JMAI Jurnal Media Akuakultur INDONESIA

https://journal.unram.ac.id/index.php/jmai/index. E-ISSN : 2798-0553

Volume 5, Number 2, June 2025

FINANCIAL VIABILITY ASSESSMENT OF KOI (Cyprinus rubrofuscus) CULTURE THROUGH SELECTIVE BREEDING PROGRAMS : A CASE STUDY OF INDONESIAN COMMERCIAL KOI FARMS

Penilaian Kelayakan Keuangan Budidaya Ikan Koi (*Cyprinus Rubrofuscus*) Melalui Program Pembiakan Selektif: Studi Kasus Budidaya Koi Komersial Di Indonesia

Agung Luthfi Fauzan[*1], Ahnadia Wulan Ramadhana[1], Nina Nurmalia Dewi[2]

[1]Department of Aquaculture, Faculty of Food Security, Surabaya State University,
[2]Department of Aquaculture, Faculty of Fisheries and Marine, Airlangga University

Prof. Dr. Moestopo Street, Number 4, Pacar Keling, Tambaksari, Surabaya, Jawa Timur 60286

[*]Correspondence email: agungfauzan@unesa.ac.id

ABSTRAK

Penelitian ini bertujuan untuk mengevaluasi kinerja keuangan industri budidaya ikan koi (*Cyprinus rubrofuscus*) di Indonesia melalui program pengembangbiakan selektif. Data yang dikumpulkan selama tahun 2021 sampai dengan tahun 2024 yang meliputi pengembangan usaha, biaya operasional, biaya investasi, dan estimasi modal diperoleh dari 24 pelaku usaha budidaya ikan koi di wilayah Jawa. Pelaku usaha yang menggunakan skrining genetik bertujuan untuk mengurangi disparitas finansial yang berbeda dengan metode budidaya tradisional. Hasil analisis menunjukkan bahwa penerapan program pengembangbiakan selektif secara ilmiah menghasilkan margin keuntungan yang lebih tinggi, yakni sebesar 34,2% dibandingkan dengan metode tradisional yang hanya mencapai 18,7%. Meskipun investasi awal lebih besar (sekitar Rp28,5 juta per hektar), jangka waktu yang dibutuhkan untuk melunasi investasi tersebut lebih efisien, yakni antara 18 sampai dengan 24 bulan. Harga ikan koi lebih tinggi dari harga pasaran, kemungkinan mencapai 2,8% dari harga ikan koi, dengan harga jual per ekor berkisar Rp450.000-Rp1.200.000. Selain itu, terjadi peningkatan efisiensi pakan sebesar 15% dan penurunan mortalitas sebesar 3%, yang berarti terjadi penurunan sebesar 7,8%. Dengan demikian, program pembiakan selektif ini dapat meningkatkan kinerja produksi dan penjualan budidaya ikan koi dengan menerapkan teknologi genetik, yang dapat membantu mengatasi krisis keuangan di sektor akuakultur di negara-negara berkembang.

ABSTRACT

This study aims to evaluate the financial performance of the koi fish farming industry (*Cyprinus rubrofuscus*) in Indonesia through a selective breeding program. Data collected between 2021 and 2024, covering business development, operational costs, investment costs, and capital estimates, was obtained from 24 koi fish farming businesses in the Java region. Businesses using genetic screening aim to reduce financial disparities, which is different from traditional aquaculture methods. The analysis's results indicate that the implementation of the selective breeding program in a scientific manner yielded a higher profit margin of 34.2% than the traditional method, which only reached 18.7%. Although the initial investment is more substantial (about Rp28,5 million per hectare), the time frame required to pay for the investment is more efficient, i.e., between 18 and 24 months. The price of koi fish is higher than the market price, possibly reaching 2.8% of the price of koi fish, with the selling price per tail ranging from Rp450,000 to Rp1,200,000. In addition, there was a 15% increase in feed efficiency and a 3% decrease in mortality, which means a 7.8% reduction. Thus, this selective breeding program can improve koi farming production and sales performance by applying genetic technology, which can help overcome the financial crisis in the aquaculture sector in developing countries.

Kata Kunci	*Budidaya Ikan Koi, Kinerja Keuangan, Pembiakan Selektif, Efisiensi Pakan, Teknologi Genetik*
Keywords	*Koi Fish Farming, Financial Performance, Selective Breeding, Feed Efficiency, Genetic Technology*
Tracebility	Submission: 1/6/2025. Published : 27/6/2025
Panduan Kutipan (APPA 7th)	Fauzan, A. L., Ramadhana, A. W., & Dewi, N. N. (2025). Financial Viability Assessment of Koi (*Cyprinus Rubrofuscus*) Culture Through Selective Breeding Programs : A Case Study of Indonesian Commercial Koi Farms. *Indonesian Journal of Aquaculture Medium,* 5(2), 1-7. http://doi.org/10.29303/mediaakuakultur.v5i2.7332

INTRODUCTION

The global ornamental fish trade represents a multibillion-dollar industry, with an estimated *market* value exceeding 15 billion annually (Hassan et al., 2024). Among ornamental species, koi fish (*Cyprinus rubrofuscus*) hold particular prominence due to their distinctive coloration patterns, longevity, and cultural significance in Asian markets. The species commands premium prices in international markets, with superior specimens valued at thousands of dollars per individual (Wijaya et al., 2024). Indonesia has emerged as a significant player in the global koi market, leveraging favorable climatic conditions and established aquaculture infrastructure. However, the financial sustainability of koi farming operations remains variable, with many producers struggling to achieve consistent profitability (Sari et al., 2023).

The *implementation* of selective breeding programs has been proposed as a strategy to enhance production efficiency and market competitiveness, yet comprehensive economic assessments of such interventions remain limited. Selective breeding in aquaculture has demonstrated substantial benefits across various species, improving growth rates, disease resistance, and product quality (Gjedrem and Robinson, 2014; Holloway et al., 2021). Recent advances in genomic selection and molecular techniques have further enhanced breeding program effectiveness, enabling targeted improvement of economically important traits (Nielsen et al. 2022). However, the economic implications of implementing sophisticated breeding programs in ornamental fish operations require careful evaluation, particularly regarding initial investment costs and long-term profitability.

The present study addresses this knowledge gap by conducting a comprehensive financial viability *assessment* of koi aquaculture operations incorporating selective breeding programs. Through detailed analysis of Indonesian commercial farm operations, this research quantifies the economic benefits and challenges associated with advanced breeding technologies in ornamental fish production.

METHODS

Study Sites and Farm Selection

Twenty-four commercial koi farms across Java Island, Indonesia, were selected for this study based on operational scale, production capacity, and willingness to participate in data collection. Farms *were* categorized into two groups: twelve facilities implementing structured selective breeding programs (SBP farms) and twelve conventional operations (control farms). Se- lection criteria included minimum operational duration of five years, production capacity exceeding 10,000 individuals annually, and comprehensive record-keeping systems.

Data Collection and Analysis Period

Financial and production data were collected over a 36-month period from January 2021 to December 2024. Monthly records included operational costs, revenue streams, production volumes, mortality rates, and market prices. Additional data encompassed initial investment costs, infrastructure requirements, and labor expenses.

Economic Parameters and Calculations

Key financial indicators evaluated included:

Initial Investment Costs: Infrastructure development, breeding stock acquisition, equipment procurement Operational Expenses: Feed costs, labor wages, utilities, veterinary services, maintenance Revenue Streams: Direct sales, breeding stock sales, consultation services Profitability Indices: Net profit mar- gin, return on investment (ROI), break-even analysis Production Efficiency: Feed conversion ratio (FCR), survival rate, growth performance.

Selective Breeding Program Assessment

SBP farms implemented standardized protocols including: Genetic diversity maintenance through pedigree management, Quantitative trait evaluation (coloration, body conformation, growth rate), Molecular marker-assisted selection where applicable, Systematic record-keeping of breeding performance.

Statistical Analysis

Financial and production data were analyzed using SPSS 28.0 software. Independent t-tests compared the means between SBP and control farms. Correlation analysis examined relationships between breeding program investments and profitability outcomes. Statistical significance was set at $p<0.05$.

RESULT AND DISCUSSION

SBP farms required significantly higher initial investments compared to conventional operations (Table 1). Average establishment costs for advanced breeding facilities totaled 28,500 per hectare, compared to 16,200 for basic operations. Major cost differentials included specialized breeding tanks (3,400 vs. 1,200), water quality monitoring systems (2,800 vs. 800), and genetic screening equipment (4,200 vs. 0).

Table 1. Initial Investment Costs Comparison Between Farm Types

Parameter	SBP Farms	Control Farms	Improvement (%)
Survival Rate (%)	92.2±2.1	87.7±3.4	+5.1
FCR	1.8±0.2	2.1±0.3	+14.3
Growth Rate (g/month)	85.4±8.2	70.1±7.9	+21.8
Market Size Achievement (months)	14.2±1.8	17.8±2.1	+20.2

Monthly operational costs averaged 2,340 per hectare for SBP farms compared to 1,890 for control operations. However, revenue generation was substantially higher in SBP farms, averaging 3,640 per hectare monthly versus 2,320 for conventional operations (Figure 1). Feed costs represented the largest operational expense category, accounting for 45-52% of total monthly expenditures. SBP farms demonstrated superior feed conversion efficiency, achieving FCR values of 1.8:1 compared to 2.1:1 in control farms. This improvement translated to reduced feed costs per unit of biomass produced, partially offsetting higher overall operational expenses.

Net profit margins demonstrated substantial differences between farm types. SBP operations achieved average profit margins of 34.2% compared to 18.7% for control farms (p ¡ 0.001). Annual return on investment averaged 28.6 for SBP farms versus 16.4 for conventional operations. Break-even analysis revealed that SBP farms recovered initial investments within 18- 24 months, despite higher establishment costs. Control farms achieved break-even at 15-20 months but generated lower absolute profits thereafter.

Selective breeding programs produced substantial improvements in market value realization. Premium specimens from SBP farms commanded average prices of 680 per individual, compared to 240 for comparable-sized fish from control operations. The highest-quality breeding stock achieved market values exceeding 1,200 per individual. Quality improvements attributable to selective breeding included: Enhanced coloration intensity and pattern definition: 1. Improved body conformation and swimming behavior 2. Increased disease resistance and survival rates 3. Extended lifespan and reproductive performance.

SBP farms demonstrated superior production efficiency across multiple parameters (Table 2). Survival rates improved from 87.7% in control farms to 92.2 in SBP operations. Growth rates increased by an average of 22%, with sexually mature fish reaching market size 3-4 months earlier than conventional stocks.

Table 2. Production Efficiency Comparison

Parameter	SBP Farms	Control Farms	Improvement (%)
Survival Rate (%)	92.2±2.1	87.7±3.4	+5.1
FCR	1.8±0.2	2.1±0.3	+14.3
Growth Rate (g/month)	85.4±8.2	70.1±7.9	+21.8
Market Size Achievement (months)	14.2±1.8	17.8±2.1	+20.2

The findings demonstrate substantial economic benefits associated with implementing selective breeding programs in koi aquaculture operations. Despite requiring 76 percent higher initial investments, SBP farms generated 57 percent higher monthly revenues and achieved 83 percent higher profit margins compared to conventional operations. These results align with previous studies documenting the economic benefits of genetic improvement programs in aquaculture species (Gjedrem and Robinson, 2014; Janssen et al., 2017). The enhanced profitability of SBP farms stems from multiple factors. Premium market positioning allows for significantly higher selling prices, with superior specimens commanding 2.8-fold price premiums. Improved production efficiency, particularly enhanced feed conversion ratios and survival rates, reduces operational costs per unit of production. Additionally, faster growth rates enable more frequent production cycles, increasing annual throughput and revenue generation.

The 18-24-month break-even period for SBP farms compares favorably with typical aquaculture investment recovery time frames. While initial capital requirements are substantial, the accelerated revenue generation and higher profit margins enable rapid cost recovery. The economic model demonstrates resilience to market fluctuations, with premium product positioning providing protection against price volatility affecting commodity-grade ornamental fish. The risk mitigation benefits of selective breeding include improved disease resistance and environmental tolerance in bred populations. These characteristics reduce production losses and associated economic impacts, contributing to more stable and predictable financial performance. The diversified revenue streams available to SBP farms, including breeding stock sales and genetic material licensing, provide additional economic security.

The substantial price premiums achieved by selectively bred Koi reflect strong market demand for high-quality ornamental fish. Consumer preferences increasingly favor specimens with distinctive characteristics, superior health status, and documented genetic provenance. This trend supports the economic viability of premium production strategies and suggests continued market growth potential for high-quality breeding programs. International market expansion opportunities exist for Indonesian koi producers implementing advanced breeding technologies. Export markets in Europe, North America, and other Asian countries demonstrate strong demand for premium ornamental fish, with established distribution networks facilitating market access. The reputation for quality associated with selective breeding programs enhances competitiveness in these premium market segments.

Recent advances in genomic selection and molecular breeding technologies offer opportunities for further enhancing breeding program effectiveness and economic returns. Implementation of marker-assisted selection, genomic selection protocols, and precision breeding techniques could accelerate genetic improvement rates while reducing generation intervals (Nielsen et al., 2022; Palaiokostas et al., 2020). The integration of digital technologies, including automated phenotyping systems and artificial intelligence-based selection protocols, promises to reduce labor costs while improving selection accuracy. These technological advances could further enhance the economic competitiveness of selective breeding programs and facilitate their adoption by smaller-scale producers.

The demonstrated financial viability of selective breeding programs in koi aquaculture has important implications for industry development strategies. Government support for breeding program implementation, including technical assistance and financial incentives, could accelerate adoption and enhance sector competitiveness.

Educational programs targeting aquaculture producers could facilitate knowledge transfer and technology adoption. Development of cooperative breeding programs and genetic resource sharing initiatives could reduce individual farm investment requirements while maintaining genetic di- diversity and breeding program effectiveness. Such collaborative approaches have proven successful in other aquaculture sectors and could enhance the accessibility of advanced breeding technologies for smaller-scale operations.

CONCLUSIONS

This comprehensive financial analysis demonstrates that selective breeding programs substantially enhance the economic viability of koi aquaculture operations. Despite requiring 76 percent higher initial investments, farms implementing structured breeding protocols achieved 83 percent higher profit margins and 74 percent superior return on investment compared to conventional operations. The 18-24 month investment recovery period compares favorably with industry standards, while premium market positioning provides protection against price volatility. Key economic benefits include enhanced production efficiency, reduced operational costs per unit output, and premium market value realization. Survival rate improvements, superior feed conversion ratios, and accelerated growth rates contribute to overall production efficiency. Premium specimens command 2.8-fold higher market prices, reflecting strong consumer demand for genetically superior fish. The findings support policy recommendations encouraging selective breeding program adoption through technical assistance, financial incentives, and cooperative breeding initiatives. Continued technological advancement in genomic selection and precision breeding technologies promises further enhancement of economic returns and program accessibility. Future research should focus on long-term economic sustainability analysis, market expansion opportunities, and technological integration strategies. Comparative studies across different geographic regions and production systems would enhance understanding of breeding program implementation strategies and economic optimization approaches.

REFERENCES

Gjedrem, T., & Robinson, N. 2014. Advances by selective breeding for aquatic species: A review. *Agricultural Sciences*, 5(12), 1152- 1158..

Hassan, M., Rahman, M. A., & Islam, K. R. 2024. Global ornamental fish trade: Market dynamics and economic implications. *Aquaculture International*, 32(3), 1445-1462.

Holloway, A. C., Kestemont, P., & Yamamoto, T. 2021. Selective breeding strategies in ornamental fish aquaculture: Current status and future prospects. Reviews in *Aquaculture*, 13(4), 2234-2251.

Janssen, K., Chavanne, H., Berentsen, P., & Komen, H. 2017. Impact of selective breeding on European aquaculture. *Aquaculture*, 472, 8- 16.

Nielsen, H. M., Ødega˚rd, J., Olesen, I., Gjerde, B., Amer, P. R., Th- odesen, J., & Chatain, B. 2022. Genomic selection in aquaculture species: Lessons learned and future perspectives. *Frontiers in Genetics*, 13, 896040.

Palaiokostas, C., Ferraresso, S., Franch, R., Houston, R. D., & Bargeloni, L. 2020. Genomic prediction of resistance to viral nervous necrosis in European sea bass (*Dicentrarchus labrax*) using RAD sequencing. *Genetics Selection Evolution*, 52(1), 1-11.

Sari, D. P., Wijaya, A., & Kusuma, H. 2023. Economic analysis of ornamental fish farming in Indonesia: Challenges and opportunities. *Indonesian Aquaculture Journal*, 18(2), 89-98.

Wijaya, A., Sari, D. P., & Rahman, F. 2024. Market analysis of koi fish trade in Southeast Asia: Price determinants and consumer preferences. *Aquaculture Economics and Management*, 28(2), 156-174.