FAO FISHERIES AND AQUACULTURE TECHNICAL PAPER

554

ISSN 2070-7010

Carp polyculture in Central and Eastern Europe, the Caucasus and Central Asia

A manual

Carp polyculture in Central and Eastern Europe, the Caucasus and Central Asia

A manual

FAO FISHERIES AND AQUACULTURE TECHNICAL PAPER

554

by
András Woynarovich
FAO Consultant
Budapest, Hungary

Thomas Moth-Poulsen
Fishery Officer
FAO Subregional Office for Central and Eastern Europe
Budapest, Hungary

and

András Péteri
FAO Consultant
Budapest, Hungary

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2010

ISBN 978-92-5-106666-9

Preparation of this document

Carp pond polyculture is the most widely practiced fish production system in Central and Eastern Europe[1] (CEE), the Caucasus[2] and Central Asia[3] (CCA). The total area of fish ponds, as well as water reservoirs smaller than 100 hectares, that is available for carp polyculture in these countries is almost 500 000 hectares[4]. This vast water area could, even under a conservative estimate, support about the double of the present yearly 170 000 to 200 000 tonnes of fish production which was given by the Food and Agriculture Organization of the United Nations (FAO) for the reporting years of the 2000s (FIGIS, 2009).

In CEE and CCA countries, the economic and social conditions changed profoundly in the early 1990s. The market economy was introduced and an overwhelming majority of the previously owned state or cooperative fish ponds and farms were privatized. The new owners and operators, often new to the aquaculture industry, had and still have to face many production-related technical problems. Field visits and consultations confirmed the lack of basic knowledge of farmers on identifying their own resources and selecting production technologies adaptable to their conditions.

Throughout the last decades, FAO has continuously supported the development of aquaculture by issuing technical papers, books and training materials. Though these have been very useful, specific concise technical publications, directly and fully applicable in the CEE and CCA regions, are still missing.

The reasons mentioned above called for the writing of this technical paper, which is a concise overview and inventory of the basic information on carp polyculture and its most applicable production patterns.

It is expected that this document will fill in the gap and will help not only with the realistic planning and successful realization of carp pond polyculture in CEE and CCA countries, but will also support the better and more efficient use of related publications of FAO.

Both the aim and the content of this publication are in line with the recommendations of the Rome Declaration on World Food Security and the World Food Summit Plan of Action (Tacon, 2001), directly supporting both the production of much needed affordable aquatic food and the generation of employment and income-earning opportunities.

[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] The total is about 350 000 hectares in CEE countries, about 100 000 hectares in the Russian Federation and approximately 50 000 hectares in the countries of the Caucasus and Central Asia.

Abstract

This technical paper is a basic guide to carp pond polyculture practicable in the Central and Eastern Europe (CEE) and the Caucasus and Central Asia (CCA) countries. It provides an overview on the guiding principles, aspects and tasks, and presents the most applicable production techniques and patterns of carp polyculture. For further reading and more in-depth information on the suggested techniques and technologies, it also includes a list of relevant FAO publications.

It is expected that this publication will help identify resources and contribute to the successful planning and realization of fish production by those fish pond owners and operators who need to strengthen and improve their knowledge on the subject.

Woynarovich, A.; Moth-Poulsen, T.; Péteri, A.
Carp polyculture in Central and Eastern Europe, the Caucasus and Central Asia: a manual.
FAO Fisheries and Aquaculture Technical Paper. No. 554. Rome, FAO. 2010. 73p.

Acknowledgements

The authors of this document acknowledge with appreciation the valuable comments and suggestions of Rohana P. Subasinghe, Senior Aquaculture Officer and Mohammad R. Hasan, Aquaculture Officer from the Aquaculture Service of the FAO Fisheries and Aquaculture Department, Rome.

The authors would like to express their gratitude to Ms Mária Láng, Doctor of Veterinary Medicine, from the Laboratory of Parasitology, Fish and Bee Diseases at the Central Agricultural Office, Department of Animal Health and Diagnosis, Budapest, for her professional support in the finalization of the health management section of this publication.

The authors also would like to express their gratitude to the valuable editorial assistance and publication support of Ms Tina Farmer (FAO), Ms Maria Giannini and Mr José Luis Castilla Civit. All illustrations are courtesy of András Woynarovich.

Contents

Annexes

Tables

Figures

Boxes

1. Introduction

In the last twenty years economic and social conditions profoundly changed in the countries of Central and Eastern Europe (CEE), the Caucasus and Central Asia (CCA). Therefore, earlier known and successfully practiced fish production technologies in these countries became unprofitable. The attitude of persons involved in aquaculture also changed as the previously exhibited typical willingness to exchange ideas and share experiences noticeably diminished. Obtaining technical information and knowledge became difficult. The lack of modern, market-economy-based extension services and reliable technical literature resulted in insufficient technical knowledge for the new fish pond owners and operators. These all contributed to the under exploitation of fish pond resources in the countries of CEE and CCA.

This paper is compiled to fill in the gap and equip fish pond owners and operators with basic knowledge on identifying their own resources and to select production techniques and technologies adaptable to their specific conditions. In order to satisfy interest for further details, a glossary is compiled and tables and annexes are attached to this paper. For the sake of finding additional information, asterisk symbols (*) are used after those words in italics and are explained in the glossary. The descriptions, explanations and related illustrations are short and informative in order to facilitate easy understanding. Still, it is suggested to consult with specialists in the subject in order to share ideas and discuss problems. This will help quicker perception of the technical and economic aspects of carp pond *polyculture** discussed in this paper.

Last, but not the least, a detailed list of carp production related FAO publications is attached as Annex 5. The objective of this list is to help find related further readings among FAO publications.

2. Pond fish culture

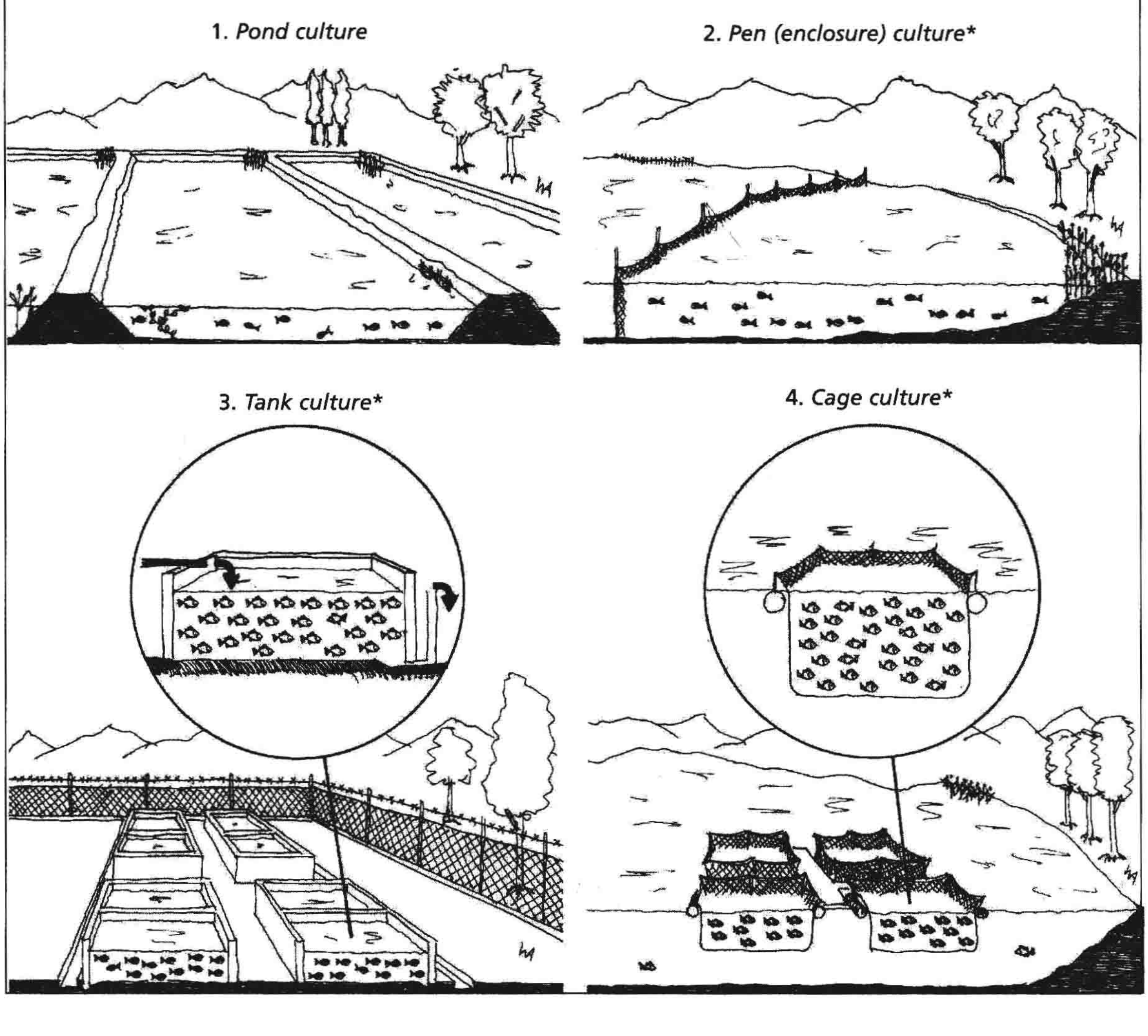
Pond fish culture is the most widely practiced fish production system. It facilitates the mass production of many different fish species all over the world.

2.1 TYPES OF PONDS

In the everyday English language a fairly small still water is called a pond, while a lake is described as a larger area of water surrounded by land. Many dictionaries distinguish between lake and pond simply by their size. In aquaculture literature, ponds are those earth structures which are built for storing water and/or for fish culture purposes, whereas lakes, regardless of their dimensions, are waterbodies of natural origin. Ponds are shallow. Their depth is usually around one metre and rarely exceeds a few metres. Water reservoirs are deeper. Most ponds are suitable for culturing fish.

Depending on the configuration of the terrain, different types of ponds can be constructed. Barrage ponds are built in hilly areas, while contour ponds are typical on

FIGURE 1
Different fish production systems



gently sloping or flat lands. The water supply of ponds can be rain and/or water from a nearby surface or underground water source. Depending on the formation of the surface, the water supply and drainage of ponds can be done partly or fully by gravity or pumping.

The actual size of a fish pond determines its fish rearing capacity and affects the profitability of production. The proportion of the surface of the bottom and dikes and the volume of water is more favourable (higher) in smaller ponds than in larger ones. Consequently, more insect larvae can develop in small ponds, and the nutrient transfer through the relatively large contact area between water and soil is more intensive. Moreover, the management of smaller ponds is easier. The disadvantage of smaller ponds is their relatively higher costs of construction and maintenance.

2.2 CHARACTERISTICS OF POND FISH CULTURE

Pond fish culture is the most ancient practice for producing fish under controlled conditions. The culture of carps developed simultaneously on different continents several centuries ago. Accordingly, Chinese, Indian and European carp polyculture can be distinguished from each other.

Carp polyculture was dramatically improved in the 1960s when *Chinese major carps** were widely introduced to most countries of Europe and Asia. Today, it is a widely practiced pond fish culture technique, not only in temperate but also in subtropical and tropical climates.

Recent country reviews of FAO (Hasan, *et al.*, 2007) support that the characteristics of pond fish culture make it very suitable to produce fish in an inexpensive integrated way.

The main feature and advantage of pond fish culture is that the *natural food** of fish can be produced in the same waterbody, i.e. in the pond where the fish are reared. The production of natural food organisms in ponds can be supported by applying *manure** and/or fertilizers. These materials increase the production of bacteria, plants and animals (worms, insects, etc.) which live in the water and in the bottom of ponds. By consuming these living organisms, fish can satisfy their protein requirements and, in order to maintain their optimal growth, they only need to be fed the relatively cheap, energy-rich supplementary feeds. Hence, one of the advantages of pond fish culture in comparison to the intensive fish production systems is that the protein requirement of fish is satisfied by the *natural fish food** instead of using expensive sources of *allocthonous** protein, i.e. fish meal.

Ponds can be stocked with one or with more than one fish species. The first stocking method is *monoculture,** while the second one is the polyculture. It is a general rule that more fish can be produced in the same waterbody if many fish species, different in their feeding habit and other biological features, are cultured together. This is because the utilization of natural food is much more efficient by a multispecies fish population. Furthermore, if the species composition of fish is properly established and maintained, the production of *plankton** is stimulated by the intensive consumption by the fish. Synergetic effects between some species may also support the higher fish production in polycultural ponds. For example, the production of common carp can be higher if reasonable quantities of silver carp and grass carps are in the same pond (Ruttkay, 1996).

Monoculture of fish can utilize natural fish food less effectively than polyculture. Consequently, unless very low stocking densities are applied, the production of fish in monoculture is much more feed dependent than in polyculture. Monoculture of common carp is widely practiced in many geographic regions of CEE and CCA. Nevertheless, the production figures of common carp are much lower in monoculture than in polyculture. The profitability of production is also less favourable in monoculture.

The water quality, the optimal growth of fish and their good health condition can be maintained with proper pond management. This means maintenance of carefully balanced fish stock, sufficient manuring/fertilization and rational supplementary feeding in accordance to the size of the *standing stock** of fish. As production intensifies, the improvement of water quality has to be ensured by *aeration** and/or the exchange of water.

The calculation of production in ponds is based on the unit area, such as the number of fish per unit area (fish/hectare) and/or weight of fish per unit area (kg/hectare, or tonne/hectare). However, for exact comparison of the technologies of the different production systems, only the produced fish per unit water volume (fish/m^3 and kg/m^3) is suitable.

2.3 ROLE OF POND FISH CULTURE IN LAND UTILIZATION AND ITS INTEGRATION WITH OTHER ACTIVITIES

In the distant past, fish ponds were built on agricultural lands which were not suitable for crop production. Even today good-quality arable lands are preserved, and only *water-affected areas and lands** are considered for building fish ponds or water reservoirs. This is even if fish ponds constructed on good quality soil are more productive than ponds constructed on swampy areas or unfertile lands.

In addition to the better utilization of land resources, fish ponds may contribute to the better management of water resources. They are suitable not only for the production of fish, but also to accumulate water which can be used for irrigation during dry periods. Moreover, ponds support the life of their surrounding *biotopes**.

Pond fish culture is suitable for the utilization of farm wastes such as manure from animal husbandry. These materials introduced in the water can support the development of natural fish food. Wastes from the milling industry and the by-products of crop, vegetable and fruit production can be used directly as fish feed. Consequently, agricultural activities which produce these by-products can be efficiently integrated with pond fish culture.

If pond fish culture is integrated with animal husbandry, the manure of the animals can be used for supporting the development of natural fish food. Therefore, pond fish culture is one of the most environmentally friendly and profitable tools for decomposition of huge quantities of animal wastes produced in agriculture. Most frequently, the production of poultry (chicken or duck) or pig, or husbandry of ruminants, is integrated with pond fish farming.

The integration of carp polyculture with irrigation is an option when water reservoirs are used for fish production. In these waterbodies, manuring and irrigation should be carefully balanced and done in accordance with the standing stock of fish and the actual quantity of water. Stock management in water reservoirs may differ greatly from the stock management performed in fish ponds. The applied fish production technology should be adapted to the length of the irrigation season and the quantity of the available water. For example, when water harmfully lowers in the reservoir, fish must be harvested way before the actual end of the production season.

In fish ponds, there is an intensive (0.5–1.0 cm/year) development of mud rich in nutrients and organic materials. From time to time, the mud should be dried and removed from the pond. If this material is distributed over less fertile land, the fertility of the soil will increase considerably. Consequently, this way of fish farming can support horticulture or the production of other terrestrial plants.

An increasingly popular way of pond utilization is the integration of fish culture with a recreational activity such as angling. Its advantage is that anglers pay for the fish and the fee for catching fish. They also pay for their accommodation, eat at the local restaurants and buy locally made products and souvenirs.

Carp polyculture can be integrated with intensive rearing of other fish such as trout or catfish. In this case, the flow-through tanks of the intensive system is constructed near the fish pond. The *effluent** of the intensive unit is discharged into the pond where the drifted-in fish faeces and other products of *metabolism** increase the natural fish food production in the same way as manure does. The unconsumed feed particles drifted from the intensive tanks into the pond are directly utilized as feed. If the ratio of the intensive unit and the pond area is determined properly, a high level of water purification can be achieved.

Integration of intensive and extensive fish culture practices in a traditional pond fish farm is also possible. The small wintering ponds can be used as the tanks of intensive production unit, whereas the large fish ponds can support the intensive unit as a mechanical and *biological filter**. Another way for integration of intensive fish culture with carp pond polyculture is the cage culture. If cages are placed in the fish pond during the production season, wastes from the cages will be utilized by the pond *ecosystem**, including by the fish that are produced there.

3. Background information on pond fish culture

For determining the most appropriate production technology and for taking day-to-day decisions, fish farmers and pond operators should be familiar with the principles of water quality, the life of pond habitat, and the role of manure, fertilizer and supplementary feeds.

3.1 CHARACTERISTICS OF POND WATER

The important *physical characteristics** of pond water have direct effects on fish production. For this reason they should be known and considered.

Temperature determines the growth, production and reproductive activity of all aquatic organisms. They are *poikilotherm**, so their metabolism is temperature dependent. All fish species have a range of *water temperature** optimal for their growth. When the water temperature is low during winter, fish stop feeding, they *hibernate** and remain dormant at the pond bottom.

Density or **specific weight** of water changes with the temperature. The specific weight of warm water is lower than that of cooler water. This physical characteristic is the reason why the calm or undisturbed water stratifies in layers. The cold water sinks down, while water of higher temperature stratifies on the surface. As a consequence, a diurnal vertical circulation can develop in ponds during the days when the wind does not create other currents. This process means that the upper layer of water contacting with relatively cold air at night cools down more quickly than the water at the pond bottom. The specific weight of this cooler water increases. Therefore, the surface water sinks to the bottom and the warmer and lighter water from the bottom rises to the surface. This circulation can transfer oxygen to the bottom but also ensures the exchange of nutrients between water and mud. Because of the chemical composition and molecular form of water, when water cools down in winter the specific weight increases only up to 4 °C. At this value the specific weight is the highest, which is 1 g/ml. At lower temperatures than 4 °C, the specific weight of water again decreases. This is the reason why ice floats on the surface. Consequently, under the ice, in deep, undisturbed waterbodies, the water temperature is always 4 °C at the bottom. If the water is deep enough, this phenomenon protects the fish from freezing.

Specific heat ensures waterbodies to warm up and to cool down slowly, much slower than the surrounding air temperature. This characteristic of water defends the aquatic organisms from quick and radical changes of water temperature.

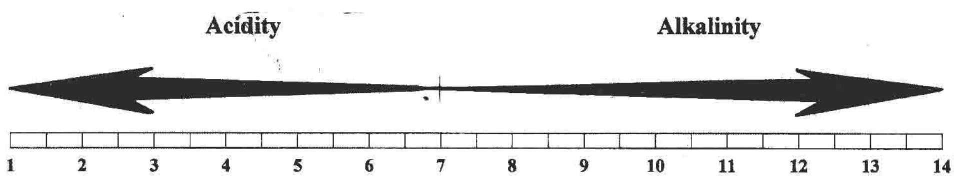
Surface stress is caused by the cohesion of water molecules. It allows insects (water cricket, pond scatter, etc.) to walk and others organisms (mosquito larvae) to float on the surface of the water.

Light conditions in pond water determine the intensity of the *photosynthesis**. Light conditions in a pond depend on the transparency of water, which is influenced by *turbidity**, *colour of water** and by biological factors such as density of plankton and the number and size of the different fish species. The transparency of water is measured with a *Secchi disk**, as described in Chapter 6.5. Transparent water allows an intense penetration of sun, which is unfavourable for *phytoplankton**. Moreover, the penetration of light supports the intensive growth of macrovegetation, which is less desirable in fish ponds.

Movement of pond water also has an important effect on the pond ecosystem. Wind, *thermal circulation of water**, currents developed by inflowing and outflowing waters create horizontal and vertical streams in ponds. These movements ensure healthy pond life through supporting the exchange of gases and dissolving nutrients to and from the pond bottom.

The **pH** value is an important figure of pond water. Fish farmers should know and regularly check the *pH** of pond water, because all chemical and biological processes which determine the production depend on this. Among others, pH influences the solubility of and accessibility to the different minerals.

FIGURE 2
Scale of pH



On the pH scale of 1–14, acidity of water increases from the neutral 7 towards the value of 1, while alkalinity increases gradually from the neutral 7 towards 14.

In fish ponds where the density of phytoplankton is high, the daily fluctuation of pH is considerable. This is because in the course of *assimilation** (photosynthesis) and *dissimilation** (respiration) phytoplankton reduces or increases the concentration of carbon dioxide (CO_2). During daytime, when phytoplankton assimilates, it consumes CO_2 therefore pH increases. At night, when the plants dissimilate, they consume oxygen and produce CO_2. This decreases the pH of the water.

Water ranging in pH between 6.5 and 9.0 before dawn is considered the most suitable for pond fish culture. At pH 6.5–5.5, fish production will be less, either because of the direct effect on the fish and/or on the growth of fish food organisms. Acid water with pH 5.0–5.5 can be harmful to fish. Water with excessive alkalinity (above 10) can also be harmful to fish (Hepher and Pruginin, 1981).

Many gases and solid materials dissolve well in pond water, which is explained by the molecular structure of water. Gases dissolved in water derive either from the air, from the pond bottom, or they are produced during the metabolism of different living organisms. Oxygen, carbon dioxide, sulphur hydrogen, free ammonia and methane are the gases which can have both supportive and harmful effects on the aquatic life in general and on fish in particular.

Oxygen (O_2) dissolves well in water. Dissolved oxygen (DO) in pond water ensures the respiration of fish. The oxygen content of water is expressed in mg/l or in percentage of saturation. Oxygen content of fully saturated water varies with temperatures as presented in Figure 3. Oxygen can penetrate into the water from the atmosphere, but the majority of DO in pond water is produced by phytoplankton in the course