

REPRODUCTIVE BIOLOGY OF COMMON CARP (CYPRINUS CARPIO LINNAEUS, 1758) AND FACTORS AFFECTING REPRODUCTIVE PERFORMANCE: A REVIEW

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Abstract: This article reviews the current scientific literature on the reproductive biology of common carp (*Cyprinus carpio* Linnaeus, 1758) and the major ecological and physiological factors affecting reproduction. Particular attention is given to the effects of water temperature, dissolved oxygen, nutrition, photoperiod, hormonal regulation, and genetic factors on reproductive performance. In addition, the scientific basis for broodstock management, enhancement of fecundity, and the application of modern reproductive technologies in aquaculture is summarized.

Keywords: common carp, *Cyprinus carpio*, reproductive biology, gametogenesis, fecundity, broodstock, aquaculture, ecological factors, selective breeding.

Introduction: In recent decades, aquaculture has become one of the fastest-growing sectors of global food production, playing a crucial role in ensuring food security, supplying high-quality animal protein, and reducing fishing pressure on natural aquatic ecosystems. According to the Food and Agriculture Organization of the United Nations (FAO, 2024), aquaculture currently contributes more than half of the fish consumed worldwide, and its production continues to increase annually. Consequently, improving fish reproductive performance and developing efficient broodstock management strategies have become major priorities for sustainable aquaculture development. Among cultured freshwater fish species, the common carp (*Cyprinus carpio* Linnaeus, 1758) occupies a prominent position because of its rapid growth, high adaptability to diverse environmental conditions, efficient feed utilization, strong reproductive capacity, and high economic value. Owing to these biological characteristics, common carp has become one of the most widely cultured freshwater fish species in Asia, Europe, and many other regions of the world. In Uzbekistan, it represents one of the principal aquaculture species cultivated under pond farming systems and contributes significantly to the country's fisheries production. The reproductive biology of common carp is a

complex process regulated by the interaction of genetic, physiological, endocrine, nutritional, and environmental factors. Successful reproduction depends on normal gonadal development, gametogenesis, spawning behavior, fertilization efficiency, embryo survival, and larval quality. These processes are strongly influenced by water temperature, dissolved oxygen concentration, photoperiod, feeding regime, water quality, and the physiological condition of broodstock. Therefore, comprehensive knowledge of reproductive biology is essential for improving artificial propagation techniques and increasing the productivity of aquaculture enterprises.

Numerous researchers have investigated the reproductive physiology of common carp and other cyprinid fishes. Huet (1970) emphasized the importance of environmental conditions, particularly water temperature and dissolved oxygen, in regulating fish reproduction. Bardach et al. (1972) highlighted that the use of genetically superior and physiologically healthy broodstock is one of the key factors determining reproductive success in aquaculture. Hickling (1974) demonstrated that broodstock nutrition and environmental management directly influence reproductive performance and offspring quality. Billard (1986) provided comprehensive information on gametogenesis, ovulation, and artificial reproduction of cyprinid fishes, while Mylonas et al. (2010) and Zohar et al. (2010) described the endocrine mechanisms regulating gonadal maturation and spawning in teleost fishes. Recent advances in aquaculture have demonstrated that reproductive efficiency is determined not only by hormonal induction but also by integrated broodstock management, including optimal nutrition, environmental control, stress reduction, and genetic improvement. Modern reproductive technologies, such as hormonal stimulation, selective breeding, molecular genetic approaches, and cryopreservation of gametes, have significantly enhanced the production of high-quality fish seed in commercial aquaculture. Despite considerable progress in carp breeding technologies, comprehensive studies evaluating the combined effects of environmental conditions, broodstock management, and physiological characteristics on reproductive performance under the pond aquaculture conditions of Uzbekistan remain limited. Scientific information regarding the optimization of broodstock selection and reproductive management under local environmental conditions is still insufficient. Therefore, the objective of this review is to summarize current scientific knowledge on the reproductive biology of common carp (*Cyprinus carpio* Linnaeus, 1758), with particular emphasis on the ecological, physiological, and nutritional factors influencing reproductive performance, and to identify



future research directions for improving broodstock management and reproductive technologies in pond aquaculture.

Materials and Methods: This study was conducted as a comprehensive review of the scientific literature on the reproductive biology of common carp (*Cyprinus carpio* Linnaeus, 1758) and the major factors affecting its reproductive performance. Relevant scientific publications were collected from internationally recognized databases, including **Scopus, Web of Science, ScienceDirect, SpringerLink, Google Scholar**, and publications of the **Food and Agriculture Organization of the United Nations (FAO)**. Peer-reviewed journal articles, scientific books, review papers, conference proceedings, and international guidelines published between **1970 and 2025** were analyzed. Classical references describing the biological and physiological characteristics of common carp reproduction were evaluated together with recent studies on broodstock management, endocrine regulation, nutrition, environmental factors, and reproductive technologies. The literature was selected according to the following criteria: (i) scientific relevance to common carp reproductive biology; (ii) methodological reliability; (iii) publication in peer-reviewed scientific journals or internationally recognized scientific publishers; and (iv) applicability of the reported findings to pond aquaculture systems. Information from duplicate publications and studies lacking sufficient methodological detail was excluded from the analysis. The collected information was classified into the following thematic categories: reproductive physiology, gonadal development, gametogenesis, environmental factors affecting reproduction, broodstock nutrition, hormonal induction of spawning, selective breeding, and modern reproductive technologies. Comparative analysis and synthesis methods were employed to identify common scientific findings, differences among studies, and current research trends. The reviewed data were critically evaluated and synthesized to provide scientifically grounded conclusions regarding the reproductive biology of common carp and practical recommendations for improving broodstock management and reproductive efficiency under pond aquaculture conditions.

Results and Discussion: The analysis of the reviewed literature demonstrated that the reproductive performance of common carp (*Cyprinus carpio* Linnaeus, 1758) is determined by the complex interaction of genetic, physiological, nutritional, and environmental factors. Successful broodstock management depends not only on the physiological maturity of fish but also on the maintenance of optimal environmental conditions throughout the



reproductive cycle. One of the principal factors influencing reproductive success is **water temperature**. According to Huet (1970), common carp exhibit normal gonadal development and spawning activity at water temperatures ranging from **20 to 24°C**, while temperatures below 18°C delay gonadal maturation and temperatures exceeding 28°C may reduce gamete quality. Similar observations have been reported in recent studies, indicating that temperature regulates endocrine activity through the hypothalamic–pituitary–gonadal (HPG) axis and directly affects vitellogenesis, spermatogenesis, and ovulation.

Dissolved oxygen concentration is another critical environmental parameter affecting reproductive performance. Most researchers recommend maintaining dissolved oxygen levels above **5–6 mg L⁻¹** during broodstock conditioning and spawning. Oxygen deficiency suppresses metabolic activity, decreases sperm motility, reduces egg quality, and lowers fertilization and hatching rates. Consequently, continuous monitoring of water quality is essential for maintaining reproductive efficiency in pond aquaculture systems. The reviewed publications consistently emphasize the importance of **broodstock nutrition**. Balanced diets rich in high-quality protein, essential amino acids, polyunsaturated fatty acids (particularly ω -3 and ω -6 fatty acids), vitamins (A, D, E, and C), and trace minerals improve gonadal development, fecundity, fertilization success, and larval survival. Conversely, nutritional deficiencies result in delayed gonadal maturation, smaller egg diameter, reduced egg viability, and poor offspring performance. Endocrine regulation plays a fundamental role in carp reproduction. Billard (1986) demonstrated that gonadal maturation is regulated through the hypothalamic–pituitary–gonadal axis, where gonadotropin-releasing hormone (GnRH) stimulates the secretion of follicle-stimulating hormone (FSH) and luteinizing hormone (LH), ultimately controlling gametogenesis and final maturation of gametes. Mylonas et al. (2010) further reported that hormonal induction using carp pituitary extract, human chorionic gonadotropin (hCG), and GnRH analogues has significantly improved spawning synchronization and reproductive efficiency in commercial aquaculture. Recent advances in reproductive biotechnology indicate that hormonal stimulation alone cannot ensure consistently high reproductive performance. The physiological condition of broodstock, stress management, genetic background, and environmental stability collectively determine spawning success and the quality of offspring. Zohar et al. (2010) emphasized that minimizing handling stress and maintaining stable environmental conditions enhance endocrine responses and reproductive output. Selective breeding has become one of the major approaches



for improving reproductive characteristics in common carp. Modern breeding programs integrate morphometric evaluation, reproductive traits, growth performance, disease resistance, and molecular genetic markers to identify superior broodstock. These approaches have contributed to increased fecundity, improved fertilization rates, enhanced larval survival, and faster growth of subsequent generations. Despite substantial progress in reproductive technologies worldwide, relatively few studies have comprehensively evaluated the combined influence of environmental factors, broodstock management, and reproductive physiology under the pond aquaculture conditions of Uzbekistan. Most available studies focus on individual aspects of reproduction, whereas integrated investigations linking ecological conditions, nutrition, endocrine regulation, and reproductive performance remain limited. Overall, the reviewed literature indicates that reproductive efficiency in common carp depends on maintaining optimal hydrochemical conditions, providing balanced nutrition, selecting genetically superior broodstock, and applying scientifically based reproductive management strategies. Integrating these factors can significantly improve spawning performance, offspring quality, and the overall productivity of pond aquaculture systems.

Conclusion: The reviewed scientific literature demonstrates that the reproductive biology of common carp (*Cyprinus carpio* Linnaeus, 1758) is regulated by the complex interaction of genetic, physiological, nutritional, endocrine, and environmental factors. Successful reproduction depends on the coordinated processes of gonadal development, gametogenesis, hormonal regulation, spawning, fertilization, and early larval development, all of which are strongly influenced by broodstock quality and culture conditions. Water temperature, dissolved oxygen concentration, water quality, photoperiod, and balanced nutrition were identified as the principal environmental factors determining reproductive performance. Maintaining optimal hydrochemical conditions and providing nutritionally balanced diets rich in essential proteins, lipids, vitamins, and minerals are essential for improving gonadal maturation, fecundity, fertilization rate, and larval viability. The literature further indicates that modern broodstock management should combine selective breeding, proper nutritional strategies, environmental control, stress reduction, and scientifically based hormonal induction techniques. Such an integrated approach enhances reproductive efficiency and contributes to the production of high-quality fish seed for sustainable aquaculture. Although considerable progress has been achieved in understanding the reproductive physiology of common carp, comprehensive



studies integrating ecological, physiological, nutritional, and genetic factors under the pond aquaculture conditions of Uzbekistan remain limited. Future research should focus on the combined effects of hydrochemical parameters, feeding regimes, endocrine regulation, molecular genetic markers, and reproductive traits to improve broodstock selection and reproductive technologies adapted to local farming conditions. Overall, the findings summarized in this review provide a valuable scientific foundation for improving broodstock management, optimizing artificial propagation techniques, and increasing the productivity and sustainability of common carp aquaculture.

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