in Table A17, 75 percent of the total quantities of manure and fertilizers should be applied in smaller doses during the production season. When planning and executing the followings should be considered:

- Fresh manure is more suitable than manure prepared for plant production.
- When deciding the actual quantities of manure its BOD and dry matter, organic material, total nitrogen and phosphorus content, as well as freshness, are what count.
- Frequent smaller doses have better effect. Though daily doses would be ideal, from an economic point of view, weekly or minimum bi-weekly doses of manure and fertilizers will ensure expected results.
- Application of manure and fertilizers should be done during the mornings of sunny days.
- Similarly to manure and fertilizers, lime should also be used both at pond preparation and during the entire production in doses recommended in Table A19. When using lime it is important to know and consider:
- Lime increases pH and puffers pond water.
- Quick lime reacts aggressively; therefore, burns and kills plankton where

it makes contact with water. For this reason, it is better to use milk of lime during growing season.

- Monthly doses of lime should be distributed in strips over the water surface during sunny mornings.
- About 7–10 days interval between application of manure/fertilizer and lime will increase the effects of both.

Role of fish manure is also significant and should be increasingly considered as production intensifies. This is because the number of fish in general and the number of fed grass carp and carp in particular, release more faeces. These, similarly to the manure of terrestrial animals, will increase natural fish food production in ponds. Therefore, recommended quantities of manure and fertilizers should be cautiously applied as intensity of fish production increases.

One of the simplest ways of recycling plant nutrients trapped in mud is dragging a heavy chain over the pond bottom. This will not only recycle essential minerals and compounds, but it will also aerate mud and create a healthier environment for the benthos.

Follow-up of manuring, fertilization and liming

Follow-up of manuring and fertilization is an integral part of BMP. It is done through:

- Estimation of colour and transparency of pond water. Greenish[18] living water with a transparency of about 20–30 cm is a good indicator of healthy water life.
- Observation of fish stock during early morning, when, especially at the second half of production season, fish may gulp for air. This is because the increased biomass of phytoplankton consumes too much oxygen during night. This creates oxygen shortage by dawn. If oxygen shortage at dawn remains regular, reduction of the biomass of phytoplankton with lime, cupper[19], or according to a new technology with straw (Horváth, 2011) becomes inevitable.
- Regular, at least weekly checking the proportion and development stages of rotifers, Cladocerans and Copepods in the Zooplankton helps to judge the necessity of manuring/fertilization. Copepods are good indicators. As soon as they start producing fertilized eggs (winter eggs) frequent small doses of manure/fertilizer and lime should be applied.

Secchi disk and plankton net are the simple equipment of checking the effect of manuring/fertilization and liming. Out of them, the plankton net for fish farmers is very important. Figure 22 shows the steps of making it.

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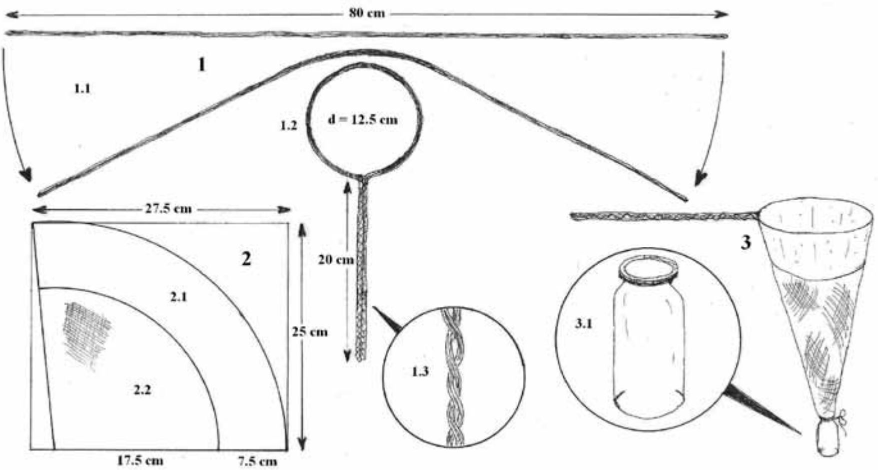
18 Though colour of water is important alone this quality does not count, only together with sampling plankton and observing of fish during critical periods of the day such as afternoon, dawn and feeding.

19 Copper sulphate is one of the options or similar compounds of copper if permitted to be used in fish culture.

FIGURE 22

Making a plankton net



1) An about 80 cm long strong wire should be bent into a frame (see 1.1, 1.2 and 1.3).

2) Sieve (about 70–80 micron) should be cut out (see 2.2). Material which holds the sieve on the frame should also be cut and sewed to the sieve (see 2.1).

3) When the sieve is fixed on the frame a transparent vial or small glass container should be fixed on the plankton net (see 3.1).

Illustration courtesy of Andras Woynarovich.

BOX 11

Frequent management problems at feeding

The most frequent management problems at feeding are:

- Quantity and quality of applied feeds are disproportionate to the size and number of stocked fish.
- Feeding is irregular.
- Due to improper feeding, carp becomes fatty and its flesh is loose and soft.
- Unhealthy, spoiled or even rotten feeds contaminated with fungus or chemicals are applied.
- Grass carp does not receive green feeds therefore it consumes carp feeds.
- Consumption of feed is not regularly checked and FCR is rarely or not at all calculated.

3.4.4 Feeding

BMP of feeding are related to type, quality and quantity of feeds, as well as to the techniques how they are distributed.

In carp polyculture, only carp and grass carp are fed directly. Though silver and bighead carps are not fed, they filter small floating particles of carp feeds. Grass carp is fed with fresh green terrestrial plants.

Quality and type of feeds

It is a basic rule that only good-quality feeds should be given to carp. When feeding carp, the type of used feeds should be changed according to intensity of production as presented in Figure 30 of Chapter 5.

In the course of extensive, and at the beginning of semi-intensive production, energy-rich supplementary feeds (wheat, maize, sorghum, etc.) listed in Table A21 should be given. When the standing crop grows big, carp should be fed with the mixture of protein and energy rich supplementary feeds or with pelleted feeds as presented in Table 5. This table is a good example, where sorghum can be replaced with other type of grain (wheat, maize, etc.).

Quantity of feeds

Absolute daily quantity of feeds should be proportional to the actual standing stock of carp. It is a general rule that each day carp should receive as much supplementary feeds as they can consume within about 3–6 hours. A bulky feed will be consumed during a longer period of time (5–6 hours), while a more concentrated feed will be finished faster (3–4 hours).

Relative daily quantity of feeds should not be more than about 1–3 percent of the biomass of growing one-summer-old, and about 3-5 percent of the biomass of elder age groups of carp. This will force fish to search for natural food. In case of factory-made carp feeds the manufacturers recommend the applicable quantities.

Quantity of fresh green feeds for grass carp should be as much as the fish can and will consume with about 12–18 hours.

TABLE 5

Standing crop based mixture of supplementary and pelleted balanced feed of carp

Standing crop (kg/ha)	Sorghum (%)	Pellets* (%)	Total (%)
below 700	100	-	100
700–1 200	75	25	100
1 200–1 500	50	50	100
1 500–1 800	25	75	100
over 1 800	-	100	100

* 25% protein contents.

Source Herpher and Pruginin, 1981.

FIGURE 23

Storing and distribution of carp feeds and equipment for checking feed consumption

Photos courtesy of András Woynárovich.

Preparation of feeds

It is evident that feeds for smaller carp should be properly ground and soaked before they are given. Though larger carp can consume grains in hole, crashing and soaking will help their digestion. In addition to grinding and soaking, some other feeds should even be boiled, steamed or roasted before fish are fed (see Table A21).

Execution of feeding

Fish should be fed daily. First, in the morning, the feeding frames of grass carp should be filled with fresh green plants. Feeding carp is the second step, when feeds are deposited at fixed points of the pond marked with sticks or small buoys. If possible, the daily portion of carp's feed should be split and given in two portions (Tasnádi, 1983).

BOX 12

FCR of supplementary feeds in carp polyculture

Supplementary feeds with divers energy and protein contents listed in Table A21 have different FCR. These absolute values of FCR are gained if the listed feeds are fed as mono diet alone, without natural fish food.

If supplementary feeds are fed in fish pond environment, their FCR will be less. This reduced value of FCR of supplementary feeds is relative and depends on many factors:

- Climatic and weather conditions.
- Quantity and quality of natural fish food.
- Daily frequency of feeding.
- Ratio of energy and protein rich supplementary feeds given to fish.
- Age of carp and size of their standing stock.
- Combination of different large Cyprinids.
- Biomass of unwanted feed competitors, such as small Cyprinids or other feed and/or natural food consuming fish species.
- Number and type of water birds.

Among usual fish pond conditions, measured FCR of supplementary feeds will also change in the course of production seasons. Accordingly, it is more favourable in the first period when natural food is in abundance, and worsening later, as standing stock of carps increases and the quantity of accessible natural fish food declines.

Relative values of FCR of grains for the entire season of extensive or semi-intensive production of one-summer-old, two-summer-old and table fish should be about 1–2, 1.5–2.5 and 2–3.5 (Woynarovich, Moth-Poulsen, Péteri, 2010).

Follow-up of feeding

Physical checking of feed consumption is one of the last steps of feeding fish. For this purpose, a spoon-like simple tool with a long handle serves well (see Figure 23).

Regular sampling, weighing and estimation of actual total weight of carp stock are essential to determine whether or not the given feeds are well utilized. During this process Feed Conversion Rate (FCR) should be monthly calculated. This will help to detect and correct feed and feeding related problems.

Aspects summarized in Box 12 presents the necessary background information for calculating FCR of supplementary feeds of carp.

Percent of the total quantity of supplementary feeds of carp used during the entire season will be about 2, 5, 8, 14, 17, 40, 10, and 4 in March, April, May, June, July, August, September and October respectively (Antalfi, Tölg, 1971). These figures help fish farmers to plan feed consumption.

3.4.5 Water management

As soon as ponds of one-summer-old, two-summer-old and table fish are filled the only task of farmers is to keep the highest possible water level.

When neither eradication of phytoplankton blooms, nor aeration do not help, the supply of fresh water in mornings or about 7–15 percent partial change of pond water might be justified. This situation is expectable during the second half of the season of semi-intensive and intensive production.

BOX 13

Frequent management problems when planning and evaluating grow-out operations

Intensity of production is disproportional to actual physical, economic and social conditions:

- Physical state and water supply of pond do not facilitate the planned intensity of production.
- Production results losses. Price of fish does not cover the price of inputs.
- Labour is incapable and/or unmotivated for proper work.
- Security of fish farm and guarding of ponds are unsolved.
- Lack of noted figures of earlier years. Hence, there is no reliable information to work with and evaluate earlier results.

3.4.6 Planning and evaluation of production

Figure 20 shows the basic correlation between size, number of stocked fish and intensity of fish production. The same figure can help in planning production.

When planning, all physical, economic and social conditions should be taken carefully into account. In order to reduce risks and financial losses, elaboration of physical and financial plans are essential.

Planning of production

After the above-mentioned considerations, subsequent steps should be made[20]:

1. Decision on the size of produced fish
   (250 gr., range: 250±50 gr.)
2. Decision on the size of stocked fish
   (25 gr., range: 25±50 gr.)
3. Decision on the intensity and gross production
   (Semi-intensive: 1 750 kg/ha, 7 000 fish/ha,)

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20 Figures in brackets are the examples.

4. Estimation of survival rate
   (70 %, range: 70±10%)
5. Decision on the proportion of species
   (carp: 50%, silver/bighead carps: 35%, grass carp: 10%, predators: 5%)
6. Calculation of the total weight of harvested fish by species
   (carp: 875 kg/ha, silver/bighead carps: 610–615 kg/ha, grass carp: 175 kg/ha, predators: 85–90 kg/ha)
7. Calculation of the number of stocked fish
   (100/70 x 7 000 = 10 000 fish/ha) [21]
8. Calculation of the number of stocked fish by species
   (carp: 5 000 fish/ha, silver/bighead carps: 3 500 fish/ha, grass carp: 1 000 fish/ha, predators: 500 fish/ha)
9. Calculation of the total weight of stocked fish by species
   (carp: 250 kg/ha, silver/bighead carps: 85–90 kg/ha, grass carp: 25 kg/ha, predators: 10 kg/ha)
10. Calculation of total net growth of fish
   (carp: 600–650 kg/ha, silver/bighead carps: 500–550 kg/ha, grass carp: 150 kg/ha, predators: 75–80 kg/ha)
11. Calculation of used feeds
   (carp: 1 500–1 600 kg wheat[22], grass carp: 4000–5000 kg fresh grass)

As soon as the above listed estimations and calculations are ready, financial planning can also be completed on the basis of actual prices of fish and inputs.

Evaluation of production

Evaluation of production includes both physical and financial calculations. When evaluating production fish farmers should check and calculate actual survival, growth, FCR and profits, as well as compare results against plans. Precondition of these calculations is the correctly conducted registers of purchased and used materials/equipment, feeds and stocking, mortality and fishing data of fish (see Figures 24, 25, 26, 27 and 28).

FIGURE 24

Register of purchased and used materials and equipments

Date	Item	Qty.[23]	kg	Price		Pond No.	Observation
				Purchased	Used		

Source Woynarovich, Moth-Poulsen, Péteri, 2010.

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[21] F100 divided by the value of survival rate and multiplied with the number of fish expected to be harvested.

[22] FCR at carp it is around 2.5 and at grass carp it is around 30.

[23] Qty. = Quantity.

FIGURE 25

Feed register

Date	Pond 1		Pond 2		Pond 3		Pond 4		Pond 5	
	Type of Feed	Qty.	Type of Feed	Qty.	Type of Feed	Qty.	Type of Feed	Qty.	Type of Feed	Qty.

Source Woynarovich, Moth-Poulsen, Péteri, 2010.

FIGURE 26

Register of fish mortality

Date	Pond No.	Dead Fish			Observation
		Species	Qty.	kg	

Source Woynarovich, Moth-Poulsen, Péteri, 2010.

FIGURE 27

Fish stock register

Date	Pond No.	Species	Stocked		Fished	
			Qty.	kg	Qty.	kg

Source Woynarovich, Moth-Poulsen, Péteri, 2010.

FIGURE 28

Table of planning and evaluation of fish production

Species	Stocking				Surv.[24] %	Fishing				
	Age Group	Size (gr.)	Qty.	Total kg		Age Group	Size (gr.)	Qty.	Total kg	Total Net kg
Total/Average										

Source Woynarovich, Moth-Poulsen, Péteri, 2010.

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24 Surv. % = Surviate in percentage.

4. WATER MANAGEMENT

It is very important to carry out routine checks in the farm and observe the abnormalities. Change of water level, flooding, storming and pollution of water source are required to be checked daily. If there is any abnormal change necessary actions should be taken in time.

Basic water management principles are to keep the required quantity and quality of water in ponds. It is important to act without delay in case the quantitative and qualitative parameters of water are outside of the desirable ranges.

FIGURE 29

Screening water

Wooden frame with a screen bottom, placed under the water pipe will stop unwanted fish from entering fish ponds. Screen for a smaller (left) and for a large pond (right).

Photos courtesy of András Woynárovich.

4.1 Quantitative management of water

It is a general rule that a fish pond should always be properly filled with good quality water (see Table 3 in Chapter 2). This includes the supplement of seeped and evaporated pond water, which should be done in every 10–15 days. In case of heavy rains and melting snow too much water may accumulate in ponds. If so, ponds should be properly drained. This is especially likely in barrage ponds, because they collect run-off waters from the surrounding watershed.

When it comes the quantitative management of pond water, both when filling and draining, it is important to prevent fish from escaping ponds.

- Depending on the size of produced fish, ponds should be filled through sieves in case of nursery ponds, or through screens of different mesh sizes (see Table A15). This will prevent unwanted fish from entering the ponds. Screening of arriving water will also stop fish escaping against the current.
- At harvest, ponds are fully drained. In this case the speed of draining is important (see Table A14). If it is too fast fish remain back without water and die.
- In the course of both partial and total drainage of fish ponds screens of appropriate mesh size should be used. This includes their regular cleaning.

4.2 Qualitative management of water

The fish pond should be kept clean and hygienic during production season. Removing rubbish and unconsumed weeds from water surface should be part of daily routine. In order to keep the water quality in ponds as required some important details should be known and observed.

4.2.1 Water quality parameters

Basic water quality parameters include temperature, pH, oxygen, carbon dioxide, nitrogen compounds, organic materials, inorganic pollutants and pesticides[25]. All of these should be checked either regularly or when problems occur.

Temperature

Temperature of aquatic animals adjusts to the temperature of their environment. They are less or even intolerant to rapid changes and fluctuations of temperature. This makes water an ideal living habitat for them, because water is a bad conductor of heat. Water bodies can absorb large amounts of heat energy without change in their temperature.

For each species there is a minimum and maximum tolerance limit, as well as an optimum range of temperature for living and growth. This range of optimum temperature, also known as standard environmental temperature (SET), may vary with species and development stage of fish, even within the same category of temperature tolerance.

Water temperature affects the feeding pattern and growth of fish. Fish generally experience stress and disease breakout, when temperature is chronically near their maximum tolerance, or when it fluctuates suddenly. It is therefore important to acclimatize fish gradually when moving them from one location to another.

Warm water holds less dissolved oxygen than cool water. In general, every 10°C increase in temperature doubles the rate of metabolism, chemical reaction and oxygen consumption of fish.

Dissolved oxygen

Dissolved oxygen (DO) is by far, the most important parameter in aquaculture. Amount of dissolved oxygen in water increases as temperature reduces, and decreases when altitude increases. Either directly or indirectly low dissolved oxygen levels are responsible for more fish kills, than all other problems together. Oxygen consumption is directly linked to size, feeding rate, activity level and temperature. Large fish consume relatively less oxygen than smaller fish because of their higher metabolic rates.

Dissolved oxygen is important not only for fish, but also for phytoplankton

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[25] Presence of pesticides in pond water, those known to be used in the watershed, should also be tested periodically at different rainfall levels to determine their concentrations.

which produces it during daytime and consumes it during nights, when there is no light.

Dissolved oxygen often becomes limiting during nights because of the combined respiration of fish, phytoplankton and mud-dwelling organisms. This is especially true during late summers when the level of phytoplankton biomass is high. Therefore a late night – early morning oxygen deficit may develop. If this early morning deficit is not offset by aeration, reduced dissolved oxygen levels may kill fish. With early morning identification of those ponds which require aeration at dawn fish can be kept alive. Aeration is initiated when dissolved oxygen concentrations fall to a level considered critical. This is usually around 3–4 mg/litre. Under current production practices nearly every fish pond has dissolved oxygen concentrations less than 2 mg/litre at dawn during mid- and late-summer. Duration of such low dissolved oxygen concentrations at nights usually ranges from 3 to 6 hours/day. Aeration should stop when measurements indicate that dissolved oxygen concentrations are increasing.

In intensive fish ponds aerators (about 4.5–6 kW/ha) should be installed to provide oxygen for fish. Operation time of such aerators should be regulated depending on the rhythm of daily dissolved oxygen content of pond water.

Carbon dioxide

High rates of respiration in ponds with abundant plankton and high densities of fish result in rapid loss of dissolved oxygen and accumulation of carbon dioxide during summer nights. In fish ponds dissolved carbon dioxide concentrations of 5 to 10 mg/litre are common on summer mornings and carps appear to tolerate it well. They can survive in waters containing as much as 60 mg/litre dissolved carbon dioxide, provided dissolved oxygen concentration is also high. Higher concentrations may cause death, but chronic problems are rare because daytime photosynthesis consume the carbon dioxide produced during nights.

pH

The pH of water represents the hydro chemical quality of water. In general, optimum pH value for pond fish culture is between 6.5 and 8.5. The value beyond this range will affect fish yield and even may cause mortality.

Acceptable range for fish culture is usually between pH 6.0 to pH 9.0. On the one hand, when water is very alkaline (> pH 9), ammonium in water is converted to toxic ammonia, which kill fish. On the other hand, acidic water (< pH 5) leeches metals from rocks and sediments, and leads to reduction and halt fish growth.

Alkalinity is the sum of the carbonate and bicarbonate alkalinities. These are responsible for neutralizing acid in the water without changing the overall pH level.

Correct pH, alkalinity and hardness are essential for successful pond fertilization.

Nitrogen compounds

TABLE 6

Dangerous quantity of total ammonia at different pH values

pH	7	8	9	10	11	12
$NH_3 + NH_4^+$ (mg/l)	100.0	33.3	5.55	1.54	1.05	1.00

Source Dévai and Dévai, 1980.

Ammonia is the major nitrogenous waste product, excreted by fish. The fact that pond culture is possible at high feeding rates indicates that transformations and losses of nitrogen compounds act to reduce ammonia concentration. When ammonia begins to accumulate, fish respond with reduced appetite. This leads to lower rates of ammonia excretion and reduced ammonia concentrations in the water. However, ammonia levels can be used to predict the onset of possible nitrite accumulations.

Nitrite is an intermediate product in nitrification, which is a common bacteria-mediated transformation of ammonia to nitrate in soils and water. Nitrite accumulates to significant levels in ponds only when ammonia concentrations are relatively high and ammonia oxidation to nitrite exceeds the rate of nitrite oxidation to nitrate. Accumulation of nitrite can be toxic to fish even at relatively low concentrations (see Tables 3 and 6).

TABLE 7

Concentration of hydrogen sulphide lethal for young carp

pH	5.2	6.1	7.4	8.2
H_2S (mg/l)	0.55	0.95	3.3	8.0

Source Dévai and Dévai, 1980.

Organic materials

In case of anaerobic decomposition of proteins or off-odour compounds production of algae and bacteria fish pond water environment deteriorates. These are either poisonous or they change the quality of the produced fish.

- Hydrogen sulphide (H_2S) is a by-product of the breakdown of organic matter, usually under anaerobic conditions. Pond mud that has moderate to high organic concentrations and anaerobic conditions can be a significant source of hydrogen sulphide which is toxic to fish even at low concentrations (see Table 7).
- If stink of spoiled eggs is noticed when sediment is disturbed, it is an indication of anaerobic conditions and the presence of hydrogen sulphide in the mud of pond bottom. Hydrogen sulphide is usually released because

of drastic changes of atmospheric pressure. Tilling dry pond bottom and raking the bottom mud are effective preventions against production and accumulation of hydrogen sulphide.

BOX 14

Off-flavour of carp

When carp are fed a grain-based diet and are raised in clean waters, they have a characteristic mild flavour. Pond-raised carp may, however, develop flavours that can be disturbing.

Most of off-flavours are organic compounds produced by aquatic bacteria or algae. These microorganisms synthesize and release them into the water from where they are absorbed through the gills, skin, or gastrointestinal tract of fish.

Managing off-flavours can be divided into two general approaches:

- Purging the compound by moving fish to a "clean" environment.
- Using algaecides to kill odorous aquatic bacteria or algae.

Many farmers choose a more passive approach. They simply wait to harvest fish when they are on-flavour. This approach works to some degree because composition of phytoplankton constantly changes. When it changes earlier absorbed off-flavours will be purged from the flesh and flavour of fish will improve. However, it is impossible to predict how long the odour-producing microorganisms will remain in ponds. They may disappear in a week or may persist for months.

If such odour appears, harvested fish should be kept in flowing water for a required period of time to eliminate the off-flavour before marketing.

- "Taste of mud" is a frequent complaint about carp grown in old muddy ponds where water is constantly reused for years. Quality of such carp can be improved if fish is kept in good quality running water until the bad taste disappears.
- Off-flavour is another frequent problem. Most off-flavours in pond-raised fish are caused by odorous compounds absorbed by fish from the water (see Box 14).

BOX 15

Algae bloom

Phytoplankton consists of microscopic algae that float in open water. They carry out photosynthesis using dissolved carbon dioxide and release oxygen into pond water which is the most important source of dissolved oxygen in ponds.

Phytoplankton also breaks down waste of fish metabolism into harmless components.

Phytoplankton forms the base of the food chains for fish. All green plants need light, proper temperature and plant nutrients for growth. If conditions are suitable including the presence of plant nutrients in the form of manure and chemical fertilizers (nitrogen and phosphorous), biomass of phytoplankton increases.

Blooming algae is disadvantageous. It can be controlled by stopping manuring and fertilization, or by using chemicals, such as lime, or diluting pond water.

Use of straw is also good, which is a recently elaborated technique (Horváth, 2011).

- Organic water pollutants include detergents, by-products of disinfection, chloroform, food processing wastes, fats and grease, insecticides and herbicides, as well as a huge range of organo-haloids and various chemical compounds found in personal hygiene and cosmetic products. Tree and bush debris from logging operations may also be pollutant to fish ponds.

- Volatile organic compounds, such as industrial solvents, from improper storage, chlorinated solvents, which are dense non-aqueous phase liquids, may sink to the bottom of the pond, since they are denser and do not mix well with water.
- Petroleum hydrocarbons, including fuels (gasoline, diesel fuel, jet fuels, and fuel oil) and lubricants (motor oil), and fuel combustion by-products from storm-water runoff should not enter the fish ponds. In case of pollution, suspended organic material should be collected from the pond surface.

Inorganic pollutants

Ponds should be safe-guarded against inorganic water pollutants, such as acidity caused by industrial discharges (especially sulphur dioxide from power plants), ammonia from food processing waste, chemical waste as industrial by-products, fertilizers containing nutrients (nitrates and phosphates) which are found in storm-water runoff from agricultural lands, heavy metals from motor vehicles via urban storm-water runoff, acid mine drainage and silt (sediment) in runoff from construction and land clearing sites.

4.2.2 Water productivity

A fish pond ecosystem is a dynamic complex of the communities of bacteria, plants and animals and the nonliving environment. Pond ecosystems get energy from the sun. As with other ecosystems, usually plants (zooplankton, algae[26] and water weeds[27]) are the primary producers. The chlorophyll in their body and leaves captures energy from the sun to convert carbon dioxide and water to organic compounds and oxygen. This is the process of photosynthesis. Carbon, nitrogen and phosphorus are important nutrients for water plants. Addition of these substances will increase primary productivity. Phytoplankton is direct food for silver carp.

Zooplankton includes microscopic animals that consume detritus, bacteria, phytoplankton or smaller zooplankton. Some are single-celled animals, tiny crustaceans, or tiny immature stages of plankton crustaceans. As phytoplankton, zooplankton also occupies the water column of ponds. Zooplankton is food for many different fish species, including carps.

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[26] Microscopic algae attach to substrates (rocks and sticks) also carry out photosynthesis and produce oxygen.

[27] These are plants either floating on the water surface or rooted at the bottom. Many of the rooted plants have leaves floating in the water while others emerge from the water. Shore plants grow in wet soil at the edge of the pond.

Out of invertebrates insects and their different development forms are the most important members of larger consumers. They may be parasitic to or pray on fish, but they are also feed for many fish species.

BOX 16

Pests in fish ponds

Fish production in ponds is commonly affected by pests and predators. They either compete with, or predate on cultured fish.

Herons, kingfishers and other water birds must be prevented from frequenting the ponds. They devour fish and fingerlings and are also carriers of parasites. Ponds without shallow areas are less attractive to many water birds.

Snakes prey on small fish. Keeping banks and dykes of ponds clean will prevent snakes from harbouring in the ponds.

Frogs eat fry and fingerlings. Tadpoles also compete with the fish for space and oxygen. Their population can be controlled by removing their eggs from the water.

Vertebrates are animals with backbones. In a pond these are the fish, frogs, snakes, salamanders, and turtles, as well as birds and mammals which live in and near, and feed from fish ponds.

Animal waste and dead and decaying plants and animals form detritus on pond bottom. Their decomposers are bacteria and other organisms that break down detritus into material that can be used by primary producers. Consequently, decomposers return detritus to the ecosystem. In the process of breaking down detritus, decomposers produce water and carbon dioxide. Decomposers are also important food for zooplankton and larger consumers.

Different waters have different capacities to sustain fish populations. This is because their natural fish food producing capacities differ from each other. Improving the productivity of water is one of the most characteristic features of producing carps in fish ponds. Pond operation usually includes many related activities. Here only improvement of pond water productivity, the organic and inorganic contents control and routine checking are discussed.

Improving the natural fish food production of pond water is an important task. Manuring and fertilizing are the source of nutrients which promote the growth of bacterioplankton and phytoplankton, on which zooplankton and other aquatic animals feed. This is why the yield of fish ponds can be increased with proper nutritional support through manuring and fertilization.

Manures

Manures refer to excrements of farm animals. With manures not only plant nutrients but also carbon is supplied. Quality of the manure of farmed animals differs from each other (see Table A16).

Fertilizers

Fertilizers are widely used in pond fish culture. According to composition chemical fertilizers can be divided into three groups such as nitrogenous, phosphoric and potash fertilizers (see Table A18). Out of them potash fertilizers are not used in pond culture unless they are combined and sold together with other fertilizers. Advantages of inorganic fertilizers are that the contents are exact, they have a fast and direct effect on phytoplankton, less pollution and small quantities are needed to be used. These allow convenient operation. Disadvantage of fertilizers is that they have a slower effect on bacterioplankton and zooplankton.

5. NUTRITION AND FEED MANAGEMENT

Combined use of natural fish food and feeds in ponds is the technique which has to observe both environmental and nutritional aspects of carp. It is why the subjects of nutrition and feed management are not only important but also special points of carp culture in ponds.

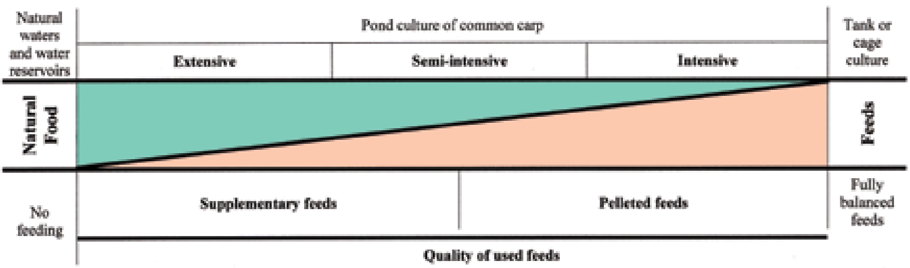
5.1 Nutritional aspects of carp feeding

Feeds, used in carp pond culture are only to complement natural food. These feeds can be grains, by-products and compounded farm-made or commercial feeds. Common characteristics of such supplementary feeds are that none of them ensures alone a biologically complete diet for carp. With these types of feeds, consumption of natural fish food in certain proportions is still needed. Otherwise fish will not grow properly. This is because not all nutritional requirements of carp are covered by them. There are essential proteins, minerals and vitamins which are missing from such feeds. Consequently, they must be supplemented by natural fish food.

If all nutritional requirements of carp are exclusively covered by feed, consumption of natural food is not needed. This type of feed should be used if carp is produced in tanks and cages.

FIGURE 30

Role of natural food and feeds according to the intensity of carp production in ponds



Role of natural fish food in a pond reduces as intensity of production increases. Parallel to the intensity of production, importance of feeding also increases. At extensive and semi-intensive production cheaper, energy rich feeds are used to supplement the protein rich natural food. Together with the intensity of production better and more complete diet is needed in which protein, energy, minerals and vitamins are increasingly included and balanced. These factory-made feeds are fully balanced and contain everything which is needed for the healthy development and growth of fish.

Illustration courtesy of Andras Woynarovich.

There are a wide range of supplementary feeds used in carp polyculture. They are listed in Table A21. With the shift towards intensive fish culture the use of balanced feeds becomes necessary. Hence, other ingredients of plant and animal origin should be also incorporated into the diet of carp. To hold these components in the feed together it is pelleted. Pelletization also helps water stability of feed and reduction of wastage.

It is a good practice that mixtures of supplementary[28] and balanced feeds are given to carp when the stranding biomass increases. In the mixture, either the proportions of protein rich supplementary feeds[29] are increased or the different grains (wheat, maize, sorghum, etc.) are supplemented with balanced feeds. The proportion of balanced feed in the mixture increases parallel to the standing crop of carp (see Table 5).

5.2 Nutritional requirements of carp

5.2.1 Crude protein requirement

Proteins play a central role in biological processes. If feed contains less protein than the requirement fish will grow slowly. Young fish require much more crude protein content in their diet than elder and adult fish. Crude protein content of feed should be between 40–45 percent until the size of fish reaches approximately 50–60 gr. Then, according to the size of fish, protein content can be reduced to 28–30 percent. This is because carp gradually requires more energy than crude protein. Energy is to be provided by lipids and carbohydrates.

5.2.2 Lipid requirement

The energy requirement of carp changes by age. Up to the age of one-summer-old, two-summer-old and in the third year the energy requirement of carp is 4 200 kJ/kg, 4 600 kJ/kg and 5 400 kJ/kg respectively (Tasnádi, 1983).

Lipids are the other important group of nutrients in carp feed. They provide energy for fish. Young carp require fewer lipids, but lipid content of feed should be increased gradually while fish is growing. Lipids are the main energy sources in both farm-made and commercial feeds.

Although lipid content of larvae feed is around 8–10 percent, the oil content will be increased until 12–15 percent according to the actual size of fish.

In recent years scientific studies suggest using vegetable lipid sources like sun flower and rapeseed oils in fish feeds. Carp can digest and utilize this kind of lipid source well which may reduce costs of feeds.

5.3 Preparation of farm-made pelleted carp feeds

There are many different receipts of carp feeds made out of locally available ingredients. If all ingredients are available preparation of pelleted carp feeds can

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28 In this case the supplementary feeds are mainly grains (wheat, corn, sorghum etc.).

29 Their maximum proportion in the carp diet is presented in Table A21.

be economic. Steps of carp feed preparation are not complicated and they can be easily followed by fish farmers. These steps are selection of ingredients, grinding, mixing, conditioning, pelleting, cooling and drying.

5.3.1 Selection of ingredients

Good quality fish feeds are prepared from good quality ingredients. Low quality ingredients cause problems and make fish sick. Feed conversion rate (FCR) of low quality feeds is higher.

Carp is omnivorous. This means they also consume and utilize well food of plant origin. Therefore, ingredients of plant origin can also be selected for carp feeds. There is a certain recommended proportion of the different ingredients in the feed of carp, which is presented in Table A21. However the key ingredients are soybean meal, wheat meal, corn, corn gluten meal (see Figure 31). Feed can be enriched with poultry by-products. Fish meal is an essential crude protein source in commercial fish feeds, but for small fish farms it is difficult to purchase it in small amounts. Although soybean and corn gluten meals are plant protein sources, they include 40–42 percent crude protein and this rate is enough to feed carp successfully, especially in their early life cycle.

The determination of ingredients is very important. Most of plant origin ingredients can be found easier than animal origin ingredients, because the later are expensive imported products. There are some ingredients which may replace fish meal, such as poultry by products, meat-bone meal etc. Some selected ingredients are presented in Table 8.

FIGURE 31
Usual ingredients of carp feeds

Soybean meal | Corn gluten meal | Wheat meal | Fish meal

Photos courtesy of Özgür Altan.

5.3.2 Grinding

Every ingredient has a different density, size and physical appearance. Grinding process reduces the size and gives them a uniform size. This facilitates easy and proper mixing.

Size of ingredients should be reduced below 0.8–1.1 mm. Hammer mills are ideal to grind ingredients of carp feeds. Motor power should be chosen to be about 5–6 kW which will provide 200-250 kg/hour grinding capacity.

5.3.3 Mixing and conditioning

Mixing is the third step of fish feed production. Absolute and relative proportions of ingredients should be the same in the pellets of fish feeds. This is why mixing is also very important. Duration of mixing is not long. Depending on the ingredient 3–5 minutes are enough to obtain a homogenous mixture.

TABLE 8

Some widely available ingredients of balanced carp feeds and their nutritional value

Ingredient	Moisture	Crude protein	Crude fat	Crude ash	Crude cellulose	Metabolic energy (Kcal/kg)
Corn meal	13	9	4	2	2.5	3 460
Wheat meal	12	13	2	2	2	3 110
Soybean meal	13	45	0.5	6	6	2 650
Corn gluten meal	10	48	1.5	6	5	2 650
Fish meal	8	63	10	16	-	3 500
Poultry by-products	7	60	13	18	-	3 550
Oil	3	-	95	2	-	8 000–9 000
Peletted feed	10	28–40	3–4	10–12	2–6	2 800–3 250

Source Mazid M.A., Zaher M., Begum N.N., Ali M.Z., Nahar F.; 1997.

Conditioning is the last step before shaping and pelleting. This is when ingredients are moistened with oil and hot water. About 15–20 l of hot water and 10 l of fish or sunflower oil are used for 100 kg feed. The obtained mixture should have a consistency of a pie.

5.3.4 Pelleting

During pelleting, feed receives the ideal shape of a cylinder. If feed is well mixed and conditioned each pellet will contain the same quantity and proportion of ingredients. During the process, the temperature of pellets increases to 80–85°C.

5.3.5 Cooling and drying

Improperly cooled and dried feed will quickly spoil. This is why this step is so important and critical. Feed which leave the pelleting machine is hot and moist hence it should cool and dry before packing. Cooling and drying may last for about 6–12 hours. During this process a large surface will be needed where pellets can be equally distributed in one layer.

FIGURE 32
Farm scale feed processing machines

Grinder (hammer mill)

Mixer and pelletizer

Photos courtesy of Andras Woynarovich.

5.4 Feed storage

A fish feed consists of ingredients, and each ingredient includes nutrients. These nutrients are proteins, lipids and carbohydrates. Each nutrient has different chemical complexity, and they are sensitive to different physical conditions. Their chemical structure can be affected by temperature, moisture, exposure to air and pests. Therefore, professional storage of feeds is important, otherwise their quality will decay and they will spoil.

5.4.1 Effect of temperature and sun light

Fish feeds should be kept ideally at room temperature (22–24 °C) in a clean and dry storage facility which should not be exposed to direct sun light. Feeds are often kept on pond side in fish farms. Nutrients which received direct sun light and warm up will loose their nutritional value. Sun light and high temperature may cause toxicological problems in the feed. Lipids consist of fatty acids which will oxidize at high temperature. This invites either diseases or toxicity. Both ways, there is a great risk of losing fish stocks.

5.4.2 Effect of moisture

Moisture is very critical for fish feeds. Therefore, feeds must be stored in dry, tidy and well organized places (see Figures 23 and 34). If not, feed will become mouldy within a very short period of time (see Figure 33). Mould carries risk of contamination and disease factors, and may also cause toxicological problems.

Feeds, chemicals, medicines and similar materials should never be stored together in the same storage facility.

5.4.3 Effect of rodents and birds

Rodents and birds are especially likely to eat fish feeds. Chemical and physical methods can be the solutions to keep rodents and birds away from feeds.

Chemical solution is to distribute granule poisons in well set boxes around the storage. The physical solution is to keep the doors tightly closed and put metal screens on the windows and doors.

Physical damage of feed bags is another problem (see Figure 33). Careful handling of bags is an essential part of keeping order in the feed store. Damaged bags should be used first and feeds scattered from damaged bags should be swiped and/or cleaned.

FIGURE 33
Bad examples for storing feeds

Untidy and damaged sacks of feeds — Sacks eaten by rodents

Photos courtesy of Özgür Altan.

FIGURE 34
Clean and order storage of feed

Photos courtesy of Özgür Altan

6. HANDLING OF FISH

BOX 17

Frequent problems of handling fish

Precondition of professional handling of fish is having and using suitable devices, equipment, instruments and tools. Frequent related problems are:

- Nets used for fishing need repair and maintenance. As they are in a poor condition, fishing with them is both ineffective and insufficient.
- Tanks and air/oxygen diffusers used for transporting fish are partly or entirely unsuitable.
- Poorly maintained tractors and vehicles risk moving live fish in time.

Handling is an unavoidable part of all carp culture technologies. Wounds and stress caused by handling is a predisposing factor to diseases, and as such, handling should be seriously considered in order to reduce its negative effects.

Handling of fish includes their transfer, release, fishing, sorting and grading, transport and storage.

6.1 Transfer and release

Between technological phases fish are removed from their earlier environment to be reared or stored in another pond. When transferring fish from one place to another, it is important to avoid thermal shock. Younger fish are more sensitive to thermal shock. Even 1 ^{o}C may cause shock and lead later to fatal consequences. To avoid thermal shock, water temperature in the container in which fish is transferred or transported should be gradually (slowly) adjusted to that one where fish is placed (stocked). As soon as the temperature is equalized and the fish adjust, they can be released. Release of fish should always be done with care as shown in Figures 18 and 21.

6.2 Fishing

Capturing fish with net is one of the most critical operations. It is particularly problematical in carp polyculture when different fish species and often different age groups are captured at the same time. Therefore, fishing should be carried out with the greatest care, and as fast as possible to minimise the period when fish welfare may be compromised. With good planning, trained and dedicated staff, and sufficient resources (manpower, good quality equipment, tools and machines) fishing can be done quickly and efficiently.

During harvesting a production or storage pond, fish are captured with nets which crowd them into a very small space. This is very critical and stressful hence specific BMP principles should be observed and implemented. These are:

- Feeding of fish should be stopped well before fishing. If water temperature is higher (18–25 ^{o}C) 1–2 days are enough but at lower water temperature (10–15 ^{o}C) 2–3 days are needed for fish to empty their digestive track. If fish are attracted with feed, the gathered stock should be encircled first then captured in groups with a smaller net.

- Only good quality knotless net with the suitable mesh size should be used (see table A22).
- Fish crowded in net should be supplied continuously with sufficient fresh, oxygen rich water, either by water current or by a pump of substantial water carrying capacity.
- Fish from net must be removed immediately and placed into a tank or happa. Once fish are harvested they should be held in clean, running water where they can flush out their gills.
- First the most sensitive fish species should be removed from the net. Another similar rule is that larger fish should be removed first if most of the captured fish are small. However, if the greater part of fish is large, the smaller fish should be removed first.
- Fish can be removed manually with a scoop net or by using mechanical means as demonstrated in Figure 35.

FIGURE 35

Removing fish from the net

Fish are being scooped and carried to the containers manually.

Fish are being removed with a crane from the net.

Supplying fresh water into crowded net reduces stress.

Photos courtesy of Azat Alamanov and Andras Woynarovich.

6.3 Sorting and grading

Harvested fish are usually sorted by species and graded by size immediately, even before they are stocked into production or storage ponds. For this purpose sorting tables are used. It is important that sorting and grading should be completed as quickly as possible to ensure the least possible time for fish to be out of water. Mechanical damage should be minimized with well equipped, skilled and dedicated staff. Related BMP principles are:

- Moving fish "from water to water" will eliminate losses.
- During sorting fish should never be dropped, thrown or piled in large batches on the sorting table.
- It is important to use good quality well lined sorting table and complete the work quickly and carefully. A sorting conveyor belt or grading machine is useful when huge quantities of fish are sorted/graded (see Figure 36).

6.4 Transport

Transport of different age groups of live fish within and between fish farms should be done according to same principles. As transport of live fish is also a very stressful procedure it should be carried out with great care and professionally. Related BMP principles are:

- In general younger fish are more sensitive to and stressed by transport.
- Before transport digestive track of fish should be emptied. It is done by stopping feeding. Depending on the size of fish this lasts about 1–2 days at higher (18–25 °C) and about 2–3 days at lower (10–15 °C) water temperature. Under 10 °C it is even slower.
- Use of open fish tanks with aeration is suitable for short distance within a fish farm, while use of well closing containers with proper oxygen diffusion is a must for longer distances.
- In general fish needs more oxygen when water temperature is higher. Minimum oxygen concentration in transporting water should be at least 5 mg/l.
- During internal transport use of low concentrations of NaCl in transport water will minimise stress of fish.
- Actual quantities of transported fish depend on age, species, water temperature and duration of transport. Corresponding figures are presented in Tables A25, A26, A27 and A28.
- Live fish should never be transported without valid health certificate.

FIGURE 36

Sorting and grading of fish

Sorted fish are placed into different containers to sift them to wintering ponds (above).

Plastic baskets placed into water will ensure that fish will remain in water (above).

At the centre of a fry and fingerling producing farm concrete tanks and shelter facilitate proper and easy work for sorting and grading fish (below left).

Photos courtesy of Andras Woynarovich.

6.5 Wintering

During winters live fish should be stored safely. It can be done in three different ways. First one is when fish is harvested only at spring. Therefore, fish remain in the production pond where they winter. Second option is when fish is already stocked into production ponds in autumn. These fish will also winter in the production pond. Third option is when the harvested fish sorted/selected by species and size (age) are wintered in small ponds in high densities presented in Tables A23 and A24. Relevant guiding BMP principles are:

- If water is covered by ice its regular cleaning from snow is important. Cutting ice holes is another important task to be completed in time.
- Before use wintering ponds should be dried, cleaned and disinfected well with quick lime.
- Continuous supply of good quality water, as well as correct setting of supply and drainage structures of storage ponds are preconditions of wintering fish in high densities.
- Checking oxygen content of water where fish are stored must be part of the daily routine.

FIGURE 37
Fish transporting vehicles and devices

Tractors and containers used for transporting fish within farms.

Lorries equipped for transporting fish within and between fish farms.

All of the devices are commonly equipped with oxygen cylinders regardless of fish transport within or between fish farms.
Photos courtesy of Azat Alamanov and Andras Woynarovich.

6.6 Welfare

Fishes, including carp, are the first level in the evolution, where the central nervous system is so well developed, that they can feel pain and they can suffer, similar to mammals. With proper management fish farmer should provide good welfare for the cultured fish.

Although carp culture, especially the extensive form, uses many techniques that are closely analogous to what these fish experience in the wild, fish culture systems inevitably introduce a number of stressors to the fish. These include inappropriate water chemistry and temperature, handling, physical damage, disease treatments and incomplete nutrition. It is impossible to avoid many of the procedures known to induce stress responses of fish and having welfare indications. Netting, sorting/grading and transport are integral components of fish farming routines and fish farmers should minimize the stress they cause.

In general, the duration of the stress response is proportional to the duration of the stress. Thus, reducing the time-course of the event (netting, sorting/grading, transport, etc.) will encourage more rapid recovery of fish. Specific BMPs on welfare of carp are:

- Carp is a relatively resistant fish species and can tolerate wide ranges of water flow, oxygen level, temperature range, water pH and suspended solid levels. Providing normal ranges of these environmental conditions is the basis of the good welfare of cultured carp.
- Rapid temperature changes, unionized ammonia, algal blooms, predation by birds and disease are the major welfare issues in carp husbandry. Therefore, farmers should pay special attention to providing optimal ranges of these factors in order to avoid welfare problems. Accordingly, by applying good husbandry farmers also provide good welfare for carp.
- To be successful and to maintain welfare standards in carp culture it is important to train staff in this subject.

7. BIOSECURITY AND AQUATIC ANIMAL HEALTH MANAGEMENT

Infectious diseases will always be encountered in any food production system. Managing aquatic animal health and biosecurity in aquaculture is particularly challenging because of the great diversity in cultured species, culture environments, nature of containment, intensity of farming practices, and culture and management systems.

BOX 18

Definitions of biosecurity and aquatic animal health management

Biosecurity is the sum total of a country's activities and measures taken to protect its natural aquatic resources, capture fisheries, aquaculture and biodiversity, and the people who depend on them from the possible impacts resulting from the introduction and spread of serious trans-boundary aquatic animal diseases (TAADs).

In its broadest sense aquatic animal health management encompasses pre-border (exporter), border and post-border (importer) activities, as well as relevant national and regional capacity-building requirements (infrastructure and specialised expertise) for addressing health management activities, and implementation of effective national and regional policies and regulatory frameworks required to reduce the risk of disease spread through movement (intra- and international) of live aquatic animals.

Trans-boundary aquatic animal diseases (TAADs) are highly contagious and can rapidly spread across national borders. They limit the development and sustainability of the sector through production losses and other negative consequences. They have direct and indirect impacts on livelihoods (income and employment), increase operating costs, restrict trade, reduce market share and result in investment losses. Diseases also have impacts on biodiversity and, in severe cases, can lead to the collapse of the sector.

Aside from TAADs, the aquaculture sector faces chronic and persistent pathogens such as parasites, fungi and bacteria. These continue to threaten the sector in terms of production losses, efforts and expense to contain and eradicate them costs which would have been better spent preventing their entry into the system.

This chapter is divided into 3 sections:

- Section 7.1 deals with a number of general BMPs that are applicable to any aquaculture species. The information is presented with a short description of the principle, followed by BMPs and recommendations targeting either governments or fishfarmers, or both.
- Section 7.2 describes husbandry- and health management-related actions directed to fishfarmers involved in different stages and phases of carp production.
- Section 7.3 provides detailed information on the causative agent, host range, clinical aspects, diagnostic methods, modes of transmission, and control and prevention of important diseases of carps.

The principles and practices presented in this chapter include the most important concerns. Throughout the document, there will be repetitions or re-emphasis because of the cross-cutting nature of the subject.

7.1 General BMPs on biosecurity and aquatic animal health management

There are two lines of defence against fish pathogens: protection and prevention.

- Protection includes hygienic practices using pathogen-free water, seed/broodstock and feeds and controlling wild fish, vectors and pests, as well as regular monitoring of health and responsible movement of fish, with quarantine if needed.
- Prevention includes maintaining good water quality, sufficient and good quality feed, appropriate stocking density and stress-free rearing environment.

The measures are grouped into ten BMPs on biosecurity and aquatic animal health management:.

7.1.1 Prevention

An ounce of prevention is worth a pound of cure. It is better and cheaper to avoid than fix a problem once it has occurred. The aim is to minimise the risk of disease entering a country:

- Maintaining alertness or vigilance is essential to achieve this. Once a pathogen or disease agent has been introduced and becomes established in the natural aquatic environment, there is no or little possibility for eradication. Therefore prevention is the best strategy.
- Preventative measures to limit exposure to pathogens and diseases, such as good governance, use of BMPs, good aquaculture practices, health certification and quarantine, appropriate use of specific pathogen free and high health stocks are encouraged.
- Innovative health management measures need to be continuously practiced and updated with changing aquaculture landscape. Funds are better spent on preventing pathogens from entering the system than containing and eradicating diseases.

7.1.2 Managing biosecurity and aquatic animal health

Managing biosecurity and aquatic animal health through effective governance includes membership of countries in international bodies[30]. This requires countries to abide with the conditions of membership, i.e. implementation and compliance with aquatic animal health-related provisions and standards embodied

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[30] The World Organisation for Animal Health (OIE), the World Trade Organization (WTO) and the European Union (EU)

in international agreements and relevant legislations and directives. There are also voluntary guidelines[31] which provide further support to both farmers and authorities.

It is important to appoint a competent authority on aquatic animal health management so that national responsibilities and obligations (including compliance with international agreements) and local services are effectively provided to fish farmers.

Whether the authority is with the fisheries/aquaculture or animal health sector, the important requirement is the authority should have the competence to carry out the task. If several authorities are involved, institutional jurisdictions and responsibilities should be clearly defined and an oversight agency identified.

National policy and planning need to be in place, including corresponding legislation and regulation to support their implementation, as well as human capacity and infrastructure to enforce them.

Development of national strategies on aquatic animal health is another task to be completed. The strategies contain:

- The government's action in the short-, medium- and long-term towards effective aquatic animal health management.
- A national level implementation plan of regional/international agreements and standards.

The strategy should be developed in a consultative and participatory manner and implemented using a phased approach based on the country's needs and priorities. In this process, each stakeholder has an important contribution to minimising the risk of a pathogen entering a country. Therefore regular engagement of all stakeholders in biosecurity governance is a good practice.

7.1.3 Movement of live aquatic animal

Responsible domestic and international movement of live aquatic animals including introductions, transfer and trade is a key part of biosecurity and aquatic animal health management. As aquaculture expands and diversifies, trade also expands. Fish and fish products are globally the most traded commodities[32]. Trading in live animals and products has become an important income generating activity for primary producers. Expectedly, trade will continue, legally or otherwise. An element of pathogen risk is always present in animal movements, which could open new pathways by which pathogens and diseases spread to new areas. Obviously, the risk is higher with unregulated and indiscriminate movement.

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31 FAO Code of Conduct for Responsible Fisheries and Hazard Analysis and Critical Control Points (HACCP)

32 Ornamental/aquarium trade, aquaculture development, live food market, baitfish, capture fisheries development/enhancement, biological control, angling/sport development, and others (e.g. animal feed, medicine and health products, etc.).

BOX 19

Risk analysis

Risk analysis is an important decision-making tool. It can be used for timely assessment of emerging threat from new or expanding species, and responsible authorities are encouraged to make use of it.

Any proposal to introduce or transfer an aquatic animal species in a territory must be subjected to a risk assessment. Risk analysis and risk mitigation will reduce the likelihood of a serious disease occurrence.

Risk management measures are recommended to be done at pre-border, on-site and at post-border. Pre-border measures include the certification of production source and the use of approved species. Species should come from approved exporting countries. On-site measures include the inspection of exporting facilities. Post-border measures include the restrictions on use of imported species, monitoring programmes and contingency planning (when a disease does occur, what is to be done?). The risk management measures should match the level of risk (the level of risk is determined by the risk analysis process).

Aquaculture zoning is also a means to establish and maintain disease-free growing areas. Zoning helps restrict the spread of pathogens. Thus, it can be used as a basis for permitting domestic and international trade of live aquatic animals originating from different zones. Movement of live aquatic animals should follow the principle that movement should be done only between zones and farms with the same health status.

7.1.4 Host, pathogen and environment

Aquatic animals live in a dynamic and complex environment; their health is not always readily visible and feed consumption and mortality are often hidden under water. Because the complexity of the aquatic system can obscure the distinction between health, sub-optimal performance and disease, more attention is required to monitor the health of fish.

The interactions between the host, the pathogen and the environment are important factors contributing to the development of a disease. Diseases in aquaculture are not caused by a single event, but are the end result of a series of linked events. This involves the interactions (see Figure 38) between:

- The host – physiological, reproductive and developmental stage conditions.
- The environment – water and the determinants of its quality, such as temperature, oxygen, pH, toxins and wastes.
- The presence of the pathogen (viruses, bacteria, parasites, fungi). Diseases may be caused by a single pathogen species or a mix of different pathogens.

FIGURE 38

Representation of the relationship between host, pathogen and the environment in disease development

Source: Bondad-Reantaso *et al*., 2001.

Good water quality will ensure optimal environment for producing healthy fish and should be maintained at all stages of production.

Good quality broodstock and seed raised in good water quality environment supported by good husbandry practices will ensure better resistance to infectious diseases and optimal survival and growth and therefore healthy harvest.

In fish culture there are many stressors. These can include poor handling, poor water quality, inappropriate stocking density, inadequate feeding and/or poor quality feed, change of environments and drug treatments. Stress can lead to abnormal behaviour and should be avoided at all stages.

Parasites and pathogens, even when present in the aquatic environment, may not develop into a disease situation if the hosts are healthy. This is best achieved by stocking fish of strong immunity and farming them in a stress-free environment, at an appropriate stocking density and with good nutrition.

7.1.5 Monitoring health

Monitoring health and keeping good records are good farming practices. Health monitoring should be done through:

- day to day observation of fish and its environment,
- regular and need-based sampling of fish and water for laboratory analysis, and
- good record keeping.

Farmers should be familiar with the normal behaviour of fish stocks and ready to take appropriate action as soon as any abnormal behaviour, feeding and physical appearance of fish is observed.

Keeping good and regular records of important husbandry and health management practices, weather and climatic conditions, and farm events are part of a good BMP. Farm records need to be accurate, up-to-date and accessible.

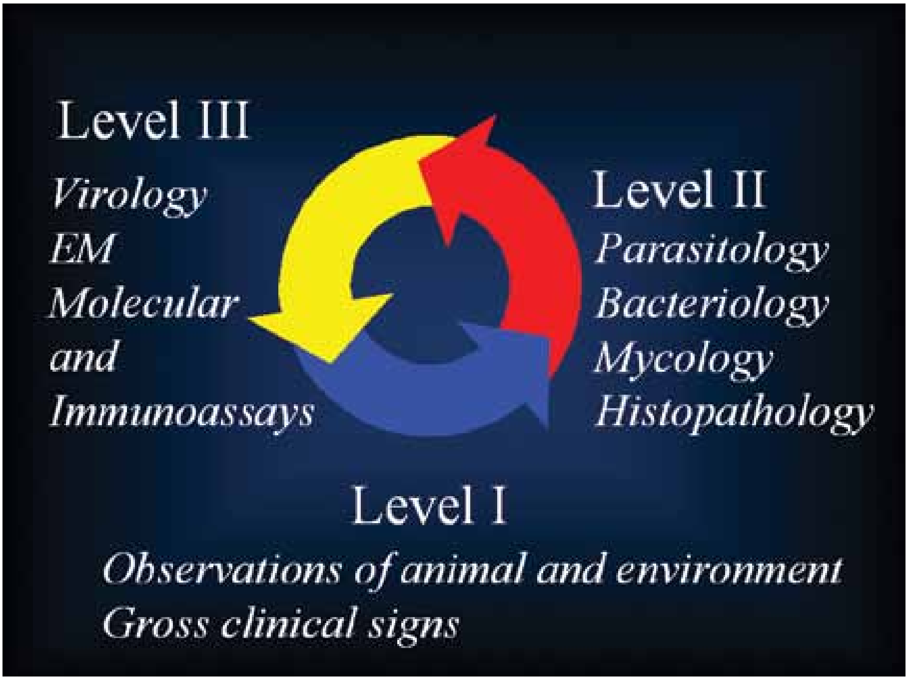
7.1.6 Diagnosis and control measures

Correct diagnosis is the basis of appropriate and effective disease control measures. Diagnosis is the determination of the nature of a disease. The two important roles of diagnostics are:

- Screening of healthy animals to ensure that they are not carrying infection. This is usually done before transfer of live aquatic animals from one area or country to another.
- Determination of the cause of unfavourable health or other abnormality in order to recommend mitigating measures applicable to the particular condition.

FIGURE 39

Levels of diagnostics



The three levels of diagnostics represent a continuum of observations from simple to sophisticated observations that ensure meaningful interpretation of the disease situation

Correct diagnosis is important for determining what the disease condition is, the severity and the cause of the condition. Wrong diagnosis can lead to ineffective or inappropriate control measures, or delay treatment and may cause further harm.

Disease diagnosis is not solely conducted through a laboratory test. Field observations are equally important which complement laboratory tests and contribute to better understanding of the health status and disease condition of fish.

Disease diagnosis spans three levels from the simple to the sophisticated. The levels of observation are:

Level I : Farm/production site observations and gross clinical observations.

Level II : Laboratory-based analysis of fish (e.g. parasitology, bacteriology, mycology and histopathology) and water samples.

Level III : Advanced diagnostic specializations (e.g. virology, electron microscopy, molecular biology and immunology).

The outcomes of each level of diagnostics contribute to an accurate and overall diagnosis and ensure meaningful interpretation of the disease situation (see Figure 39).

Diagnostics is strongly connected with surveillance work. Early detection followed by prompt response to disease epizootics prevent the rapid spread and establishment of disease.

Effective diagnostic services, through public (national diagnostic laboratories) and private sectors should be made available for farmers.

7.1.7 Health certification

Meaningful health certification and integrating quarantine into the national biosecurity framework are important guarantees for stopping the introduction and spread of fish parasites and pathogens.

Quarantine used to be considered a separate activity, a procedure that should be applied to all imports of live aquatic animals. As such it was not effective in preventing the entry and spread of exotic TAADs to national territories. Health certification, a prerequisite for national and international movement of live aquatic animals, should be and has been made an integral part of the quarantine process.

As part of the risk analysis process, quarantine measures, within the overall biosecurity programme, should be fully integrated into national strategies on aquatic animal health.

Capacity to issue international health certificates for aquatic animals based on diagnostic tests should be developed by countries as specified by the World Organisation for Animal Health (or OIE by its French name).

A national pathogen list, which is a list of serious pathogens of national concern, should be established by countries and should serve as basis of health certification, quarantine and surveillance.

Farm-level quarantine is an effective biosecurity practice and should be carried out especially for incoming new stocks, or old stocks coming from trade shows.

7.1.8 Use of veterinary medicines

On-farm biosecurity can be improved through prudent use of veterinary medicines such as antibiotics, chemotherapeutants and disinfectants, drugs or similar agents used against disease organisms.

Veterinary medicines have proved useful in aquaculture in various ways: as the next recourse when preventative therapy fails, for treatment of emerging and re-emerging infectious diseases, for developing new culture technologies, and for maintaining the well-being of fish.

While BMPs are the preferred option, the use of veterinary medicines, in some cases, may be necessary. And when they have to be used, veterinary medicines should be:

- prescribed by qualified aquatic animal health professionals[33] licensed by national and regional authorities,
- used according to accurate and appropriate diagnostic procedures, and
- applied in a responsible manner in all phases of aquaculture production.

Appropriate and well-conceived legislation and regulations should be in place, particularly those that pertain to the registration of veterinary medicines[34], licensing of aquatic animal health professionals, extra-label use, and record-keeping on veterinary medicines by manufacturers, aquaculture production facilities, and aquatic animal health professionals.

7.1.9 Disease surveillance, monitoring and reporting

Disease surveillance, monitoring and reporting are the basis of early warning of emerging disease outbreaks. They are also fundamental components of any official aquatic animal health protection programme.

Surveillance and monitoring of aquatic animal diseases are essential for detection and rapid response to serious disease outbreaks. Surveillance is a systematic process of gathering information on the occurrence of important pathogens and diseases within national territory. It provides evidence for declaring freedom from certain diseases.

Farm registration, national database on health status of registered farms, national pathogen list, diagnostic capacities, reporting procedures and practical feedback mechanisms are some of the important prerequisites for a surveillance programme, and they should be in place.

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33 They are either veterinarians or aquatic animal health specialists.

34 National authorities should be consulted for guidance concerning approved drugs for use in aquaculture.

Countries which are members of the World Trade Organization and OIE have mandatory reporting responsibilities to the OIE concerning the OIE-listed aquatic animal diseases that are relevant to the country.

7.1.10 Emergency preparedness and contingency plan

Emergency preparedness is the ability to respond quickly and effectively to disease emergencies (disease outbreaks, massive mortalities). A great deal of planning and coordination is needed and starts with early detection.

The possibility of a serious disease outbreak due to an exotic pathogen or strain will always be there as long as there is importation of live aquatic animals, therefore responsible movement of live aquatic animals should be a key action of both the government and the private sector.

BOX 20

Empowering farmers

Farmers have an important role to play in contributing to implementing effective on-farm aquatic animal health management and biosecurity practices. Empowering farmers to manage farm-level risks and continuously raising their awareness and updating their knowledge of important aquatic animal health and biosecurity issues at national, regional and international levels will help in preventing, managing and controlling aquatic animal diseases.

Such issues may include compliance with national legislation (e.g. farm registration, prudent use of veterinary medicines, disease reporting, etc.), penalties and aquatic animal health risks for non-compliance, risks in aquaculture production, certification issues, appropriate use of specific pathogen free (SPF), specific pathogen resistant (SPR) and high health stocks, farm level surveillance to support national surveillance programmes and others.

Developing emergency preparedness and contingency plans for important cultured species and diseases is desirable. This includes an implementation plan and advanced provision of financial resources.

Emergency response with strong support from the fish farming sector should be a core function of government services.

7.2 On-farm biosecurity BMPs in carp production

Empowering farmers through their being organized can be a good entry point and mechanism for (a) introducing BMPs on biosecurity and aquatic animal health and (b) monitoring their implementation.

Regional farmers' organizations could be particularly effective for coordinating biosecurity measures amongst farmers located in the same geographical areas (watershed) and sharing a common water supply. Farmers can contribute to the development of site-specific BMPs using their traditional knowledge and practical farming experience in identifying farm-level problems and risk areas that can be the subject of research or assessment.

The following section describes important on-farm biosecurity BMPs for dealing with day-to-day situations on farms. The BMPs will help in maintaining healthy status of fish stocks and to a certain extent prevent a disease emergency from occurring or spreading.

In aquaculture, prophylaxis means safeguarding the health of fish from pathogens or diseases. As mentioned in Section 7.1, there are two main concepts for on-farm biosecurity, namely, protection and prevention. Protection, the first line of defence, is intended to stop the pathogen. This can be achieved through, for example, use of pathogen-free water, pathogen-free food, hygiene practices (disinfection of habitat, equipment, and fish), control of wild fish, vector and pest control, transplant regulations (responsible movement, border inspections), quarantine, regular prophylactic surveys, independent water supply, age segregation. Prevention, the second line of defence, is intended to strengthen the fish in order to reduce the probability to contract pathogens. This can be achieved through, for example, maintaining good quality water and using high quality food, using appropriate stocking density, avoiding stress, and genetic manipulation.

The on-farm biosecurity BMPs presented in this section are a combination of good husbandry and good fish health management practices that will ensure protection and prevention of fish stocks from pathogenic infection.

The section on on-farm biosecurity principles and practices is divided into four parts. The general section refers to farm-level biosecurity BMPs that cut across all production phases. This is followed by farm-level biosecurity BMPs at hatchery, nursery and grow-out phases. The last section deals with BMPs during transport.

7.2.1 General

There are a number of basic farm-level BMPs that should be implemented through the entire production phases. Farm hygiene, reducing stress to fish, record keeping, and biosecurity practices are essential in protecting fish stocks from infection and in preventing disease occurrence.

Understanding good health management is the key to disease prevention and early warning/reporting is indispensible to minimize disease spread. Examples of relevant BMPs are as follows.

Stress should be avoided through:

- maintaining good water quality and culture environment,
- handling fish with great care, and
- segregating stock by age and size whenever it is needed.
- Farm hygiene is maintained by:
- keeping facilities clean all the time,
- fallowing pond bottom to break the life cycle of a pathogen,
- regular cleaning and disinfection of equipments (nets, dip nets, buckets), and
- using separate set of equipments in tanks and ponds where fish are infected with parasites or sick.

Record keeping is made on:

- all aspects of the farming practices including health case history,
- water quality parameters (see Chapter 4),
- production-related data (see Chapters 3 and 6), and
- registration of the operation to the local authorities.
- Biosecurity measures include:
- use of risk analysis as decision-making tool for timely assessment of threats to new or expanding aquaculture species,
- use of high quality broodstock and seed,
- quarantine of incoming fish stocks, and
- preventing wild animals and pests from entering into the fish farm facilities.

7.2.2 Brood stock management and hatchery

Farming operations are set up in various ways. Vertically integrated farming operations have better control over the quality and the movements of fish between production phases, and therefore allow higher level of biosecurity.

Production of high quality seed is one of the most important criteria to a successful aquaculture operation. Variability in quality of seed and presence of diseases can result in huge damage to both the hatchery and grow-out sections of fish farms. The hatchery phase involves handling of sensitive and fragile animals and therefore requires strict biosecurity measures.

Broodstock management enables farmers to sustain and improve the quality of progeny, thus, hatchery operators are encouraged to establish an effective broodstock management system. Movement of broodstock needs to be conducted in a responsible manner. If brood fish are sourced from outside the country, international and national regulations and relevant biosecurity procedures should be strictly enforced. Related BMPs are:

- only healthy broodstock from reliable sources with good health history should be used,
- if brood fish are purchased from outside, they must be quarantined,
- all incoming water source of the hatchery should be treated to eliminate pathogens,
- all equipments and tanks should be disinfected[35] after each use,
- all waste materials should be disposed properly to avoid contamination, and
- when a disease emergency occurs in a fish hatchery the only effective means of eradicating an infection is by destroying affected eggs and

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[35] For this purpose either hypochlorite solution at 200ppm concentration for 5 min. or approved iodophore solution at 5 percent iodine for 5 min. can be used.

larvae, disinfection of water supply facilities/system and all hatchery devices and equipments, and then restarting the works with new disease-free broodstock, eggs and larvae.

7.2.3 Nursery

Fish larvae and developing fry are delicate animals, especially when exposed to various environmental conditions and thus require close monitoring. If a farm is outsourcing fish larvae, it must purchase good quality seed from reliable hatcheries. Proper handling of fish larvae and developing fry should be conducted throughout the nursery phase. The most important BMPs are:

- screening/filtering of water (see Section 3.3 and Chapter 4),
- stocking only active, uniform-size feeding larvae free of deformity,
- larvae purchased from outside the fish farms should have valid health certificate,
- stocking feeding larvae should be done with care as described in Section 3.3, and
- performing stress test will show whether the seed are of good quality or not.

7.2.4 Grow-out

It is a common practice that carp fish farms purchase advanced fry, one- and two-summer-old fish for further rearing. However, whether fish is purchased from outside or own fish stock, the optimum rearing conditions, described in Chapter 3, must be ensured. These should be complemented with hygienic farm practice. Good pond preparation reduces the risk of disease outbreaks. Wild fish should be prevented from entering ponds because they may carry pathogens capable of causing serious harm. In addition, it is advisable to control vector animals (snails, leech and water fowls) and pests.

BOX 21

On-farm observations of fish

Observation of fish behaviour

- Abnormal fish behaviour: fish swimming near the surface, sinking to the bottom, loss of balance, cork-screwing, listlessness, flashing, belly-up, concentrated around the inflowing water supply and air-gulping
- Abnormal feeding behaviour: increased feed consumption followed by cessation of feeding and off-feeding

External observations of fish

- Damage to skin and fins: It could be due to infectious agents, mechanical damage due to contact with rough surface or predator attack or chemical trauma. It can lead to primary or secondary infection by pathogen.
- Changes and parasites on skin and fins: These could be red spots, haemorrhages, erosion, mucous build-up, loss of scales, surface parasites, encysted larvae (black or white spots)
- Abnormal growths: Tumours and malformation.
- Eye: Shape, colour, cloudiness, gas bubbles, lesions (red spots), enlargement, distension (pop-eye)
- Gills: Paleness and erosion of gills, red spots in gills, fouling, mucous build-up or presence of parasites in gills,
- Body: Lateral or dorso-vental bends in the spine and distension of the abdomen (pot belly).

Internal observations of fish

- Body cavity and organs: Haemorrhaging and a build-up of bloody fluids in a body cavity, white-grey patches present in the liver, kidney, spleen or pancreas and swollen intestines.

Monitoring the state and condition of growing fish and its environment should be done as described in Box 21. If problems are found, the applicable BMPs are:

- affected fish should be isolated,
- dead or moribund[36] fish should be removed and buried. When burying dead fish use of quick lime will disinfect fish and the site,
- fish or any equipment from a pond with sick or dead fish should not be moved to another pond,
- veterinary medicines should be used in a responsible manner based on accurate and appropriate diagnostic procedures by aquatic animal health professionals,
- excess of veterinary drugs and other hazardous chemicals must be disposed without affecting the culture stocks and humans,
- In case of persistent or increased mortalities consultation with fish health specialist and preparation of samples for laboratory examination are the appropriate actions (see Box 21), and
- disease outbreak or suspicion of any abnormal behavior/appearance in fish stock should be reported to concerned authorities.

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[36] Sick and dying fish should be killed quickly in the most considerate way possible.

7.2.5 Transport

Transport of live fish may become necessary between each phase of production and finally during marketing. Transport of fish should be conducted with great care using clean, oxygen-rich water and adequate density to minimise the stress to the fish. Key factors for consideration include: type of species, duration of transport, volume of water, physiological condition of fish (food consumption), stocking density and environmental factors (temperature).

Transport of brood fish is another delicate operation. Brood fish should be gently anesthetised before transport to prevent fish from jumping and hurting themselves.

BOX 22

Steps of sample preparation for submission to laboratory

Pack live fish in plastic bag with one third of water and 2/3 volume of air/oxygen. If live fish is not available, take sample of clinical lesions (< 1cm^3) from freshly dead fish. Fix the sample with formalin for 24 hours and wrap fixed tissues in plastic bag.

Label the sample with information, such as date, time, location of collection, species, size of fish, type of tissue/organs, used of fixative and name of collector/sender.

Pack the plastic bags and post/deliver to laboratory and inform the laboratory about the samples being sent.

Observing and following related BMP guidelines summarised in Chapters 3 and 6 will ensure suitable healthy environment and stress-free at transport.

7.3 Selected diseases of carps

Some of the common diseases affecting carps are described in this section. Two examples of important viral diseases of carps are presented, with details on causative agent, host range, clinical aspects and host susceptibility, diagnostic methods, modes of transmission, control and prevention and some notes of reporting are presented.

The sections on bacterial, parasitic and fungal diseases are presented with general information of the pathogens and how they, as a group rather than as individual pathogens, affect fish farming.

7.3.1 Viral diseases

Spring viremia of carp (SVC)

1. Causative agent: Spring viremia of carp virus (SVCV) or Rhabdovirus carpio (RVC), ssRNA Vesiculovirus (Rhabdoviridae)
2. Host range: Common carp (*Cyprinus carpio*), koi carp (*Cyprinus carpio koi*), grass carp (*Ctenopharyngodon idellus*), silver carp (*Hypopthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*), crucian carp (*Carrasius carrasius*), goldfish (*C. auratus*), orfe (*Leuciscus idus*), tench (*Tinca tinca*).

Have also been isolated from non-cyprinid European catfish or wells (*Silurus glanis*) and rainbow trout (*Oncorhynchus mykiss*) and detected in pike (*Esox lucius*).

3. Geographical distribution: All countries where carp is cultured.
4. Clinical aspects and host susceptibility: Young fish up to 1 year old are most susceptible to clinical disease, but all age groups can be affected. Carp and other susceptible cyprinids up to 1 year old are most severely affected and mortalities can range between 30–70 percent. Obvious infection manifests from water temperatures ranging between 11–17 ºC.
5. Diagnostic methods: Non-specific behaviour and gross signs include lethargy, gathering at water inlets or sides of ponds, loss of equilibrium, abdominal distension, protruding vents and trailing mucous faecal casts, haemorrhaging at the bases of fins and vent, bulging eyes or exopthalmia, overall darkening and pale gills. These gross signs, as well as virology tests and transmission electron microscopy, may be used as presumptive tests. Immunoassays and nucleic acid assays are needed as confirmatory diagnostic methods.
6. Modes of transmission: Horizontal transmission via direct ways (contact with virus shed into the water by faeces, urine, reproductive fluid, skin mucous) and indirectly through vectors (fish-eating birds, the carp louse *Argulus foliaceus* or the leech *Piscicola geometra*).
7. Control and prevention: There is no treatment. Avoid exposure to the virus. Protective measures could be the following: good hygienic practices (egg disinfection by iodophor treatment, regular disinfection of ponds, chemical disinfection of farm equipment, careful handling of fish to avoid stress and safe disposal of dead fish), reducing stocking density during winter and early spring to reduce spread of the virus. Raising the water temperature above 19–20ºC prevents and stops SVC outbreaks. New stocks should be put into quarantine for at least two weeks prior to release into ponds for grow-out. The spread can be controlled through immediate removal and destruction of infected and contaminated fish and reducing stocking density during winter and early spring.
8. Reporting to OIE. SVC is a notifiable disease of OIE, therefore occurrence, first time or recurring requires immediate notification of OIE through the Chief Veterinary Officer of the country.

Koi herpesvirus (KHV)

1. Causative agent: koi herpesvirus
2. Host range: common carp (*Cyprinus carpio carpio*), koi carp (*Cyprinus carpio koi*), ghost carp (*Cyprinus carpio goi*)
3. Geographical distribution: Israel, Germany, Austria, Belgium, Denmark, France, Italy, Luxembourg, The Netherlands, Poland, Switzerland, United Kingdom, China (Hong Kong), Chinese Taipei, Indonesia , Japan, Korea (Rep. of), Malaysia, Singapore, Thailand, South Africa, and the USA.

4. Clinical aspects and host susceptibility: All age groups appear susceptible. Risk factors include water temperature (between 16–25°C), viral infectivity, fish size/age, population density and stress factors (transportation, spawning, poor water quality). Mortality of affected population is between 70–80 percent to as high as 90–100 percent. Secondary and concomitant bacterial and/or parasitic infections are commonly seen in diseased carp and may affect the mortality rate and display of signs.
5. Diagnostic methods: Via field observations the following signs can be noticed: increased mortality in the population of all age groups, pale discolouration or reddening of the skin and pale discoloration of gills. Other gross signs include sunken eyes, haemorrhages on the skin and base of the fins and fin erosion, adhesions in the abdominal cavity. Behavioural signs include lethargy. Polymerase chain reaction (PCR) is the required test for confirmatory diagnosis.
6. Modes of transmission: Horizontal (fish to fish or through vectors) transmission. Clinically infected fish and covert virus carriers among cultured, feral or wild fish serve as reservoirs of the virus. Virulent virus is shed via faeces, urine, gills and skin mucus. Biotic (other fish species, parasitic invertebrates, piscivorous birds and mammals) and abiotic (water) vectors and fomites may be involved in transmission. Intensive fish culture, koi shows and regional and international domestic trading are the three main mechanisms that have contributed to the rapid global spread of KHV.
7. Control and prevention: No protective vaccine or effective chemotherapeutant is available and control of KHV in natural water bodies is impossible. Biosecurity measures at farm level and border controls may reduce the introduction and spread of KHV. These measures are: fish from disease-free sources, quarantine of incoming fish for a minimum of 4 weeks to 2 months, careful handling of fish to avoid stress and safe disposal of dead fish. Good farm hygiene (regular disinfection of ponds and farm equipments) and good record keeping can assist in understanding the farm situation. Gross and environmental observations and stocking records (movement of fish) should be properly registered. Where possible, fish from different sources should not be mixed. Control of wildlife vectors may also help. Education of farmers and hobbyists on good health management is also essential.
8. Reporting to OIE. KHV is a notifiable disease of OIE. Therefore, occurrence, first time or recurring requires immediate notification of OIE through the Chief Veterinary Officer of the country.

7.3.2 Bacterial diseases of carps

Common bacterial diseases affecting carps include those belonging to Myxobacteria, *Pseudomonas fluorescens*, *Enterobacter* sp., and *Aeromonas* spp. Morphological criteria and biological characteristics should be used for diagnosis. Identification of bacterial pathogens to species level requires the use of culture methods and observations of the characteristics of monoclonal colonies and details of their interaction with the culture medium.

Susceptibility of fish to bacterial infections occurs during adverse environmental conditions, e.g. extreme temperature, heavy load of organic matter in the water, overcrowded conditions. Maintaining optimal growth conditions in the pond is an indispensable preventative measure against occurrence of both acute and chronic bacterial infection. Routine application of suitable antibiotics or disinfectants to fish after each handling procedure may prevent bacterial contamination resulting in skin or gill injuries and may enable the fish to recuperate. However, it should be noted that susceptibility of fish to handling injuries vary with species as some species are more sensitive than others. Drug sensitivity test is a must for strains of bacteria which has been isolated during diagnosis

7.3.3 Parasitic diseases of carps

Important parasite infection of carps includes members of the group of protozoans (sessiline parasites such as *Epistylis* sp. and mobiline parasites such as *Trichodina* sp., *Trichodinella* sp., *Ichthtyopthirius multifiliis*), myxozoans (e.g. *Myxobolus koi*, *Thelohanellus pyriformis*) and crustacean parasites (*Lernaea cyprinacea*).

Preventative measures against parasite pathogens include creation of environmental conditions that are unfavourable for them, such as healthy pond life, reduction of potential vectors and regular examination of fish for presence of parasites. Good pond preparation described in Chapter 3 is good practice to avoid infection. Quarantine of incoming fish and prophylactic treatments are also good preventative methods.

7.3.4 Fungal disease of carps

The presence of mould-like coating on the skin, or presence of fluffy growth is characteristics of fungal infection. While it is easy to recognize such conditions, identification of fungal pathogens should be done by a qualified aquatic animal health professional before treatment with a suitable antifungal product.

A common fungal infection affecting carps is caused by *Saproglenia* spp. Infection with *Saprolegnia* is often linked with damage of skin due to rough handling of fish. Such infection is amplified by increase of water temperature. While *Saprolegnia* infections are commonly found on skin, it can also invade most other tissues. Penetration of hyphae can lead to skin destruction thus leading to osmotic imbalance and respiratory impairment, and eventually to death. Important biosecurity measures include proper and professional handling of fish, described in Chapter 6. In addition the physical and health condition of fish should be maintained in a stress-free rearing and storing environment. Emergency harvest of affected fish can be cost effective before the fungus spreads and affects the whole fish stock.

8. SOCIO-ECONOMIC ISSUES IN CARP PRODUCTION

This chapter covers the social and economic issues of better practices in investments, institutional and legal aspects, risk management, labor and safety and marketing. Each issue comprises key operational principles and better management practices. A guiding principle provides the starting point. For each set of BMPs, there are recommended government activities to facilitate the development and promote the adoption of the BMPs by farms and firms.

The purpose of this chapter is:

- To suggest and describe strategies to achieve two basic objectives. These are to improve the ability of farmers to develop and comply with BMP and to strengthen the capacity of governments to support the development and implementation of an effective BMP programme.
- To provide practical guidelines for BMP for carp farms and firms to achieve their profitability objectives without compromising their responsibilities to society and the environment.
- To recommend activities addressed to the government agency in charge of aquaculture to support development and adoption of the BMP.

The overall guiding principle is that the development of the carp aquaculture sector shall follow a balanced approach to the pursuit of economic, social, and environmental objectives. To enable this, the governance of the sector, which comprises command and control, market, and self-management mechanisms, should ensure the following conditions:

- The pursuit of profitability shall not compromise environmental sustainability and social responsibility.
- The pursuit of environmental and social objectives shall, as much as possible, provide opportunities for improving the profitability objective of farms and firms (IISD 2006).
- Laws and regulations and legally prescribed or voluntary standards shall help farms to be socially and environmentally responsible without compromising their financial objectives and stifling the growth of the carp aquaculture sector.

8.1 Investments

BOX 23

Examples of bad practices of investment

Haphazard planning of development, without consideration of the environmental and social impacts which have a consequence on the environmental, social and financial risks to the investment.

Too much focus on profitability factors with little consideration of the sustainability of the investment.

Investment in a new carp farm and expansion or renovation of an existing one should be guided by an assessment of technical, economic and financial feasibility and, as much as possible, an environmental and social impact assessment of the investment. Related BMPs are the followings.

Feasibility criteria

The feasibility criteria to an investment, summarised in Appendix 7, are determined in a step-wise manner. It is important that:

- The cost of devices, structures and procedures, which ensure that the investment impacts are within prescribed or legislated environmental standards, are included in the assessment of financial feasibility.
- The items that would require pre-investment costs are the determination of financial feasibility and, if law requires, environmental and social impact assessments. These are usually carried out by an expert whose findings are the basis of the decision as to whether the investment should proceed or stop.

Better investment practices for social and environmental responsibility

If the decision is to proceed, the features and practices that enhance the environmental and social responsibility of the investment should be incorporated. These include the following practices.

Natural capital:

- Investment in maintaining or enhancing the natural and biological assets such as soil, water, wildlife, and vegetation.
- Energy efficiency:
- Maintenance of the efficiency of all equipment and, if economically feasible, replacement of old and energy-wasteful facilities and equipment.
- Installation of energy conservation measures including a record of the farm energy conservation performance.
- Development of on-farm energy sources using of farm wastes, wind, water or the sun.
- Cooperation:
- To maintain and efficiently operate the water distribution and discharge systems.
- To maintain the ecological integrity of the common water body such as a lake or reservoir designated for culture.
- To replant denuded patches of land or plant trees in bare areas around the water body.
- To maintain rural roads which connect the farms to the major roads.

8.2 Institutional and legal aspects

BOX 24

Examples of bad practices in institutional and legal aspects

Taking legal shortcuts to be profitable.

Using personal connections to avoid legal obligations.

Joining farmers' organization or association for the wrong reasons such as being able to avail of grants or easy loans.

A farm or firm acquires the capacity to comply effectively with rules and regulations and legally set standards, and the additional capacity to adhere to codes of conduct and better practices.

Compliance with legal standards is not a better management practice; acquiring the ability to comply effectively with regulations is. This can be achieved through individual autonomous effort and through a farmers association. An association would increase the effectiveness of individual capacities. Autonomous efforts of individual farmers include the following practices:

- understanding the requirements of the licensing and registration system,
- maintaining updated inventories and status reports of physical and financial assets and liabilities,
- maintaining updated records of farm improvements, and other key management and operational information, and
- making improvements on leased property instead of using it for speculative purposes.

Group efforts would first include being organized into an association, and then cooperating in these practices. A primary goal of a farmer association should be to improve its capacity to manage the association professionally. This should involve among others representation, technical assistance and training. The association should participate actively in sector related activities:

- development of policies, regulations and standards, which includes the obligation for providing government with all information needed in formulating or amending laws, regulations and standards,
- formulation of an industry code of practice enhancing the performance and image of the industry,
- formulation of rural development strategies and plans,
- organizing activities to exchange opinions and experiences among the members, and
- working with technical institutions to bring scientific and technical advice to the association.

8.3 Risk management

BOX 25

Examples of bad practices at risk management

Discharging farm waste or effluent into public waters to avoid paying for an on farm waste treatment facility.

Operating the farm as if it had no links with the community.

Ignoring good relations with the community.

Ignoring performance efficiency standards and improvements for the farm.

There are two important points to note regarding risk management:

- adherence to BMP whether technical or economic would avoid risks or mitigate risk impacts, and
- social and economic risks and the risks that originate from natural, physical, biological and environmental hazards are linked; the biological, natural and physical risks impact on the economic performance of farms.

Mitigating risks costs money. Being profitable without cutting corners is probably the only way to bear the cost without becoming insolvent or provoking a challenge from society. Therefore, being economically viable is a social responsibility. The application of risk analysis and risk management together with the adoption of BMP improves the prospect of long term economic viability (FAO 2008, Umesh *et al*. 2010).

Assessment and management of social, economic and environmental risks are a part of the key operational principle. Therefore, management strategies and operational procedures should include it to enhance profitability.

Risk analysis[37] should be part of the better management practices of a fish farm or firm. Adoption of BMPs that mitigate natural, biological, physical and environmental risks also prevent or at least mitigate social and economic risks (Bekefi *at al*, 2006 and Kelly, 2005 as cited by Bueno, 2009 in Bondad-Reantaso 2009). A social and economic risk–oriented BMP should aim:

- to avoid causing harm to society with its practice and products, and
- to enhance the contribution of the farm to the welfare of society.
- The practical activities to achieve the above two purposes, would include:
- safety assessments of management and operating procedures and of products, based on risk analysis,
- training farm managers on risk assessment and management, and
- installing a HACCP system which is applicable for an on-farm processing facility,
- installing an effluent and solid waste management system including water and waste recycling,

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[37] Application of the process requires training and experience. A risk analysis manual has been developed by FAO Fisheries and Aquaculture Service (FAO 2008).

- keeping of records of performance against standards to improve on previous performance,
- buying a crop insurance policy or, if it is not available, working with government to develop it,
- working with government in the formulation of policies on pricing and taxation of input supplies,
- working with government to develop group insurance credit schemes of reasonable terms, and
- establishing a reputation for reliability in terms of timely supply of quality products.

8.4 Labor and safety

BOX 26

Examples of labor and safety related bad practice

Exploiting workers by making them work longer hours for the same wage.

Hiring child labor.

Discriminating against women with lower wage and/or working hours

Hiring without a clear written contract.

Ignoring hazards on the farm.

Paying lower than the minimum wage prescribed by law.

Giving priority to labor from outside the community.

A code of conduct on labor and employment that contains better management practices should be separately developed. It should be guided by ILO standards, international framework agreements, the national labor code, and relevant codes of practices of similar industries (Schömann *et al*, 2008).

Responsible labor practices and the elimination of hazards to the life and health of workers are the key operational principles. These increase the technical and economic efficiency of the farm and avoid costly liabilities.

The BMPs include the policies and practices on employment, workers' compensation, provision of welfare benefits, healthy and safe working conditions, founded on the principles of fairness and social justice. Fair labor practices prevent labor-management conflicts, conflict with the community, social sanctions and legal actions. It is also avoids bad publicity. A harmonious labor-management relation improves the efficiency and profitability and enhances the sustainability of a farm. Good working conditions improve workers' efficiency and morale, and avoid dangerous situations, injuries or death. BMPs include the following:

- practice of open and transparent recruitment by publicly announcing job openings,
- recruitment of as many workers as possible from the community where the farm is located,
- clear explanation of the terms and conditions of the employment,

- execution of clearly understood written employment contract with every worker,
- provision for a remuneration package to workers commensurate to responsibility,
- implementation of a workers performance scheme, and provision of incentive for above average performance,
- provision for equal opportunity employment to women and not discriminating women in terms of wages and working hours,
- removing or reducing the hazards to health and life,
- provision for medical and health insurance to workers, arranging for emergency medical treatments, first aid service, and regular health check-ups,
- arranging fair work shifts and granting of off-days and holidays,
- not employing minors in other words child labor must not be employed,
- hiring practices and decisions should never be influenced by race, ethnicity, and religious belief,
- safety regulations, applicable in the country should be observed and enforced, including training of safety regulations on water and ice,
- training programmes should be provided for those who wish to upgrade their skills,
- if labor saving technology is adopted, workers in excess should be given other tasks, rather than being terminated, and
- instituting a grievance and negotiation mechanism is important but, as much as possible, grievances and conflicts should be settled amicably.

8.5 Marketing

BOX 27

Examples of bad practices of marketing

Conniving with other farms to manipulate market price of product.

Ignoring market trends, including demand, prices and competing or substitute products.

Engaging in a price war or other unhealthy form of competition with other farmers.

Ignoring product safety standards.

An efficient market mechanism enables farmers to be better connected to economic development activities. It also makes the cost of products affordable to the poorer people and allows producers and traders to obtain justifiable returns from their investments (Van Anrooy 2003a).

Key operational principle is that marketing practices of farms should be in line with the social objective of assuring that quality and safe food is available and accessible to all.

Better marketing practices are carried out more efficiently by an organized industry. Farmers' organizations should include marketing in their functions to achieve economy of scale, reduce costs and reliably supply the market with fish of good quality and reasonable price. Farmers, input suppliers, fish traders (both wholesalers and retailers) and representatives of consumers should establish collaborative relations based on mutual interest and trust to improve efficiency and obtain equitable benefit from the production and marketing of fish (Van Anrooy, 2003b).

The specific practices of farms should include the following measures:

- farmers, traders and processors should participate actively in the development and adoption of safety and quality standards,
- use standard refrigeration, icing and transport facilities,
- scheduling the marketing of fish when there is the highest demand for it, and
- development of value added product forms preferred by the market.
- A farmers' association has an indispensable role in marketing. It should:
- ensure that every member complies with the standards to avoid a bad image and adverse public perception of the entire sector, and
- improve the capacity of members to obtain and analyse market information to ensure product quality and safety with maintaining freshness of fish with

8.6 Government support to BMPs

This section reviews the role of government in promoting, regulating and supporting aquaculture development and suggests specific support and facilitating activities to the development and adoption of BMP in carp aquaculture.

8.6.1 Government support for investment BMPs

The best signal to investors is assurance that investments are secure. This would require a policy that is specific to aquaculture. The policy should include among others clear guidelines and regulations for investments, incentives to investors, statements of priorities, and an aquaculture development plan that is elaborated with the involvement of all primary stakeholders.

The three major roles of governments are to regulate, to promote and to support private sector investments. Governments should invest in research and development activities, capital infrastructure, and public services and utilities. Governments should develop or strengthen the technical capacities of private farms and firms, avoiding subsidies that distort the markets and weaken the competitiveness of the carp aquaculture sector in the long term. In the context of these roles, government specific support for investment BMP would include the following:

- governments should improve efficiency of water supply and distribution systems, providing safeguards for the quality and reliability of water supply used for carp culture in ponds, and for the environmental integrity of water bodies designated for carp culture,

- if applicable, governments should delineate aquaculture zones and develop regulations to access, manage and utilize the aquaculture zones, and provide reasonable incentives to users,
- infrastructure investment of governments improves the efficiency of the aquaculture sector too. This would include well-maintained farm-to-market roads,
- governments should assure a reliable energy supply and a policy to increase efficiency of energy use. This could include an incentive system for efficient and disincentives for inefficient use of energy, as well as technical and financial support for the development and use of green energy sources,
- support of governments to technology development, training and extension will increase the technical efficiency of fish farms,
- governments should concentrate on genetic research and development to improve and maintain the quality of carp stocks (see Box 6),
- governments should support development and technical assistance in the establishment of a national feed and aquaculture supplies manufacturing industry in case the scale of fish production justifies this. If it is not feasible, a national feed and aquaculture supplies trading and distribution system operated by the private sector should be promoted, and
- governments should initiate and encourage activities to commercialize carp farming but refrain from activities that compete with the private sector.

8.6.2 Government support for institutional BMPs

Government regulations and standards should strengthen the overall capacities of farms and firms by providing the following assistance:

- encouraging and facilitating formation of farmers' organizations and industry associations,
- organization of stakeholder consultations in the formulation of standards, policies, laws and regulations and in the development of industry code of practices,
- integration of carp aquaculture in rural development projects as well as involvement of other economic sectors in the strategic planning for carp aquaculture (ADB/NACA, 1998),
- involvement of other stakeholders of common resources in regular consultations, especially suppliers and users of water (ADB/NACA 1998),
- provision for correct long term leases on land and water bodies designated for carp aquaculture which should include disincentives or even penalties

on improper use of the resources and property speculations (ADB/ NACA, 1998),

- supporting the establishment of a market economy-based technical support and extension services for carp aquaculture,
- promulgation or improvement of the aquaculture licensing and registration system, and
- development of incentives for improving standards and implementing a monitoring system for compliance with standards.

8.6.3 Government support to risk management BMPs

The ability to avoid or manage risks depends largely on the capacity for risk assessment. Government support should thus promote activities to enable the carp aquaculture sector to acquire or strengthen this capacity. In particular, to improve social and economic performance of the carp aquaculture sector governments should:

- provide training and technical advice on risk analysis and management,
- disseminate the information on risk analysis and management as applied to aquaculture developed by FAO,
- develop and provide training and advice to professionals and farmers on environmental and social risk assessment,
- train and grant license to qualified professionals and technicians for EIA,
- promote environmental standards and monitor the compliance to standards,
- provide or encourage the private sector to include a crop insurance scheme for aquaculture in their portfolio,
- provide an aquaculture credit scheme through a government bank or private banks or legitimate lending operations,
- establish a favourable and progressive pricing policy and taxation scheme for imported and locally produced supplies for carp farming; this would reduce financial risks, and
- establish a transparent and market-based pricing policy for fish and fish products from carp aquaculture farms to also reduce financial risks.

8.6.4 Government support for labor and safety BMPs

To be able to regulate farms or firms, they should be part of the formal sector. In other words, they should be registered and licensed to operate. The government should thus conduct a survey and develop a simple and inexpensive system of registration and licensing of fish farms.

For labor matters including work safety, governments need to improve the capacity of farms to understand and comply with regulations. Governments can work with the industry to develop a code of conduct on labor and employment.

Its practical support could include the following:

- adoption, update and dissemination of a minimum wage for the aquaculture sector and monitoring its implementation,
- dissemination of national labour laws, regulations and standards that pertain to aquaculture and fish processing and monitoring their implementation, and
- developing and implementing a "skills development programme" for aquaculture workers at all levels.

8.6.5 Government support for marketing BMPs

A critical responsibility of governments is ensuring an efficient market. It should thus prevent market distorting arrangements such as monopolies, oligopolies and monopsonies from forming or operating. The specific support to industry would include the following:

- price control mechanisms for farm products should be used prudently to keep the price of fish (i.e. carps) at a level that makes the product affordable to the poor, at the same time provide sufficient benefit to producers (Van Anrooy 2003a),
- safety and quality standards should be developed and widely promoted,
- ensuring that retailers and wholesalers do not form a cartel to dictate prices to producers,
- establishment or promotion of the establishment of ancillary industries that support product quality improvement and maintenance such as ice plants, refrigeration, and cold storage,
- introduction of simple market regulations and support of the establishment and operation of public fish markets which are efficient, sanitary and convenient. The latter is to encourage private investors to establish and operate efficient public fish markets,
- establishment or improvement of a national market statistics and information system,
- updating product price information, supply and demand information and providing these information in real time, and
- support of market research on product preferences, supply and demand, potential competition which should include advice on the results and implications of the findings to both producers and traders.

8.7 Strategy to promote the development and adoption of BMPs

The essential requirement for the development of a sector, such as carp aquaculture is to include it in the national aquaculture development strategy and plans. In this context, the elements of the strategy to promote the development and adoption of BMPs are detailed below.

Science-based

BMPs should be guided by scientific information or, in the absence of such, the best available empirical and proven experience. BMPs are not static and fixed they, should be updated as new information becomes available.

Proven practices from other sources

Best practices in policy and regulations can be borrowed from other countries and other aquaculture industries and adapted to carp aquaculture and to the local setting. This would be facilitated by a regional cooperation arrangement.

International guidelines

The development of BMPs should be informed by relevant international conventions, agreements, protocols and principles that pertain to fisheries/aquaculture and its impacts to or links with the environment, biodiversity and trade, as well as climate variability.

Stakeholder consultations

The formulation of policies and development of BMPs are always better informed with a multi-stakeholder consultation. It will need more resources to conduct stakeholder consultations but the benefits will likely outweigh the cost. The benefits include, among others, the balanced consideration of the welfare and needs of various sectors, the widespread acceptance and support of the resulting policy, better compliance with laws and regulations, and a more effective implementation of the better management practices. This mitigates the risks of non-compliance and occurrence of opportunistic behaviours, which would be more costly to government and harmful to society.

Farmers' organizations

The formation of farmers' associations should be encouraged and facilitated by both the government and the farmers. The benefits include the smaller farms being able to achieve economy of scale:

- having a stronger collective transaction power with suppliers and buyers,
- being more effective at adopting and implementing BMP, and
- reducing the cost and increasing the efficiency of providing (by government) and acquiring (by members) of technical services, technology and information.

Cooperation among market chain players

Experiences in different aquaculture sectors of many countries have shown the benefits of the players in the market chains (seed producers, feed suppliers, producers, traders, processors, buyers) cooperating rather than taking advantage of each other (Umesh, et al, 2010, Van Anrooy 2003b). This reduces social and economic risks and increases overall efficiency of the marketing chain.

Capacity building

Strengthening the capabilities of institutions and people is the foundation of a progressive and sustainable aquaculture industry. A nationwide or sector-wide assessment of capacity building needs will better inform a national development strategy and plan. It will increase the efficiency of resource allocation for education and training and increase the effectiveness of manpower and institutional capacity building activities by concentrating resources and efforts on priority needs.

Business and technological innovations

This is a subset of capacity building but it should be considered seriously because current problems will find effective and efficient resolution through innovations. One application of innovativeness is finding a way to turn a problem into a business opportunity (Drucker, 2001).

In summary, the governance issues that relate to the achievement of the social and economic objectives of carp farming are:

- policy and regulations should ensure allocation of national resources to the carp aquaculture sector, assure and protect property rights, grant or deny legal license for farms to operate,
- support of the adoption of BMP and penalizing opportunistic behavior such as corruption and fraudulent transactions, free-riding and rent-seeking,
- regulation of the market only as necessary,
- allowing and supporting an efficient market mechanism which should include judicious use of regulations to encourage efficiency and competitiveness of farms,
- providing the incentives for efficiency and responsible behavior and penalizing inefficiency and irresponsible behaviour,
- self-governance reduces the cost of managing and governing the sector and improves efficiency of government services. Organized producers improve their economy of scale, and
- social institutions, traditions and social norms can be very effective and efficient in resolving conflicts between employers and workers on equal partnership basis.

8.8 Conclusion

The growing body of documented cases of adopted BMP and codes of conduct by fish farmers has provided stronger evidence to the statement that being environmentally responsible makes good business sense.

This raises the question as to whether the market can be relied on to instil social responsibility. The answer is it can, and the voluntary adoption of codes of conduct and BMPs and adherence to standards confirm the efficiency and effectiveness of the market.

The market however is only one of a number of governance mechanisms, which include laws and regulations, social norms of conduct, and self-management by organized farmers. Social responsibility increases the positive impacts of a farm on society. It mitigates the impacts of probably all types of risks that a farmer faces. Because carp farms have to be economically viable the mechanisms that facilitate social responsibility should not be only effective, they should also assure that these farms operate efficiently.

9. IMPLEMENTATION, MONITORING AND UPDATING

9.1 Implementation of BMPs in this document

These voluntary BMPs for carp production are to be interpreted and applied in their entirety in a manner consistent with national laws and regulations and, where they exist, international and regional agreements.

All carp producers (owners and employees) in Central and Eastern Europe, Caucasus and Central Asia and all members of the Central Asian and Caucasus Regional Fisheries and Aquaculture Commission should collaborate in the fulfilment and implementation of the principles, BMPs and recommendations in this document.

The Central Asian and Caucasus Regional Fisheries and Aquaculture Commission members, relevant international bodies and national organizations should promote the understanding of these BMPs for carp production among people involved in aquaculture, particularly owners of carp hatcheries and farms, and employees of these establishments.

Both governmental and nongovernmental national and relevant international organizations of the aquaculture industry and financial institutions should recognize the special circumstances and requirements of carp producers and other stakeholders in developing countries, especially those in the land-locked Low-Income Food-Deficit Countries (LIFDCs) in the Central Asian and Caucasus region. They should support the effective and progressive implementation of these BMPs and recommendations. States, relevant intergovernmental and non-governmental organizations, research and education institutions, and financial institutions should work to address these implementation needs, especially in the areas of financial and technical assistance, technology transfer, capacity building and training.

9.2 Monitoring the implementation of the BMPs

In its region the Central Asian and Caucasus Regional Fisheries and Aquaculture Commission, in collaboration with government agencies and aquaculture associations, will monitor among its member countries the application and implementation of the BMPs for carp production and its effects on growth of the sub-sector, profitability, fish health, environmental impact, fish quality and safety.

The Central Asian and Caucasus Regional Fisheries and Aquaculture Commission will, through its regular sessions, report every three years on the status of implementation of these BMPs for carp production in its region.

9.3 Updating of these BMPs

In its region, the Central Asian and Caucasus Regional Fisheries and Aquaculture Commission, through its Technical Advisory Committee (TAC) and in collaboration with carp culture experts, may revise these BMPs for carp production, taking into account new developments in reproduction, culture and management of carp species, as well as findings derived from the monitoring of implementation of these BMPs.

9.4 Future directions

Common carp is both an excellent food and a popular sport fish which, together with its affordability, ensure its leading role and steady presence on the markets of the countries of not only CEE and CCA but also of countries such as Russia and China.

Until today the only economically feasible way of carp production is pond polyculture or natural culture of carps in water reservoirs and principle irrigation canals. It is unlikely that techniques, practices and used facilities and equipment presented in this document will radically change in the coming years. Still it is expected that further innovations on details of overall common carp production will improve its profitability. It is that justifies the need for future updates of these BMPs, mentioned in the previous chapter.

At present there are no alternatives of pond polyculture of common carp when fish protein is produced from inexpensive farm and food industry wastes. But witnessing how fast the economic, social and environmental conditions are changing, together with the rapid development of fish feed industry, the feasibility and importance of tank and cage culture of common carp may increase in the future considerably. This will call for the elaboration of the specific BMPs of carp culture in tanks and cages as a separate new publication.

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Appendix 1

CARPS CULTURED IN CEE AND CCA

There are many different smaller and larger carp species. All of them belong to the family of Cyprinids and can be found in most of the natural and manmade waters of CEE and CCA countries.

Smaller and medium size carps such as bleaks (*Alburnus sps.*), chubs (*Leuciscus sps.*), crucian carp (*Carassius carassius*) and gibel (*Carassius auratus gibelio*), dace, souffie and ide (*Leuciscus sps.*), minnows (*Phoxinus sps.*), rasbora (*Pseudorasbora parva*), roaches (*Rutilus rutilus*) and rudds (*Scardinius sps.*) are common in the natural waters from where they enter into the fish pond with water. They may be a nuisance in ponds especially in nursery ponds. However they can also be useful as food fish for valuable predator species, or they can be fished and sold as bait fish.

Breams (*Abramis sps.*) and barbs (*Barbus sps.*) are medium and larger carps which can be both accidently or deliberately part of carp culture in ponds. They are especially popular as sport fish.

Asp (*Aspius aspius*) and tench (*Tinca tinca*) have special status among the carps. Asp is a predator therefore it is sought after by angling lakes and fee fishing farms, while tench is a highly valued delicacy in many countries.

The real large carps cultured in CEE and CCA are the common carp (*Cyprinus carpio*) and the Chinese major carps (silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Aristichtis nobilis*), grass carp (*Ctenopharyngodon idella*) and black carp (*Mylopharyngodon piceus*).

Common carp is a freshwater fish native to Eurasia which has been introduced to every part of the world with exception of Northern Asia and the poles. Common carp or simple carp is the oldest domesticated fish, and for that reason there is a long standing relationship with this animal.

Popularity of carp as food fish differs from country to country, even from region to region within a given country. Although initially carp was a food fish, in later times its importance as sport fish also increased.

Carp exploits large and small manmade and natural reservoirs and pools in slow or fast moving rivers. Though they prefer larger still or slower moving water bodies with soft sediments, they are tolerant and hardy fish that thrive in a wide variety of aquatic habitats (Page and Purr, 1991, Froese and Pauly, 2002).

Attributes of carp include high environmental tolerances such as temperature (2–40 ^{o}C), salinity up to about 14 parts per thousand, pH from 5 to 10, and oxygen levels as low as 7% saturation. These, as well as being omnivorous, with a high reproductive capacity are reasons why the fish is widely distributed and found in most types of freshwater habitat.

Carp often grow 30 to 60 cm in length and weight 0.5 to 4 kg, but it is not exceptional for common carp to reach 15 –20 kg.

Carp is characterized by its deep body, serrated dorsal spine and its mouth which makes the fish capable of digging in the mud of the bottom of a water body.

Colour and proportions are extremely variable, but scales are always large and thick.

When wild carp was introduced into ponds it naturally started to change its torpedo shaped body into a deep, laterally compressed and hunchbacked body. Later individuals appeared that did not have a regular, geometrical arrangement of scales, but showed irregularities including forms where number of scales reduced, partly or totally disappeared. These variations soon became a foundation for artificial selections. Ultimately, domesticated common carp are represented by a large variety of forms, such as the fully scaled carp, linear, mirror carp and leather (or naked) carp.

Common carp generally spawns in the spring and early summer under the climate of CEE and CAA countries. They segregate into groups in the flood plains to spawn. Carp prefer shallow waters with dense water weed cover. Males externally fertilize eggs which the females scatter over the surface of water weeds in a very active manner. Eggs stick to the substrate upon which they are scattered. As soon as fertilized eggs attach to the substrate, there is no further parental care. Incubation of eggs and hatching is rapid and the newly hatched larvae stick to the substrate. However they develop very quickly and start to swim and search for feed within days.

In nature a typical female (about 45 cm in length) may produce 300 000 eggs at one spawning, with some estimates as high as one million over the breeding season. Total length of hatched larvae is between 5 to 5.5 mm. Temperature, stocking density and availability of food influence individual growth and by the time the fish reach 8 mm, the yolk is consumed and they begin to feed actively.

Carp usually reach sexual maturity when the testes and ovaries develop. Sexual maturity can occur at a very early age in carp where waters are constantly warm. Under climatic conditions of CEE and CCA the sexual maturity of carp is reached when males are 2–3 year old and female are around 3–4 year old.

Term “Chinese major carps” is the collective name of silver carp, bighead carp, grass carp and black carp. They are native in the large eastern rivers of Chine, from where they were introduced to many countries all over the world. Chinese major carps were introduced into both natural and manmade waters of CEE and CCA during the 1960s and 1970s.

Chinese major carps were and still are important fish species of carp polyculture. They are produced with carp because together they utilize entirely the different type of natural fish food which grows in a pond. Silver carp and bighead carp feed on the phytoplankton and zooplankton, grass crap consumes water weeds, while common carp feeds on insects and insect larvae and it digs for food in the mud of the pond bottom.

Chinese major carps are riverine fishes. They migrate upstream for spawning where they mate in clean fast flowing sections of the river.

Released and fertilized eggs float in the water column where they incubate rapidly and hatch within about a day. Hatched larvae continue floating with the current for an additional 3–4 days. By the end of this period, they consume their yolk sack, gulp air and start to swim horizontally. At the same time they start to feed from their environment. In the nature this is the time when they usually arrive to the floodplain, where the young developing fry find enough food.

Under the climatic conditions of CEE and CEE Chinese major carps become sexually mature when they are about 4–6 years old. Similarly to other fish species males become sexually matured 1–1.5 year earlier than females.

Appendix 2

TRADITIONAL CARP MONOCULTURE

Before the introduction of Chinese major carps in Central and Eastern Europe, the Caucasus and Central Asia common carp was the only large Cyprinid which was produced in fish ponds in these regions. Though carp was stocked together with other fish species, mainly with predators, this culture system was the classic monoculture of carp which developed on experiences gained during many centuries.

Techniques of carp culture in ponds significantly progressed parallel to the development of interrelated sciences such as chemistry, limnology, hydrobiology, and fish biology. Foundation of modern, science based carp culture in Europe was established by the 1930s. Already during these years many useful BMP, in the form of practical books, were published on carp culture in many different countries.

In the course of planning carp production overall qualities (location, soil and water) of fish ponds were suggested to be carefully considered together with economic aspects and market demands.

TABLE A1

Categories of carp pond productivity

Categories of natural productivity	Natural net carp production (kg/ha)	Net carp production increased by manuring and feeding	
	kg/ha	Fold	kg/ha
Very productive (very good ponds)	> 180	4–5	700–900
Productive (good ponds)	120–180	3–4	360–720
Less productive (medium ponds)	80–120	2–3	160–360
Poorly productive (week ponds)	< 80	2	< 160

Source: Hankó, 1928.

Similarly as today, the actual productivity of ponds was the first and most important determining factor to be taken into account when planning fish production.

Accordingly, fish ponds were classified into four categories presented in Table A1.

Other specialists of the period (Répassy, 1914) established a slightly different range for categorising natural productivity of ponds. This varied between 100 and

210 kg/ha net carp production with extremes less than 80 and more than 350 kg/ha.

Already in the first decades of 1900s the three year long cycle was the widely practiced way of producing table fish carp. This time the recommended sizes of one-summer-old and two- summer-old carp to stock were 0.05–0.1 and 0.5–1.2 kg respectively, while size of table fish varied between 2 and 3 kg.

During these decades fish farmers learned the importance of correct pond preparations, well planned and executed stocking and proper grow-out management practices including manuring, fertilization and feeding.

TABLE A2

Recommended number of stocked carp in unfed and fed ponds

Produced age group of carp	Stocked fish (No./ha)	
	Without feeding	With feeding
Two-summer-old fish	350–500	500–1000
Table fish	170–350	350–700

Source Fisher, 1931.

After the Second World War, most of the CEE countries became part of USSR led socialist block. Here fish farms were also nationalised or annexed to fisheries and agricultural cooperatives. Therefore, until the early 1990s production was driven by three and five year plans on state and cooperative fish farms all over CEE and CCA.

Changed political and economic conditions in CEE and CCA countries did not considerably effected carp production in ponds. Though size of table fish carp somewhat reduced to 1–1.5 kg and in some regions of the USSR 0.3–0.5 kg fish was already consider ready for consumption, carp production intensified.

During the 1950s the term “economic individual growth of carp” was introduced and widely used. Accordingly tables were compiled in order to guide fish farmers in correct planning. One of these tables is presented in Table A3.

TABLE A3

Economic growth and number of stocked carp of different age groups recommended during 1960s

Size of fish (gr.)		Economic gain of weight (gr./fish)	Growth rate	Survival rate (%)	Expected net carp production (kg(ha)					
					500	800	1 000	1 200	1 400	1 750
at Stocking	at Harvest				Number of stocked fish					
5	200	195	40	50	2 560	4 100	5 130	6150	7 180	8 970
10	350	340	35	70	1 470	2 350	2 940	3530	4 120	5 150
20	400	380	20	75	1 320	2 110	2 630	3160	3 680	4 610
30	450	420	15	75	1 190	1 900	2 380	2860	3 330	4 170
50	500	450	10	80	1 110	1 780	2 220	2 670	3 110	3 890
70	600	530	8.6	80	940	1 510	1 890	2 260	2 640	3 300
100	700	600	7	80	830	1 330	1 670	2 000	2 330	2 920
150	850	700	5.7	83	710	1 140	1 430	1 710	2 000	2 500
200	1 100	900	5.5	85	560	890	1 110	1 330	1 560	1 940
250	1 300	1 050	5.2	85	480	760	950	1 140	1 330	1 670
300	1 500	1 200	5	90	420	670	830	1 000	1 170	1 460
350	1 700	1 350	4.9	90	370	590	740	890	1 040	1 300
400	1 900	1 500	4.8	90	330	530	670	800	930	1 170
450	2 100	1 650	4.7	90	300	480	610	730	850	1 060
500	2 250	1 750	4.5	93	290	460	570	690	800	1 000
600	2 650	2 050	4.4	95	240	390	490	590	680	850
700	3 000	2 300	4.3	95	220	350	430	520	610	760

Source Ribiánszky and Woynarovich, 1962.

TABLE A4

Economic growth and number of stocked carp for producing two-summer-old fish recommended during 1970s

Size of fish (gr.)		Economic gain of weight (gr./fish)	Growth rate	Survival rate (%)	Expected net carp production (kg(ha)					
					600	800	1 000	1 200	1 600	2 000
at Stocking	at Harvest				Number of stocked fish					
10	200	190	20	50–70	3200	4200	5300	6300	8400	10500
15	220	205	14.7	50–70	2900	3900	4900	5900	7800	9800
20	300	280	15	60–80	2100	2900	3600	4300	5700	7100
25	330	305	13.2	60–80	2000	2600	3300	3900	5200	6600
30	350	320	11.7	70–80	1900	2500	3100	3800	5000	6300
40	400	360	10	75–85	1700	2200	2800	3300	4400	5600
50	450	400	9	75–85	1500	2000	2500	3000	4000	5000
60	500	440	8.3	75–85	1400	1800	2300	2700	3600	4500
70	600	530	8.6	80–90	1100	1500	1900	2300	3000	3800
80	700	620	8.8	80–90	970	1300	1600	1900	2600	3200

Source Antalfi and Tölg, 1971.

TABLE A5

Economic growth and number of stocked carp for producing table fish recommended during 1970s

Size of fish (gr.)		Economic gain of weight (gr./fish)	Growth rate	Survival rate (%)	Expected net carp production (kg(ha)					
					600	800	1 000	1 200	1 600	2 000
at Stocking	at Harvest				Number of stocked fish					
100	800	700	8.0	80–90	860	1100	1400	1 700	2 300	2 900
120	820	700	6.8	80–90	860	1100	1400	1 700	2 300	2 900
150	900	750	6.0	80–90	800	1100	1300	1 600	2 100	2 700
200	1 000	800	5.0	85–95	750	1000	1300	1 500	2 000	2 500
220	1 120	900	5.1	85–95	670	890	1100	1 300	1 800	2 200
250	1 300	1 050	5.2	90–95	570	760	950	1 140	1 520	1 900
300	1 500	1 200	5.0	90–95	500	670	830	1 000	1 330	1 670
330	1 630	1 300	4.9	90–95	460	620	770	920	1 230	1 540
350	1 750	1 400	5.0	90–95	430	570	710	860	1 140	1 430
400	1 900	1 500	4.8	90–95	400	530	670	800	1 070	1 330
450	2 050	1 600	4.6	90–95	380	500	630	750	1 000	1 250
500	2 250	1 750	4.5	95–98	340	460	570	690	910	1 140
600	2 500	1 900	4.2	95–98	320	420	530	630	840	1 050
700	2 800	2 100	4.0	95–98	290	380	480	570	760	950

Source Antalfi and Tölg, 1971.

At the classical carp monoculture proportions of total pond area of one-summer-old, two-summer-old and table fish production were 10, 15 and 70-75 percent respectively. Concept, regarding economic growth rate of carp, slightly changed during the 1970s (see Tables A4 and A5).

By today the concept of economic individual growth of carp further simplified. Extensive field experiences proved that, if stocking densities are within the ranges presented in Tables A6 and A7, the growth rate will be as follows below (Horváth, Béres and Urbányi, 2011):

- First year: 50–100 (from 0.2–0.3 gr. to 15–30 gr.) fold.
- Second year: 10–15 (from 15–30 gr. to 200–400 gr.) fold.
- Third year: 4–5 (from 200–400 gr. to 1 200–2 000 gr.) fold.

TABLE A6

Results of extensive monoculture of different age groups of carp

Produced age group (from - to)	Stocked				Survival (%)		Harvested			
	No./ha		kg/ha				No./ha		kg/ha	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
From: larvae To: one-summer-old fish	100 000	200 000	-	-	5	30	10 000	40 000	200	400
From: advanced fry To: one-summer-old fish	40 000	60 000	8	15	50	60	20 000	35 000	300	700
From: one-summer-old fish To: two-summer-old fish	5 000	7 000	100	200	50	70	3 000	4 000	600	800
From: two-summer-old fish To: table fish	600	800	120	200	50	70	400	500	600	700

Source Horváth, Béres and Urbányi, 2011

In all ponds where pond monoculture of one-summer-old, two-summer-old and table fish production is practiced, about 3–10 percent of the total number of fish is predators (e.g. pike, pike-perch or catfish). Their actual number depends on the number and species of unwanted fish which will serve as food fish of them.

TABLE A7

Results of semi-intensive and intensive monoculture of different age groups of carp

Produced age group (from - to)	Stocked				Survival (%)		Harvested			
	No./ha		kg/ha				No./ha		kg/ha	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
From: larvae **To: advanced fry**	1 000 000	4000 000	-	-	30	60	300 000	2 000 000	90	400
From: larvae **To: one-summer-old fish**	300 000	600 000	-	-	5	30	25 000	70 000	400	1 000
From: advanced fry **To: one-summer-old fish**	60 000	120 000	20	30	50	70	35 000	60 000	900	1 400
From: one-summer-old fish **To: two-summer-old fish**	10 000	15 000	100	300	50	70	6 000	10 000	1 200	1 800
From: two-summer-old fish **To: table fish**	1 000	2 500	200	500	60	80	800	2 000	1 200	1 600

Source Horváth, Béres and Urbányi, 2011.

The Czech example, where 85–90 percent of national fish production is carp, shows that there are certain physical, environmental and economic conditions and circumstances which justify classical carp monoculture in ponds.

The national average of carp production is 450 kg/ha. Only 25–30 percent of carp production is based on supplementary feeding. The rest of the carp production is based on the natural productivity of ponds. The market size carp is about 3–4 year old and weights about 1.5–3 kg (Adamek, Berka and Huda, 2009).

In regions with similar climatic conditions, fish farmers, can learn from the national and regional results of Czech fish production (see Table A8).

TABLE A8

Selected production data of pond farming in the different regions of Czech Republic

Region	Results (kg/ha)			Proportion of species (%)							
	Min.	Avg.	Max.	Carp	Chinese m. carps	Tench	Pike	Pikeperch	Wels	Trout	White-fish
South Bohemia	302	532	1100	86	5	2	0.5	0.5	0.5	-	-
West Bohemia	381	393	413	86	2	2	-	-	-	-	-
Central Bohemia	321	321	321	86	5	2	-	-	-	-	-
Eastern Bohemia	667	667	667	86	5	2	-	-	-	-	-
Czech-Moravian Highland	358	521	843	75	-	-	-	0.5	-	5	0.5
South Moravia	907	907	907	82	12	-	-	-	0.5	-	-
Central Moravia	599	599	599	80	5	-	-	-	-	-	-
Northern Moravia	552	552	552	86	5	2	-	-	-	-	-
Czech Republic	302	529	1100	86.6	5.9	1.3	0.6	0.3	0.4	3.7	0.2

Source Orzeszko (FIPP), 2005.

Appendix 3

NATURAL CULTURE OF CARP

In case of natural culture of carp the management of fish stock with planned stocking and fishing is the only human intervention. It is widely practiced in water reservoirs and large ponds where use of manure, fertilizers and supplementary feeds is impossible, banned or economically not feasible. Thus fish production in these waters is exclusively and entirely based on their natural fish food production capacities (see Figure 30 in Chapter 5).

When practicing natural culture, common carp is not the only fish species. There are other large Cyprinids and/or predator fishes which are stocked together with carp. The actual proportion of different carps and predators depends on the physical and biological qualities of the given water body. For sake of simplicity such waters can be grouped according to their temperature.

Partly and locally warming up waters

Temperature of oligotrophic waters located on higher altitudes does not warm up. Depth and temperature stratification keep water cool even during summer months. These waters are typically trout and whitefish waters unless there are locations where water depth is shallow enough to warm up to the point which supports the growth of carp.

Waters of this type will produce less than about 22–25 kg/ha if they are irregularly and disproportionally stocked (Van Anrooy, Mena Millar, Spreij 2006). However with proper fish stock management production can be about 25–100 kg/ha in which proportion of carp can be as much as 80–90 percent. Actual results depend on length of warm months, total area of shallow warming up parts of the water body and overall productivity of the given water.

FIGURE A1

A typical deep cold water mountain reservoir

In this type of waters carp does not grow well.

FIGURE A2

A typical shallow water reservoir

Shallow reservoirs warm up in the same way as fish ponds.

Photo courtesy of György Hoitsy and András Woynárovich.

Moderately warming up waters

Temperature of moderately warming up waters remains around 18–20 °C during the summer months. Therefore it is pointless to stock Chinese major carps which require higher temperature to feed and grow intensively. In this case carp is the only feasible choice among large Cyprinids. With planned stocking and yearly fishing natural carp production of such waters may vary between 50 and 200 kg/ha. Actual results depend on length of warm months and productivity of the given water.

Warming up waters

In reservoirs and ponds where water warms up considerably during summers higher fish production can be expected. If water temperature of these waters warm up steadily to 20–24 °C, not only stocking of common carp, but also stocking of Chinese major carps become feasible.

Fish production of this type of waters may vary between 100–400 kg/ha. Fish production of such waters depends on the number of warm summer months and the actual productivity of the given water body.

Hypertrophic waters

Due to different reasons, there are hypertrophic waters where fish grow extremely well (see Figure A3). In these waters production can be as much as the result in a well manured unfed fish pond.

FIGURE A3

Different fish species from a hypertrophic water reservoir in Hungary

Out of a net total yearly production of about 600 kg/ha common carp, grass carp and predator fishes represented only about 4–5 percent. Remaining 95–96 percent was silver and bighead carps.

Photos courtesy of Kumarbek Kylychev and András Woynárovich.

Appendix 4

CONTROL OF WATER WEEDS WITH CARPS

TABLE A9

Consumption preferences of grass carp

Latin name of water weeds	Rate of preference (1–4)*
Ceratophyllum demersum	4
Chara sp,	4
Cladophora sp.	4
Elodea canadensis	4
Hydrocharis Morsus-ranea	3
Iris pseudacorus	2 (Hard stems were not consumed.)
Myriophyllum spicatum	4
Najas marina	4
Phragmites communis	3 (Hard stems were partly consumed.)
Polygonum amphibium	2
Potamogeton crispus	3
Potamogeton lucens	4
Potamogeton natans	4
Potamogeton pectinatus	3
Potamogeton perfoliatus	4
Ranunculus trichophyllus	1 (Only 25–30 percent was consumed.)
Schoenoplectus tabernaemontani	3
Sium latifolium	3
Spirogyra sp.	4
Trapa natans	3
Typha angustifolia	2 (Hard stems were partly consumed.)
Typha latifolia	3 (Hard stems were partly consumed.)

* Rate 4: Consumed within 8 hours with huge appetite. Rate 3: Consumed within 24 hours with medium appetite. Rate 2: Consumed within 48 hours. Rate 1: Did not consume.

Source Antalfi and Tölg, 1972.

Excessive quantities of water weeds in ponds, reservoirs and canals are disturbing therefore their control is an important part of managing such waters.

Biological control with carps is one of the most suitable options of keeping waters free of water weeds. Though grass carp has the main role, common carp is also active in controlling water weeds. While grass carp directly consumes plants, common carp digs roots.

Water weed consumption of grass carp depends on age, size, water temperature, quality of water plants.

Younger and smaller fish consume more tender shoots, but larger specimens (about 0.4–0.5 kg) will also feed increasingly on the solid parts of plants, especially if tender parts are less abundant.

Grass carp over one kilogram of body weight will graze on reeds if water temperature is high enough and other, more preferred plants are not available (see Table A9).

Water temperature when grass carp intensively feeds is around 22–25 °C. If water temperature is above 25 °C grass carp will search for food so aggressively that it grabs incurving grass and edible terrestrial plants from the edge of water.

Daily water weed consumption of grass carp can be as much as 60–120 percent of body weight[40]. FCR of water weeds is listed in Table A21 which varies between 20 and 70 (Antalfi and Tölg, 1972).

When controlling water weeds with carps there are some important aspects to be considered:

- it is easier to control upcoming vegetation of water weeds than to get rid of an already established one. Therefore early stocking of grass carp is essential,
- different size of grass carp will feed on different types and parts of water plants, hence stocking of different age groups is also important, and
- as soon as water weeds are consumed in a water body grass carp should be either harvested or fed with fresh terrestrial plants.

At planning, still before deciding the quantity and size of stocked grass carp the actual or likely upcoming biomass of water weeds should be estimated. If about half of the water surface is or will be covered with unwanted vegetation expected to be consumed by grass carp, stocking option presented in Table A10, can be followed or adopted.

TABLE A10

Biological control of water weeds with carps

Species	Stocked per hectare				Survival (%)	Harvested per hectare			
	Size (gr)	Number	%	Weight (kg)		Size (gr)	Number	Gross weight (kg)	Net weight (kg)
Common carp	25	50	2	-	50–70	750	30	20	20
Silver and bighead carp*	25	100	3	-	50–70	750	60	50	50
Grass carp	25	1 250	42	30	50–70	750	750	560	530
	100	1 000	33	100	60–80	750	700	530	430
	250	500	17	130	80–90	1 250	430	540	410
	750	50	2	40	80–90	2 500	40	100	60
	Total	**2 800**	**93**	**300**	-	-	**1920**	**1 730**	**1 430**
Predators	20	50	2	-	50–70	500	30	20	20
Total	-	**3 000**	**100**	**300**	-	-	**2 040**	**1 820**	**1 520**

* Ration between silver and bighead carp should be about 80–90 and 10–20 percent.

Source Woynarovich, Moth-Poulsen, Péteri, 2010.

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40 For the sake of comparison the daily consumption of grass carp out of terrestrial plans is about 30–60 percent. FCR of this type of plant vary between 20 and 30 kg (see Table A21).

Appendix 5

CARP CULTURE IN TANKS AND CAGES

BOX A1

Basic characteristics of tank and cage culture

Those fish species are suitable for growing in tanks or cages which tolerate high density (stress and disease resistant) and their feeding is economical, as in both cases giving expensive biologically complete feeds is a basic condition of success (see Figure 30 in Chapter 5). Production in tanks and cages should be expressed as the quantity of fish produced in unit volume of water (fish/m^3 and kg/m^3).

Tank culture is a widely used method for intensive production of fish. Tanks, regardless of their size and material (earth, concrete, fibreglass, etc.), are suitable to keep fish if quality of water is good (rich in dissolved oxygen and free of waste products of metabolism). Water quality in the tanks can be maintained through continuous change of water and supply of air/oxygen. Tanks can be supplied by flow-through water, but the water can be partially or fully recirculated after its mechanical and biological cleaning.

Cage culture is a method suitable for intensive production of fish in different floating compartments prepared from nets or grids. Cages are few metres deep and can be kept in rivers, lakes, reservoirs or even in deeper sections of fish ponds. Cage culture is based on the same principles as tank culture. Water quality is maintained in cages by continuous change of water. Usually the required change of water is naturally ensured by flow of rivers or by currents caused by winds or movement of fish in the cages located in confined waters.

Source Woynarovich, Moth-Poulsen, Péteri, 2010.

There is a wide range of marine and freshwater fish species which is commercially produced in tanks and cages. These species are similar in some important key characteristics. It is that their production is profitable under conditions summarised in Box A1.

Though common carp is among those fishes which are suitable for being produced in tanks and cages its intensive commercial tank and cage culture have not spread widely.

In some cases production of advanced fry and fingerling (one-summer-old fish) of carp might be feasible in regions where pond and environmental conditions are unfavourable for growing them in ponds.

Production of elder and larger carp in tanks or cages is less feasible. This can be explained with the relatively low price of carp which makes such operations unprofitable, or at least less profitable than carp production in ponds. It is, however, predictable that tank and cage culture of common carp will be extensively practiced as soon as these production systems become profitable.

BMPs of tank and cage culture of carp should be similar to other warm freshwater fish species which are already widely produced in tanks and cages.

1. Principles of tank culture of carp

Tanks suitable for carp production are made out of membrane, fibreglass and concrete or are small rectangular rearing and wintering ponds, because;

- membrane and fibreglass trough and tanks of different shapes are especially suitable for rearing advanced fry and fingerling of carp, and
- rectangular rearing and wintering ponds are widely available in traditional fish farms all over in CEE and CCA.

Rearing ponds are suitable only if water inlet and outlet are located on their opposite sides which positions ensure the change of water in them.

TABLE A11

Predictable results of carp production in tank

Produced age group	Gross production		Change of water (time/day)
	1000 fish/m³	kg/m³	
Advanced fry (1–2 gr.)	5–10	-	12–36
Fingerling (20–50 gr.)	-	5–20	6–24
Grow-out of carp	-	5–40	3–24

Wintering ponds are built for keeping fish under continuously changing of water. Therefore, water supply of such ponds is ideal. Disadvantage of earthen wintering ponds is that carp will dig on the bottom and destroy dykes. Therefore, unless they are paved or covered with geomembrane, costs of maintenance and repair might be considerable (Katics, 2011).

Quality and management of water in tanks

There are some important aspects which should be observed at tank culture:

- water used for carp culture should be free of pollution and warm enough (about 18–24 °C but preferably over 20–22 °C),
- continuously changing of water in tanks is essential for maintaining the required oxygen content of water (minimum 5–6 mg/l) and remove wastes, such as waste products of metabolism and unconsumed feeds. According to the size and actual density of fish, water should be changed in tanks several times per day. Aeration of water will allow a lower rate of water change, and
- a rule of thumb is that quality of discharged water should be the same as the water which was taken and used. Therefore, effluents of tank culture should not be discharged directly into the environment without their mechanical and biological cleaning.

There are different options for mechanical and biological cleaning of effluents:

- use of simple and mechanised mechanical filters (settling tanks, hydrocyclones, screens, drums, etc.) and biological filters will ensure the required rate of cleaning,
- during summers cleaning of effluents of intensive culture of carp through a nearby fish pond is a technically and economically feasible option, and

- cleaning effluents through wetlands is another feasible option, even if this system is rather inefficient in the cold months of the year.

Most probably the future of cleaning effluents of both indoor and outdoor intensive tank systems is recycling water. Out of the available options recycling water through a fish pond is possible during summer months. Out of the natural growing season of carp intensive recycling systems should be supported by suitable devices. These can be purchased from specialized companies.

Feeding in tanks

In certain cases screened plankton collected in fish ponds may also serve as a starter or as a supplement to the dry starter feed of carp larvae. Later the only technically feasible way of feeding is if industrial feeds of guaranteed qualities are used.

Use of home-made feeds runs the risk that fish does not receive a suitable diet which contains the required ingredients (protein, energy, minerals, vitamins etc.) in the needed proportions. Therefore many fish feed producing companies offer full ranges of industrial carp feeds. These include starters for feeding larvae, feeds for grow-out fish and even for broodstock. Fish feed producing companies also offer the knowhow of using their products. Therefore they advise feeding programs according to how their feeds should be used.

2. Principles of cage culture of carp

Technically, cage culture of carp may be feasible. In South-East Asia rearing carp in happa is a known technique. This is when carp kept and fattened with kitchen waists in cages fixed to floating homes.

In modern large-scale aquaculture cage culture of younger generations of carp is less feasible. This is because the net in which the small and fragile fry is growing has to be so often cleaned that such operation hardly compensates the invested efforts.

Grow-out of carp in cages is technically feasible if the required quality and quantity of feeds are available. Gross quantity of larger carp produced in cages may be as much as 20–40 kg/m^3.

Characteristics of cages

Cages suitable for carp production may be made out planks, wire/plastic mesh or different types of netting materials. Their common characteristics are that they emerge from and float over the water surface and they resistant currents and attacks of predatory animals from outside the cage. Size of cages may vary from a few to several ten cubic metres.

Location of cages

When deciding the location of cages the followings should be considered:

- waters used for carp cage culture should be free of pollution and warm enough (about 18–24 ^{o}C but preferably over 20–22 ^{o}C),
- cages should be placed at locations where water is deep enough (several meters) and/or where it is unlikely that the unconsumed feeds and faeces will deposit under the cages, and
- cages can be placed in still waters if there the movement of water is strong and regular enough to ensure the proper change of water in the cages.

Cages in still waters: If cages are placed in fish ponds, unused feed is utilized by fish outside the cages, while faeces of carp in such cages are ideal manure for increasing the natural fish food production of a pond. However, long-term accumulation of faeces under the cages may cause oxygen depletion and deterioration of the water quality. Therefore, cages should not be fixed in the same place of a pond for a longer period of time. It is also a rule of thumb that the carrying capacity of a pond where fish are kept in cages should not be planned bigger than the carrying capacity of a pond stocked with free swimming fish (Woynarovich, Moth-Poulsen and Péteri, 2010).

In still waters the change of water in cages can be ensured with paddle aerators or similar devices. These will not only aerate but also create current.

Cages in flowing waters: Placing cages into slow flowing waters (3–4 cm/sec) is the best. In waters where water flows fast (40–50 cm/sec) fish will spend unnecessarily too much energy to keep up with currents (Müller and Váradi, 1980).

Feeding in cages

Basic aspects and principles of feeding carp in cages are similar to feeding carps in tanks. There is only one important difference. It is the consistency of feed which should be different, namely fish feed should float or sink slowly in order not to be washed out from the cage.

Cage culture of carp and related environmental considerations

Similarly to other fresh water fish species establishment of carp cages in natural waters should be done after a concise survey of pros and cons. This is true even if waters which are suitable for producing carp in cages are warm enough hence life is active in them which may guarantee the use and decomposition of unconsumed feeds and wastes of fish metabolism. Therefore, before the establishment and operation of carp cages, it should be estimated whether the self-cleaning capacity of the water body would ensure proper decomposition of produced wastes.

Appendix 6

USEFUL TABLES[41]

Tables of this appendix of BMPs carp production contain basic information and guiding figures of pond and pond water management and propagation, feeding, fishing, wintering and transportation of carp, as well as selected other species frequently cultured together with carp.

1. Artificial propagation of carps

TABLE A12

Key data of artificial propagation of common carp, silver carp and grass carp

Description	Common carp		Silver carp		Bighead carp		Grass carp	
	from	to	from	to	from	to	from	to
Sexual maturation of females (years)	4	5	5	6	7	8	6	7
Sexual maturation of males (years)	2	3	4	6	6	7	4	6
Size of matured female (cm)	30	40	40	60	70	80	50	70
Size of matured male (cm)	25	30	40	60	70	80	50	70
Size of matured brood fish (kg)	2.5	3	4	6	5	7	4	6
Water temperature at propagation (C°)	16	22	21	23	22	25	21	23
Sex ration at propagation (♂:♀)		2:1		1:1		1:1		2:1
Percent of ovulation in females after hormone treatment (%)	60	90	60	80	80	90	60	80
Ovulation after the decisive (2nd) dose (H°)	230	260	210	220	230	260	210	220
Number of eggs per 1 kg of female BW	100 000	200 000	60 000	80 000	50 000	60 000	60 000	80 000
Diameter of dry eggs (mm)	1	1.5	0.7	1	1	1.1	0.9	1.2
Diameter of swelled eggs (mm)	1.5	2.5	3.7	5.3	3.7	5.3	3.7	5.3
Number of eggs in 1 kg dry eggs	700 000	1 000 000	900000	1 100 000	600 000	800 000	800 000	900 000
Number of eggs in 1 l swelled eggs	80 000	120000	18000	22000	12 000	16 000	16 000	18 000
Rate of fertilization (%)	80	95	70	90	70	90	70	90
Hatching of fertilized eggs (%)	90	95	75	85	75	85	75	85
Survival of larvae up to taking air (%)	90	95	80	90	80	90	80	90
No. of feeding larvae from 1 kg dry eggs	500 000	700 000	500 000	600 000	400 000	500 000	400 000	600 000
Length of incubation of eggs (D°)	60	70	24	30	26	30	24	30
Length of non-feeding larvae phase (D°)	60	70	60	70	60	70	60	70
Size of feeding larvae (mm)	6	7	6	6.5	7	8	6	7
Size of 1st feed (µm)	100	300	50	250	100	150	50	300
Size at starting species specific feeding (mm)	25	30	30	35	30	35	40	50
Amount of eggs in a 7–9 l Zuger jar[5] (gr.)	100	200	40	50	40	50	40	50
Amount of swelled eggs in a 7–9 l Zuger jar (l)	1	2.5	2	3	2	3	2	3
Amount of eggs in a 60 l jar (gr.)	100	200	100	150	100	150	100	150
Amount of swelled eggs in a 60 l Zuger jar (l)	1	2.5	5	10	5	10	5	10
Amount of larvae in a 60 l jar (No.)	80 000	120 000	80 000	120 000	80 000	120 000	80 000	120 000
Amount of larvae in a 200 l jar (No.)	250 000	400 000	250 000	400 000	250 000	400 000	250 000	400 000

Source Horváth, Tamás, Tölg, 1984.

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[41] At the elaboration of the present appendix the same logic and mostly the same tables are presented, which were already compiled and published in FAO publication titled; Carp polyculture in Central and Eastern Europe, the Caucasus and Central Asia: a manual.

TABLE A13

Potentials of artificial propagation of carps (common carp and Chinese major carps)

Description	Minimum	Average	Maximum
Individual weight of brooders (kg/fish)	4	5	6
Females (pcs.)	6	6	6
Males (pcs.)	4	4	4
Total of brooders	**10**	**10**	**10**
Total weight of females (kg)	24	30	36
Stripped eggs (pcs./season)	1 800 000	2 000 000	2 500 000
Hatched larvae (pcs./season)	1 450 000	1 650 000	2 000 000
Feeding larvae produced (pcs./season)	1 350 000	1 500 000	1 900 000
Feeding larvae stocked (pcs./season)	1 350 000	1 500 000	1 900 000
Advanced fry harvested (pcs./season)	650 000	750 000	950 000
Fingerling harvested (pcs./season)	400 000	450 000	600 000
Two-summer-old fish harvested (pcs./season)	280 000	310 000	420000
Table fish harvested			
Number (pcs./season)	**250 000**	**280 000**	**380 000**
Weight (tonnes/season)	**370**	**420**	**570**

Source Khavtasi *at. al.*, 2010.

2. Pond preparations

TABLE A14

Recommended time for filling and draining ponds

Size of the pond (ha)	Length (days)
Smaller than 0.1	0.2–0.4
0.1–1	1–3
1–6	1–3
6–30	4–14
30–60	8–15
Larger than 60	15–30

Source Antalfi and Tölg, 1971.

TABLE A15

Recommended mesh size of screen at filling and drainage of ponds

Age of stocked or harvested fish	Mesh size (cm)	
	Stocking	Harvest
Fish larvae	0.2	-
Advanced fry	1	2–3
One-summer-old fish	2-3	6
Two-summer-old fish	6	15
Table fish	15	20

Source Horváth and Pékh, 1984.

3. Manuring, fertilization and liming

TABLE A16

Chemical composition of the manures of different farmed animals

	Dairy cattle	Beef cattle	Ox	Pig	Chicken		Horse
					Layers	Broiler	
Dry matter as % of fresh manure	12.7	11.6	25.0	9.2	25.2	25.2	20.9
Dry matter (%)	100	100	100	100	100	100	100
Organic material (%)	82.5	85.0	85.0	80.0	70.0	70.0	80.0
Total nitrogen (%)	3.9	4.9	4.5	7.5	5.4	6.8	2.9
Total phosphorus (%)	0.7	1.6	0.7	2.5	2.1	1.5	0.5
Total potassium (%)	2.6	3.6	3.2	4.9	2.3	2.1	1.8
Biological oxygen demand $^{5 \text{ days}}$	16.5	23.0	9.0	33.0	27.0	-	-
Chemical oxygen demand	88.0	95.0	11.8	95.0	90.0	-	-

Source Miner and Smith, 1975

TABLE A17

Recommended quantities of manure and fertilizers

Name	Total quantity (tonne/ha)	% of total quantity	
		Start	Later
Production of advanced fry			
Manure	1.5–2.5	100	0
Carbamide (urea)	0.15	100	0
Superphosphate	0.1	100	0
Production of elder age groups of fish			
Manure	3–5	25	75
Carbamide (urea)	0.4–0.5	25	75
Superphosphate	0.3–0.4	25	75

Source Horváth and Pékh, 1984., Horváth, et al., 1985.

TABLE A18

Frequently used fertilizers

Type of fertilizer	Description
Nitrogenous fertilizers	**Liquid ammonia (NH_4OH) or (NH_3 x H_2O) with a nitrogen content of 12–16%** It is a water solution of ammonia which is an important product of small-scaled nitrogenous fertilizer factories with simple synthesizing procedure and low cost. Ammonia is in an unsteady state when it is in water, easy to volatilize, so it could almost lose its effect through the volatilization if it is exposed to the air for a long period of time.
Nitrogenous fertilizers	**Ammonium sulphate ($(NH_4)_2SO_4$) with a nitrogen content of 20–21%** It is produced from the liquid ammonia directly neutralized with diluted sulphuric acid. It is white crystal when pure, apt to dissolve in water. 100 kg of water can dissolve 75 kg of ammonium sulphate. With a little absorption of moisture it is convenient to preserve and apply.
Nitrogenous fertilizers	**Urea ($CO(NH_2)_2$) with a nitrogen content of 44–46%** Ammonia and carbon dioxide are interacted and synthesized into urea under high heat & pressure. It is white crystals with a strong absorption of moisture. After dissolution in water, urea does not turn out ions and is unable to be absorbed directly by plants. It can be utilized by plants only after it is decomposed by urease excreted by urea-decomposing bacteria and transformed into ammonium carbonate. The conversion rate of urea is related with the temperature. It can be totally transformed into ammonium carbonate in 4---5 days at 20°C and in 2 days at 30°C.
Phosphoric fertilizers	**Calcium superphosphate ($Ca(H_2PO_4)_2$) H_2O with 12–18% of P_2O_5** It has a subsidiary content of $CaSO_4$, $2H_2O$, (about 50%). Usually, it is a white powder. It is corrosive and is apt to absorb moisture, smelling acidic since there is some free acid in the product.

Source Xinhua, 2011.

TABLE A19

Application of lime at pond preparation and during the production season

pH	Preparatory dose (kg/ha)	Monthly dose (kg/ha/month)
8	50–100	10–25
7.5	100–200	25–50
7	200–300	50–75
6	300–400	75–100
Less than 6	400–450	100–125

Source Woynarovich, Moth-Poulsen, Péteri, 2010.

4. Feeding

TABLE A20

Simple mixture of supplementary feeds for rearing advanced fry of carps in pond

Ingredients	%
Wheat or barley flour	25
Soya	25
Fish meal	25
Meat or blood meal	25

Source Horváth and Tamás, 1981.

TABLE A21

FCR of feeds used in carp polyculture

Name of Feed	Dry Matter (%)	Digestible Protein	Fat	FCR	Proportion in feed of carp (%)*	
		%			Min.	Max.
Grains						
Wheat	87	10	1	4–5	30	80
Rye	87	9	1	4–5	-	20
Barley	87	8	2	4–5	-	40
Oat					-	20
Maize	87	8	4	4.5	10	25
Millet	87	8	4	4–5		
Sorghum	87	6	3	4.5–5		
Legumes[43]						
Pea	87	19	1	3–4	-	8
Bean	87	20	1	3–4		
Soybean	90	28	16	2–3		
Lupine (sweet)	87	33	6	2.5–3	-	20
Lupine (bitter)	87	30	5	2.5–3.5	-	10
By-products of milling and processing industry[42]						
Wheat bran	87	10	2	8–10	-	15
Wheat germ					-	5
Wheat starch					-	3
Rice bran					-	10
Milk powder					-	2
Mill sweeping	87	10	-	5–15		
Extruded sunflower	90	16	16	3–6		
Extruded soya (46–48)					5	25
Fish oil					1	5
Sunflower oil					-	5
Soya oil					-	4
Raw fish	20	16	-	6–10		
Raw meat cuttings[43]	23	19	-	6–15		
Protein-rich meals						
Fish meal	88	44	2	2–3	-	35
Meat meal	89	64	-	2–3		
Blood meal					-	5
Meat meal (58 and 62)					5	20
Offal (liver, hearth, lung, kidney)					-	40
Green feeds						
Grass	30	2	4	20–30		
Reed	28	1	-	20–70		
Lucerne	24	3	-	15–25	-	10
Clover	18	3	-	20–30		
Others						
Nutrition lime					-	1
Salt					-	0.5

Source Antalfi and Tölg, 1971, Tasnádi, 1983; Horváth, 2000, * Hancz, 2007.

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42 Dry pea, bean and lupines should be ground and/or soaked well before use. Soybean should be steamed, boiled or roasted before use.

43 Use of raw fish and meat in aquaculture is banned in the European Union. Therefore, they should be processed (steamed, boiled, etc.) before feeding them with fish.

5. Fishing

TABLE A22

Recommended mesh size of nets for catching fish

Age groups	Full mesh (mm)
Advanced fry	2–3
One-summer-old fish	5–10
Two-summer-old fish	15–30
Table fish	30–50

Source Horváth and Pékh, 1984.

6. Wintering

TABLE A23

Practical figures of wintering fish – 1

Age groups	kg/m²	fish/m²	Quantity of water (l/min./100 kg fish)
One-summer-old fish	4–8	80–400	7–10
Two-summer-old fish	6–8	40–60	6–8
Table fish	8–12	7–10	6–7

Source Horváth and Pékh, 1984.

TABLE A24

Practical figures of wintering fish – 2

Individual size of fish (gr.)	Fish species (kg/m²)			Quantity of water (l/min./100 kg fish)
	Grass carp	Common carp	Silver carp	
10–20	8–12	8–10	7–8	6–12
20–50	12–14	10–12	8–10	6–12
200–600	18–25	15–20	10–12	6–12
1 000–3 000	20–30	18–22	12–15	6–12

Source: Antalfi and Tölg, 1971.

7. Transport of fish

TABLE A25

Transport of larvae in fish transporting containers and in plastic bag

Species	Temperature of transporting water			
	10 °C	15 °C	20 °C	25 °C
In fish transporting containers under continuous oxygen diffusion (1 m³ water) Duration of transport: 2–6 hours				
Common carp (No.)*	-	-	750 000–1 250 000	500 000–1 000 000
Chinese major carps (No.)*	-	-	750 000–1 250 000	500 000–1 000 000
In plastic bag with pure oxygen (30 l water and 30 litre oxygen) Duration of transport: 2–12 hours				
Pike (No.)	50 000–150 000	20 000–75 000	-	-
Common carp (No.)	-	200 000–400 000	100 000–200 000	60 000–120 000
Chinese major carps (No.)	-	-	80 000–150 000	30 000–80 000

Source Antalfi and Tölg, 1971, * Krisztián Szabó personal communication 2011.

TABLE A26

Transport of advanced fry (2–3 cm) in 0.1 m^3 water under continuous oxygen diffusion

Species	Temperature of transporting water (duration of transport: 2–12 hours)				
	10 ºC	15 ºC	18 ºC	20 ºC	25 ºC
Pike	3 000–8 000	2 500–5 000	1 500–3 500	-	-
Pikeperch	2 000–6 000	2 000–4 000	1 000–3 000	500–2 000	200–1 000
Common carp	-	13 000–30 000	6 000–20 000	5 000–15 000	2 000–5 000
Chinese major carps	-	-	8 000–22 000	6 000–18 000	3 000–7 000
European catfish	-	-	2 000–5 000	1 500–4 000	3 000–5 000

Source Antalfi and Tölg, 1971.

TABLE A27

Transport of advanced fry (2–3 cm) in plastic bag with pure oxygen (30 l water and 30 litre oxygen)

Species	Temperature of transporting water (duration of transport: 8–48 hours)			
	10 ºC	15 ºC	20 ºC	25 ºC
Pike	1 500–3 500	1 000–2 500	-	-
Pikeperch	700–3 000	500–2 000	300–1 000	-
Common carp	-	8 000–15 000	6 000–12 000	5 000–10 000
Chinese major carps	-	-	5 000–10 000	3 000–8 000
European catfish	-	-	4 000–8 000	2 000–3 000

Source Antalfi and Tölg, 1971.

TABLE A28

Transport of the different age groups in 1 m^3 water under continuous oxygen diffusion

Species	Temperature of transporting water and duration of transport (hours)			
	4–15 ºC		16–20 ºC	
	2–6 hours	6–12 hours	2–6 hours	6–12 hours
Advanced fry				
Common carp (No.)	-	-	150 000	100 000
Chinese major carps (No.)	-	-	120 000	80 000
European catfish (No.)	-	-	100 000	60 000
One-summer-old fish				
Common carp (kg)	120	80	70	50
Grass carp (kg)	130	90	80	60
Silver carp (kg)	50	30	30	25
Bighead carp (kg)	130	90	80	65
European catfish (kg)	140	100	80	65
Pikeperch (kg)	40	25	-	-
Tench (kg)	70	50	-	-
Two-summer-old fish				
Common carp (kg)	300	200	175	140
Grass carp (kg)	325	225	200	160
Silver carp (kg)	125	75	75	60
Bighead carp (kg)	325	225	200	160
European catfish (kg)	350	250	200	160
Pikeperch (kg)	100	60	-	-
Tench (kg)	175	125	-	-
Table fish				
Common carp (kg)	600	400	350	280
Grass carp (kg)	650	450	400	320
Silver carp (kg)	250	150	150	120
Bighead carp (kg)	650	450	400	320
European catfish (kg)	700	500	400	320
Pikeperch (kg)	200	120	-	-
Tench (kg)	350	250	-	-

Source Horváth and Pékh, 1984.

Appendix 7

FEASIBILITY CRITERIA

The purpose of determining the feasibility criteria is to establish the requirements for a project investment. It is done by using feasibility screens, which are essentially the questions that need to be positively answered to fulfil each feasibility criterion. These are the biological feasibility, technical feasibility, economic viability, financial feasibility, as well as social, cultural and environmental compatibility. Below is a brief explanation of the concept and mechanics of each criterion:

Biological feasibility

- Will the selected species reproduce in a given environment other than its natural habitat?
- Will the selected species grow to its genetic potential in a confined (rather than natural or wild) environment (as in a cage, tank or pond)?
- In short, will it grow to market size and can it be cultured to an acceptable level of yield?

Technical feasibility

- Are the resources available to reproduce and/or grow the selected species to its potential market size?
- Are the technical inputs available when needed? The technical inputs include seed, feed, fertilizer, credit, skilled labor, post-harvest facilities and services (transport, refrigeration, processing), market (domestic and export), and technological services (research, extension, information).
- Is there available farm management and technical skill required to culture the species?
- In short, has the farmer the ability and the means to culture and market it with a given resource structure?

Economic viability

If the answers to the above are "yes":

- Will it be worth investing money and allocating resources into its farming?
- Does it reward an investor (an individual, farmer or a corporate body) to engage in its culture?
- In short, does it pay the farmer to grow it? Essentially, this requires a crude cost-and-return determination. The importance of a cost and return assessment is that the technical inputs might all be advantageous, but the cost of acquisition of inputs might be prohibitively high or the price of the product is too high (i.e. the market is willing to pay less than the cost of production.).

The essential factors of economic viability are the cost of the resources and the price of the product. Economic viability indicates the possibility of the farmer gaining an acceptable level of economic returns from producing a given species under a certain production system. While the main influences are the markets the prices of inputs and product, it is also related to farmers' having the necessary own resources or access to them (the physical and financial) and the capacities (knowledge, social connections) to produce and market the product.

Financial feasibility

The financial feasibility is a more rigorous and specific test than economic viability. This is a test for financial solvency under various market conditions. Given a technical and management option, and a business model, financial feasibility involves testing for the solvency of the project at various stages of operation (cash flow). In determining financial feasibility, the important questions to answer are:

- How much the project returns to the investor for every unit of money spent?
- How soon can the investor recover investments (payback period)?
- What is the project's resilience to changes in the cost of inputs and price of outputs, in the short term and long term (sensitivity)?

Social, cultural and environmental compatibility

Determination of social, cultural and environmental compatibility of a project is the last but not least step of feasibility criteria. The following questions should be answered:

- Would the production system create conflict with other resource users?
- Is the species acceptable to consumers?
- Are the production and management practices acceptable as well as beneficial to the community?
- Are the production and management practices environmentally friendly and do not contribute to social conflicts and ecological problems?
- In brief, is anyone harmed by the practice or product of farming?

Appendix 8

SUGGESTIONS FOR FURTHER READINGS[44]

The following selection of technical papers and reports are recommended to refer to, if useful, additional carp polyculture related information is needed.

1. Fish species
2. Fish propagation and fish seed production
3. Production, management and marketing
4. Fish feeds and feeding
5. Transport of fish
6. Fish health, welfare and quality
7. Environment and water quality
8. Civil engineering (construction of hatchery and ponds)
9. Research
10. Regional and country related general and technical reviews and papers

1. FISH SPECIES

1.1 Alikunhi, K.H., 1966. **Synopsis of biological data on common carp, *Cyprinus carpio* (Linnaeus, 1758)**. (Asia and the Far East). FAO Fish.Synop., (31.1):73 p.

1.2 Backiel, T. and J. Zawisza, 1968. **Synopsis of biological data on the bream *Abramis brama* (Linnaeus, 1758)**. FAO Fish.Synop., (36):110 p.

1.3 Colby, P.J. *et al*., 1979. **Synopsis of biological data on the walIeye, *Stizostedion v. vitreum* (Mitchill, 1818)**. FAO Fish.Synop., (119):139 p.

1.4 Coppola, S.R. *et al*., 1994. SPECIESDAB. **Global species database for fishery purposes**. User's manual. FAO Computerized Info.Ser. (Fish.), (9):103 p. Database provided on four 3.5-inch diskettes for IBM-compatible microcomputers

1.5 Dadswell, M.J. *et al*., 1984. **Synopsis and biological data on the shortnose sturgeon, *Acipenser brevirostrum* (Le Sueur, 1818)**. FAO Fish.Synop., (140):45 p. Published by the U.S. Department of Commerce, Natl.Ocean.Atmosph.Admin., Natl.Mar.Fish.Serv., as NOAA Tech.Rep.NMFS, (14):45 p.

1.6 Deelder, C.L. and J. Willemsen, 1964. **Synopsis of biological data on pike-perch *Lucioperca lucioperca* (Linnaeus, 1758)**. FAO Fish. Synop., (28):52 p.

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[44] At the elaboration of the present appendix, the same list is presented, which was already compiled and published in FAO publication titled; Carp polyculture in Central and Eastern Europe, the Caucasus and Central Asia: a manual.

1.7 FAO Website, 2009. **Cultured Aquatic Species** (http://www.fao.org/fishery/culturedspecies/search/en)

1.8 Garibaldi, L., 1996. **List of animal species used in aquaculture**. FAO Fish.Circ., (914):38 p.

1.9 Gerberich, J.B. and M. Laird, 1968. **Bibliography of papers relating to the control of mosquitoes by the use of fish. An annotated bibliography for the years 1901-66**. FAO Fish.Tech. Pap., (75):70 p.

1.10 Heidinger, R.C., 1976. **Synopsis of biological data on the largemouth bass *Micropterus salmoides* (Lacépède, 1802)**. FAO Fish.Synop., (115):85 p.

1.11 Jennings, , D.P., 1988. **Bighead carp (*Aristichthys nobilis*): biological synopsis**. FAO Fish.Synop., (151):47 p. (USNat.Mar.Fish. Serv.,Biol.Rep. 88/29)

1.12 Jhingran, V.G. and V. Gopalakrishnan, 1974. **Catalogue of cultivated aquatic organisms**. FAO Fish.Tech.Pap., (130):83 p.

1.13 Nair, K.K. (comp.), 1968. **A preliminary bibliography of the grass carp (*Ctenopharyngodon idella* Valenciennes)**. FAO Fish.Circ., (302):16 p.

1.14 Raat, A.J.P., 1988. **Synopsis of biological data on the Northern pike, *Esox lucius* Linnaeus**, 1758. FAO Fish.Synop., (30 Rev.2):178 p.

1.15 RIFAC, 1997. **Report of the second session of the joint EIFAC/ ICES Working Group on Eel** (PDF 107KB),IJmuiden, the Netherlands, 23-27 September 1996. 18 p. (1997) *EIFAC Occasional Paper EIFAC/OP33*

1.16 Sarig, S., 1966. **Synopsis of biological data on common carp *Cyprinus carpio* (Linnaeus, 1758)**. (Near East and Europe). FAO Fish.Synop., (31.2):35 p.

1.17 Setzler, E.M. *et al*., 1980. **Synopsis of biological data on striped bass, *Morone saxatilis* (Walbaum)**. FAO Fish.Synop., (121):69 p. Published by U.S. Department of Commerce, Natl.Ocean.Atmosph. Admin., Natl.Mar.Fish.Serv., as NOAA Tech.Rep. NMFS Circ., (433):69 p.

1.18 Shireman, J.V. and C.R. Smith, 1983. **Synopsis of biological data on the grass carp *Ctenopharyngodon idella* (Cuvier and Valenciennes, 1844)**. FAO Fish.Synop., (135): 86p.

1.19 Thorpe, J., 1977. **Synopsis of biological data on the perch *Perca fluviatilis* Linnaeus, 1758 and *Perca flavescens* Mitchill, 1814**. FAO Fish.Synop., (113):138 p.

1.20 Toner, E.D. and G.H. Lawler, 1969. **Synopsis of biological data on the pike *Esox lucius* (Linnaeus, 1758)**. FAO Fish.Synop., (30) rev.1:32 p.

1.21 Welcomme, R.L. (comp.), 1981. **Register of international transfers of inland fish species**. FAO Fish.Tech.Pap./FAO Doc.Tech.Pêches/ FAO Doc.Téc.Pesca, (213): 120 p.

1.22 Welcomme, R.L. (comp.), 1988. **International introduction of inland aquatic species**. FAO Fish.Tech.Pap., (294):318 p.

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This technical paper aims to provide basic technical guidance for better management practices (BMPs) for small carp culture in Eastern European, Caucasus and Central Asian region. It is one of the primary documentation outputs of the “Central Asia Regional Programme for Fisheries and Aquaculture Development (GCP/RER/031/TUR - FISHDEV), a joint regional programme being implemented under the FAO-Turkey Partnership Programme (FTPP).
These BMPs, prepared by the selected aquaculture experts and consultants from China, FAO Headquarters, Hungary, India, Thailand and Turkey, are expected to be practically useful for regional fisheries and aquaculture research institutions, regional organizations including Central Asian and Caucasus Regional Fisheries and Aquaculture Commission as well as for people involved in aquaculture, particularly owners of carp hatcheries and farms, and employees of these establishments.

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