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Retrospective Assessment of Striped Catfish (*Pangasianodon hypophthalmus*) Nursery Performance and Grow-out Business Indicators in Muaro Jambi, Indonesia

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Abstract. *This retrospective case study described target-size attainment, survival, feed conversion and culture duration in six historical nursery records of striped catfish (Pangasianodon hypophthalmus) juveniles and summarised separate grow-out productivity and financial indicators from available farm records in Muaro Jambi, Indonesia. Nursery data was obtained from a 2015 demonstration report . Respondent and farm records were compiled in a June 2025 evaluation . The two data streams were analysed separately and not combined . The nursery dataset consisted of six records of farmer groups (stocking densities 35–100 fish/m²). Nine respondents with paired before-after records were compared for grow-out productivity. Five financial summaries represented nine business units at unequal levels of aggregation. The mean harvest weight of the six nursery groups was 40.15 ± 8.55 g/fish with a culture duration of 59.83 ± 26.69 days, FCR of 0.92 ± 0.16, survival of 83.38 ± 16.98% and SGR of 4.25 ± 1.71%/day. Three groups reached the 40-50 g target, one exceeded it, and two groups, both at 100 fish/m2 under documented water-supply constraints, did not reach the target. Annual grow-out productivity varied from 13.69–20.44 kg/(m²·year) in Kota Karang and 14.71–15.27 in Tangkit Baru. Revenue varied 0-28.00%, accounting profit 17.24-47.32%, and revenue-to-cost ratio after adoption 1.28-1.35 in five financial summaries. The integrated enterprise was covered by after-adoption costs. The main limitations were the small number of aggregate records, the absence of documented within-group replication, the unverified linkage between nursery and financial records, and the observational design, which precluded causal attribution. Water supply planning, joint monitoring of growth and survival, and cycle-specific cost records are practical priorities.*

Keywords: *Grow-out productivity, Nursery performance, Operating costs, Stocking density, Striped catfish*.

Abstrak. Studi kasus retrospektif ini menggambarkan pencapaian ukuran target, kelangsungan hidup, konversi pakan, dan durasi budidaya dalam enam catatan pembibitan historis ikan lele belang (Pangasianodon hypophthalmus), juvenil, dan merangkum indikator produktivitas dan keuangan terpisah dari catatan farm yang tersedia di Muaro Jambi, Indonesia. Data pembibitan berasal dari laporan demonstrasi tahun 2015, sementara catatan responden dan catatan pertanian dikompilasi dalam evaluasi Juni 2025; kedua aliran data tersebut dianalisis secara terpisah dan tidak digabungkan. Dataset pembibitan terdiri dari enam catatan kelompok petani (kepadatan penebaran 35–100 ikan/m²). Produktivitas pembesaran dibandingkan untuk sembilan responden dengan catatan sebelum-setelah yang berpasangan, dan lima ringkasan keuangan mewakili sembilan unit bisnis pada tingkat agregasi yang tidak sama. Di antara enam kelompok pembibitan, berat panen rata-rata adalah 40,15 ± 8,55 g/ikan, durasi budidaya 59,83 ± 26,69 hari, FCR 0,92 ± 0,16, kelangsungan hidup 83,38 ± 16,98%, dan SGR 4,25 ± 1,71%/hari. Tiga kelompok mencapai target 40–50 g, satu melebihinya, dan dua, keduanya pada 100 ikan/m² dengan kendala pasokan air yang terdokumentasi, berada di bawah target. Produktivitas pertumbuhan tahunan berkisar antara 13,69–20,44 kg/(m²·tahun) di Kota Karang dan 14,71–15,27 di Tangkit Baru. Dalam lima ringkasan keuangan, pendapatan berubah 0–28,00%, laba akuntansi 17,24–47,32%, dan rasio pendapatan-terhadap-biaya setelah adopsi berkisar 1,28–1,35, dengan biaya setelah adopsi menutupi perusahaan terintegrasi. Keterbatasan utama adalah sampel kecil yang teragregasi, replikasi dalam kelompok yang tidak terdokumentasi, keterkaitan pembibitan-keuangan yang tidak terverifikasi, periode pengamatan yang berbeda, dan desain observasional yang menghalangi atribusi kausal. Perencanaan pasokan air, pemantauan pertumbuhan–kelangsungan hidup bersama, dan pencatatan biaya spesifik siklus direkomendasikan sebagai prioritas praktis.

Kata kunci: Biaya operasional, Kinerja penggelondongan, Padat tebar, Patin siam, Produktivitas pembesaran

INTRODUCTION

The striped catfish (*Pangasianodon hypophthalmus*), locally known as “patin siam”, is one of the major species in freshwater aquaculture in South East Asia. A nursery stage in between hatchery and grow-out phase, locally known as penggelondongan, producing juveniles of uniform target size prior to grow-out can reduce the length of the subsequent production cycle and the reliance on very small initial stocking material for smallholder producers. A demonstration program in Muaro Jambi in 2015 introduced such a nursery stage with the objective of attaining a

transfer size of 40–50 g per fish from initial juveniles of about 1.5–2 inches, combining stocking, commercial feeding, growth monitoring and support for water quality and fish health management.

The practical value of this nursery stage is determined by the ability to achieve the target size with acceptable survival, feed utilisation and culture duration, and a large final fish size alone is not an indication of successful nursery performance (Miladiyyah & Sari, 2021). In this respect a major managerial decision is the stocking density, but its effect is a function of fish size, water volume and system design. Several controlled studies have reported reduced growth or survival at higher stocking densities, although responses and reported optimal densities vary with fish size and culture system (Zaki et al., 2023; Refaey et al., 2024; Vaishali et al., 2024; Nageswari et al., 2022). As density per unit area (fish/m2, as in ponds) cannot be directly converted to density per unit volume (fish/m3, as in tanks or cages) without knowing water depth, recommendations from these controlled systems cannot be directly applied to the Muaro Jambi ponds.

Economic studies of patin siam enterprises in Indonesia include survey-based analyses of nursery businesses producing small seed over 4–5-week cycles (Martono et al., 2024), and comparative studies differentiating nursery and grow-out management and cost–benefit characteristics (Vo et al., 2024). These studies support the need to assess nursery performance and grow-out financial indicators on different management and accounting bases. A recent business analysis in Tangkit Baru, Jambi, also assessed the striped catfish farming using revenue-cost, break-even and payback indicators (Arfiana et al., 2026). This provides a local economic context, but its business records should not be taken to represent the enterprises or accounting periods examined in the present study. As the nursery and financial records examined here are from different periods and units of observation, grow-out financial indicators are considered as a separate line of evidence from nursery performance, not assuming one explains the other.

We used historical nursery production records from a 2015 demonstration report (Solaiman et al., 2015). Respondent information and farm-level financial records were compiled in a June 2025 evaluation. The stocking density was not randomised, there was no concurrent untreated comparison group, and there was no standardised repeated-cycle design, and several management and water-quality details were not recorded at the time. The analysis is therefore descriptive of observed performance and constraints rather than a test of the causal efficacy of the nursery intervention.

The objective of this study was to describe target-size attainment, survival, feed conversion and culture duration in six historical nursery records, and to summarise separate grow-out productivity and financial indicators available from farm records in Muaro Jambi. Two questions are addressed: (1) to what extent did the six nursery groups achieve the 40–50 g target and how did survival, FCR and culture duration vary with stocking density and recorded water conditions; and (2) what operating indicators do the available grow-out financial summaries provide? The study is not designed to test hypotheses, estimate a causal program effect or show that nursery performance explains the financial outcomes.

MATERIALS AND METHODS

1. Study design and evidence periods

This study was a retrospective descriptive case study in Kota Karang Village, Kumpeh Ulu Subdistrict, and Tangkit Baru Village, Sungai Gelam Subdistrict, Muaro Jambi Regency, Province of Jambi, Indonesia. The underlying evaluation was based on questionnaires, interviews, observations and documentary evidence. Field data collection was carried out in June 2025. The nursery production and water-quality values examined here are from Solaiman et al.'s 2015 demonstration report. Thus, historical technical observations and subsequent respondent information were treated as separate streams of evidence.

The Center of Freshwater Aquaculture Development, Sungai Gelam, Jambi supported the program implementation. No randomization of stocking density, no concurrent untreated comparison group, and no standardized repeated-cycle design. Thus, the analysis is on the observed performance and constraints rather than the causal effectiveness of the intervention.

2. Respondents and units of analysis

The data set of farmers consisted of 50 respondents from groups affiliated with the program, with 25 from each village. The eligibility criteria were: being a member of the relevant farmer groups; having previous or current experience in striped catfish farming; and being willing to provide information. The wider evaluation also involved five purposively selected experts representing academia, a cooperative, fisheries administration, and the catfish farming association. Their strategic assessments were not treated as additional production observations.

Nursery outcomes were available as six farmer-group records, three per village. Each record contributed one value for harvest weight, culture duration, feed conversion ratio (FCR), and survival rate (SR). Within-group replication was not documented; therefore, within-group standard deviations (SDs) were not calculated. Accordingly,

the analytical sample for nursery summaries was six group records, not 50 farmers or the number of individual fish stocked. Respondent characteristics were presented separately and were not linked statistically to the six historical production records. The records were evaluated descriptively according to differences in stocking density; density was not randomly assigned and no causal density effect was estimated.

Of the 50 respondents, nine had paired grow-out productivity records for the before- and after-adoption periods (three in Kota Karang, six in Tangkit Baru) because they kept documented production records; no other selection criterion was applied.

3. Nursery management and outcome definitions

The historical protocol used juveniles of approximately 1.5–2 inches in length (3.8–5.1 cm), commercial feed containing 26–32% protein, and a stated daily ration of 4–5% of fish biomass offered in morning and afternoon feedings. Group stocking densities ranged from 35 to 100 fish/m² and the numbers stocked ranged from 20,000 to 50,000 fish (Table 2); implied pond areas (number stocked divided by density) were about 308–571 m². Reported initial mean weights were 4.0–5.0 g/fish (Table 2), and the target nursery harvest size was 40–50 g/fish. These protocol descriptions do not establish that every group followed the feeding schedule consistently throughout its cycle.

The parameters observed specific growth rate (SGR), feed conversion ratio (FCR), and survival rate (SR). The following formulas are used to measure the parameters for growth performance (National Research Council 2011):

$$SR\ (\%) = 100 \times (N_t / N_0)$$
$$FCR = F / (W_t - W_0)$$
$$SGR\ (\%/day) = 100 \times (\ln W_t - \ln W_0) / t$$

where N_0 = number of fish stocked, N_t = number of fish harvested, W_0 = initial mean body weight (g/fish), W_t = final mean body weight (g/fish), F = total feed supplied (g), and t = culture duration (days).

The historical harvest counts were 27,000, 35,000, 14,500, 47,400, 19,500, and 18,800 fish for the six groups in Table 2, respectively. The SR values reported were recreated by dividing these counts by the respective stocking numbers. This arithmetic check does not independently validate the original fish counts. Reported FCR values were retained because feed totals and complete biomass and mortality records were not available to recalculate independently. Individual-fish records were not available, making SGR a group-level value with no within-group variance. Reported group harvest weight was categorized as target achievement below 40 g, between 40-50 g or above 50 g. This classification is based on group value and does not reflect the proportion of individual fish reaching the target. Water temperature, pH, dissolved oxygen and transparency were extracted as reported ranges at implementation.

4. Data handling and descriptive analysis

Numerical summaries of farmer characteristics were calculated from respondent-level records. Four respondents could not reliably recall their age: one in Kota Karang and three in Tangkit Baru. Their ages were recorded as missing and excluded only from the age summaries, without imputation; valid sample sizes were 24 and 22, respectively. Total pond area denotes the sum of demonstration and non-demonstration pond areas recorded for each respondent.

Annual grow-out productivity was summarized for respondents with paired records: three respondents in Kota Karang and six in Tangkit Baru. The compared pond areas could differ even for the same respondent. These values were therefore treated as historical descriptive comparisons, not repeated measurements on confirmed identical ponds. Missing after-adoption records were not assigned zero. Nursery and grow-out indicators were kept separate, and categorical productivity distributions with undocumented denominators were not used. The before- and after-adoption labels refer to direct stocking of purchased juveniles and grow-out following nursery rearing and selection of uniform-sized juveniles, respectively.

No significance tests, density–response regression, or causal models were used. With six aggregate records, unequal culture durations, and unmeasured management differences, such analyses would not resolve confounding. Documentary explanations of water constraints were considered alongside production values without assigning a quantified effect. Qualitative material informed context; the article does not report coded interview frequencies or an adoption rate because the available records did not support these analyses. Aggregate nursery, water-quality, and financial data are presented in Tables 2–4; respondent-level information is not reproduced to protect participant confidentiality.

5. Farm-level financial records

Financial information came from historical annual grow-out business summaries compiled in the wider evaluation. Four named summaries each represent one business unit: Usaha Bersama, Sejahtera Barokah, Mina Karya

Gemilang, and Usaha Tangkit Bersama. Usaha Sukses represents an average across five business units. Thus nine units at unequal levels of aggregation are summarized in five rows. These rows were not pooled, not treated as five equivalent replicates, and not matched to nursery groups by name. A verified pond- and cycle-level linkage to the six nursery records was unavailable. The labels before and after describe production practices before and after nursery adoption. Before adoption, purchased juveniles were stocked directly into grow-out ponds without a separate nursery phase. After adoption, juveniles purchased in the same initial size class first underwent nursery rearing; fish of a uniform size were then selected from the nursery output and transferred to grow-out ponds. The comparison therefore concerns direct stocking versus grow-out preceded by nursery rearing and size selection. It is not a comparison of fish purchased at two different initial size classes. These labels do not indicate newly measured 2025 production or verified annual follow-up throughout the intervening decade. Exact calendar years and the interval between the before- and after-adoption accounting periods could not be established from the available summaries. Consequently, the comparisons were not adjusted for inflation and should be read as reported nominal accounting differences, not changes in real profitability over a specified follow-up period.

The 2015 nursery numbers and the before/after financial numbers were taken from the tables in the wider evaluation report and were not independently rechecked against the original demonstration or business documents. The grow-out financial indicators follow the methodology of Martono et al. (2024): total cost (TC), total revenue (TR), profit (P), and revenue-cost ratio (R/C), calculated as:

$$TC = TR - P$$
$$R/C = TR/TC$$
$$\text{The percentage change} = 100 \times ((\text{after-before})/\text{before})$$

Annual revenue (TR) and accounting profit (P) were copied from the wider-evaluation tables and converted from thousand IDR to million IDR; these two values were not independently re-checked by the present study. Cost and R/C are reconstructed accounting numbers (Cost = reported revenue – reported profit; R/C = revenue/cost), not audited line-item expenses, and neither was independently verified. Financial SDs were not estimated. The break-even and investment results were excluded because the underlying quantities and the source calculations could not be fully reconciled. Total costs after adoption include all costs incurred in the nursery stage (juvenile purchase, feed, labour, pond use) plus subsequent grow-out costs; thus, nursery costs are included in the integrated enterprise accounts and not removed from the comparison. The observational comparison cannot disentangle a causal profit effect of nursery rearing and size selection.

6. Ethical considerations

Participation in the respondent evaluation was voluntary, and respondents were informed of the study purpose before providing information, which was used for academic research only. Respondent characteristics are reported in aggregate without personal identifiers.

RESULTS

1. Farmer characteristics

Age information was available for 24 respondents in Kota Karang and 22 in Tangkit Baru (Table 1). Mean age was 39.04 ± 10.90 and 50.27 ± 15.80 years, respectively. Reported farming experience averaged 6.16 ± 1.95 years in Kota Karang and 10.16 ± 5.40 years in Tangkit Baru. Mean total pond area was larger in Kota Karang, although variation within both villages was substantial. These summaries describe the respondent dataset as social and economic context (Table 1).

Table 1. Farmer characteristics in the respondent dataset

Characteristic	Kota Karang	Tangkit Baru
Respondents, n	25	25
Age, years	39.04 ± 10.90 (n = 24)	50.27 ± 15.80 (n = 22)
Farming experience, years	6.16 ± 1.95 (n = 25)	10.16 ± 5.40 (n = 25)
Total pond area, m²	2,649.08 ± 1,862.34 (n = 25)	1,162.12 ± 756.73 (n = 25)
Household dependants, persons	1.72 ± 1.14 (n = 25)	0.96 ± 1.62 (n = 25)

Values are mean ± sample SD unless stated otherwise. Source: respondent records analyzed in this study.

2. Nursery production and target attainment

Across the six historical records, mean initial weight was 4.43 ± 0.37 g/fish, mean harvest weight was 40.15 ± 8.55 g/fish, and mean culture duration was 59.83 ± 26.69 days. FCR averaged 0.92 ± 0.16 and SR averaged 83.38 ± 16.98% (Table 2).

Table 2. Stocking and nursery outcomes in the 2015 demonstration records

Group and village	Density fish/m²	Stocked fish	Initial weight g/fish	Final weight g/fish	Duration days	FCR	SR %	SGR %/day
Sejahtera, KK	100	50,000	4.00	33.00	43	1.18	54.0	4.74
Usaha Bersama, KK	80	40,000	4.60	40.20	46	0.77	87.5	4.73
Mina Karya Mandiri, KK	65	20,000	4.60	54.31	38	0.80	72.5	6.50
Usaha Sukses, TB	100	50,000	5.00	30.00	80	0.90	94.8	2.24
Maju Jaya, TB	35	20,000	4.20	43.40	47	0.86	97.5	5.07
Usaha Tangkit Bersama, TB	50	20,000	4.20	40.00	105	1.03	94.0	2.15

KK, Kota Karang; TB, Tangkit Baru; FCR, feed conversion ratio; SR, survival rate; SGR, Spesific growth rate. Source: Solaiman et al. (2015). Values represent a reported outcome per farmer group; no within-group SDs were calculated because replication was not reported. Target harvest weight was 40-50 g fish.

Usaha Bersama (Kota Karang), Usaha Tangkit Bersama and Maju Jaya (Tangkit Baru) had group harvest weights within the target interval. Mina Karya Mandiri exceeded the upper target with 54.31 g/fish after 38 days, but its SR was 72.5%. Sejahtera and Usaha Sukses were still under 40 g/fish at the highest recorded density of 100 fish/m ^{2} . Their SRs differed substantially, 54.0 and 94.8%, respectively. Thus, the two high-density records had low harvest weights but did not share a common survival outcome.

Usaha Bersama had the lowest FCR (0.77) and Maju Jaya the highest SR (97.5%). Usaha Tangkit Bersama required 105 days to reach 40.00 g/fish, while Usaha Bersama took 46 days to reach 40.20 g/fish; No group topped all production indicators simultaneously. The SGR ranged from 2.15 to 6.50%/day, with the highest value in Mina Karya Mandiri and the lowest SGR in the two longest cycles (Usaha Sukses, 80 days; Usaha Tangkit Bersama, 105 days).

Four groups obtained or exceeded 40 g/fish, but only three reached harvest weights within the stated 40–50 g range; this distinction separates an oversized result from precise target achievement. Mina Karya Mandiri produced the largest fish in the shortest cycle, but survival was lower than four other groups. The results suggest a trade-off rather than a single best performer. Both records at 100 fish/m² were below the lower harvest-weight target, but different culture durations and survival rates indicate density alone does not fully explain this pattern.

3. Recorded water conditions

Reported water temperatures ranged from 28 to 31°C, pH from 4.5 to 8.0, dissolved oxygen from 1.0 to 6.2 mg/L, and transparency from 10 to 25 cm (Table 3). Sejahtera had the lowest recorded dissolved-oxygen minimum, and Usaha Sukses had the lowest pH minimum. The historical account described a 1.2 m decline in water level during the dry season and difficulty replenishing water in relation to the two groups stocking 100 fish/m². The ranges cannot identify the duration of exposure or the timing of water conditions relative to mortality and harvest.

Table 3. Reported water-quality ranges during historical implementation

Group and village	Temperature °C	pH	Dissolved oxygen mg/L	Transparency cm
Sejahtera, KK	28–30	6.0–7.5	1.0–3.5	10–20
Usaha Bersama, KK	29–31	6.5–8.0	2.0–3.6	15–25
Mina Karya Mandiri, KK	28–30	6.0–7.8	2.0–3.6	15–25
Usaha Sukses, TB	28–29	4.5–8.0	3.0–5.0	10–20
Maju Jaya, TB	28–29	5.4–7.6	1.5–5.0	10–25
Usaha Tangkit Bersama, TB	28–29	5.5–7.0	4.0–6.2	15–25

KK, Kota Karang; TB, Tangkit Baru. Source: Solaiman et al. (2015). Values are reported ranges, not mean ± SD.

4. Feed efficiency and diet

Reported FCR values ranged from 0.77 to 1.18 across the six groups (Table 2). Feed and biomass data underlying these calculations were not available, so it was not possible to isolate the effects of initial biomass estimation, mortality accounting, feed recording, or natural pond food on the reported ratios.

5. Grow-out productivity

In the paired-respondent subset, reported annual grow-out productivity in Kota Karang changed from 13.69 ± 2.58 to 20.44 ± 0.77 kg/(m²·year) (n = 3). In Tangkit Baru, it changed from 14.71 ± 1.88 to 15.27 ± 1.57 kg/(m²·year) (n = 6). These summaries describe a small subset of respondents and potentially different ponds. They are not nursery yields and do not provide a comparison between the six nursery groups. The limited coverage of after-adoption observations prevents generalization to all 50 respondents.

6. Farm-level operating indicators

The five financial summaries recorded revenue changes from 0 to 28.00% and accounting-profit increases from 17.24 to 47.32% (Table 4). Reconstructed costs increased in the three Kota Karang summaries and decreased in the two Tangkit Baru summaries. These changes describe historical accounting records; incomplete individual after-adoption ledgers prevent full validation of the reported increases. The after-adoption practice included nursery rearing and size selection before grow-out. Consequently, the observed accounting differences cannot isolate the contribution of nursery rearing from size selection or other changes in management, prices, and production conditions.

Table 4. Annual business summaries for direct grow-out and nursery-integrated grow-out

Group and village	Practice	Revenue	Cost[1]	Profit	R/C[1]
Usaha Bersama, KK	Before	1,650.00	1,330.50	319.50	1.24
Usaha Bersama, KK	After	2,112.00	1,654.00	458.00	1.28
Sejahtera Barokah, KK	Before	947.38	770.80	176.58	1.23
Sejahtera Barokah, KK	After	1,072.50	822.75	249.75	1.30
Mina Karya Gemilang, KK	Before	825.00	660.16	164.84	1.25
Mina Karya Gemilang, KK	After	990.00	747.16	242.84	1.33
Usaha Tangkit Bersama, TB	Before	506.52	394.30	112.22	1.28
Usaha Tangkit Bersama, TB	After	506.52	374.95	131.57	1.35
Usaha Sukses, TB	Before	350.05	286.21	63.84	1.22
Usaha Sukses, TB	After	364.27	280.47	83.80	1.30

Amounts are million IDR per year; R/C is dimensionless. KK, Kota Karang; TB, Tangkit Baru. Source: historical business summaries compiled in the wider evaluation. Each of the first four named summaries represents one unit; Usaha Sukses is a five-unit mean. . [1]*Cost = displayed revenue − displayed accounting profit (reconstructed); R/C = revenue/cost, ratios rounded after calculation. After-adoption costs include all nursery expenditures (juveniles, feed, labor, pond use) and subsequent grow-out expenditures*.

Usaha Sukses revenue increased from 350.05 to 364.27 million IDR (4.06%), while its reconstructed R/C increased by 6.19%, calculated from the displayed monetary amounts before rounding the ratios. Usaha Bersama revenue increased from 1,650.00 to 2,112.00 million IDR (28.00%). After-adoption R/C across the five summaries ranged from 1.28 to 1.35.

DISCUSSION

1. Stocking density and target achievement

The two groups below the 40 g target were stocked at 100 fish/m² under documented water-supply constraints, consistent with controlled studies showing reduced growth and survival with increased density (Refaey et al., 2024; Zaki et al., 2023). The two records differed in culture duration and survival (Sejahtera: 43 days, 54.0% SR; Usaha Sukses: 80 days, 94.8% SR) so that density alone does not explain the shortfall. Water availability, management and duration were confounded with density in these records and cannot be separated with six aggregate observations.

Zaki et al. (2023) and Refaey et al. (2024) used tanks, Vaishali et al. (2024) and Nageswari et al. (2022) biofloc systems with reported optima of 50 and 210-240 fish/m3, respectively, a more than four-fold difference highlighting how density recommendations highly depend on fish size and system design. A different response was reported in saline reared animals, Nurussalam et al. (2026) found the best production performance at the highest density tested (14 fish/L) in water with salinity of 4 ppt. This finding further indicates that density responses are dependent on rearing conditions and the performance indicator used, and does not indicate an appropriate stocking density for the freshwater ponds studied herein.A cage experiment at 19–25 fish/m³ indicated that individual growth and areal yield varied inversely with density, with an intermediate density being most favourable overall, conflicting production objectives rather than a transferable recommendation(Chowdhury et al., 2020). Without water depth information, it is not possible to compare the pond density per unit area with the volumetric density, which is particularly relevant in light of the documented decline in water level of the Muaro Jambi ponds.

Recent cage data from Bangladesh provide more association between density and economic return. The lowest of three densities tested (30–50 fish/m3) resulted in both the highest mean weight and highest benefit–cost ratio (Kunda et al., 2024). The highest individual growth and survival was reported at 20 fish/m³ in Salia Reservoir, India, whereas biomass production and feed conversion favoured 30–40 fish/m³ (Ramteke et al., 2019). The results show the trade-off between the individual growth and biomass production at cage conditions. This supports the notion that harvest size and economic return should be considered together rather than maximising stocking number alone. In general, these observations lend support to a hypothesis to be tested further, that water-constrained ponds stocked at around 100 fish/m² are at higher risk of missing the target weight, rather than a demonstrated density threshold for Muaro Jambi ponds.

2. Water conditions

The water-quality ranges in Table 3, including the low dissolved-oxygen and pH minima, reflect varied pond conditions but do not quantify stress exposure. A minimum may reflect a brief observation or a frequent condition; therefore, attributing low growth or survival to oxygen or pH alone would go beyond the evidence. Another possible source of variation is pond bottom conditions. Hasibuan et al. (2023) reported the relationships between pond age, bottom-soil properties, water quality and striped catfish yield in tropical earthen ponds. The pond age and sediment characteristics were not recorded in the present records, so their possible contributions could not be evaluated.Tank studies showed dissolved oxygen decreased, and ammonia, nitrite, and pH shifted with increasing density (Zaki et al., 2023), supporting the association of dated water measurements with density in future monitoring cycles rather than confirming a causal pathway here.

Similarly, a qualitative study of Vietnamese striped catfish farmers reported declining water quality, seedstock quality, and disease management as recurring concerns (Tran et al., 2025). This suggests the practical importance of monitoring water conditions in conjunction with seed quality, but does not clarify the specific historical outcomes in Muaro Jambi. pH and temperature used a narrower pH range (7.5–9.0) than the pH minimum of 4.5 cannot confirm or refute its effect (Abduh et al., 2024). An aquaponic nursery study in Jambi reported 85.18% survival at 2 fish/L versus 43.84% at 5 fish/L (Ghofur et al., 2021), supporting the general practice of considering survival along with growth, although its volumetric densities and system differ from the pond demonstrations.

3. Feed efficiency and diet

Reported FCR values below one (Table 2) are retained as historical observations. Another source of variation that cannot be separated in the present records is diet composition, as 30% protein diets have been superior to lower protein diets for growth and water quality in zero-water-exchange systems (Ediwarman et al., 2025) and have mitigated some adverse effects of higher stocking density compared with 25% protein diets (Refaey et al., 2024), while a 28% protein, 4% lipid combination performed favourably for growth and feed conversion in much larger grow-out fish (~168 g initial weight; Prakash et al., 2025). These results support the consideration of feed and water conditions in parallel, but do not prove that the historical 26–32% protein protocol was optimal for 4–5 g nursery juveniles, because fish size and rearing conditions differed. In biofloc systems, the management of carbohydrate source can also influence the water quality and fish performance. Water quality control and growth performance were improved with jaggery supplementation (Singh et al., 2024). Since the historical pond records did not document carbohydrate supplementation and biofloc management, it was impossible to directly use those findings to the present FCR observations.

Indonesian farm-made feeds have been reported to have an FCR of 1.82–1.90 (Aryani et al., 2026). Feed ingredients and physical form also warrant consideration. In a cage trial with striped catfish fingerlings, Hassan et al. (2024) reported that the use of brewery-waste-based floating feed reduced the feed cost with growth performance similar to those fed with soybean-meal-based floating feed. These findings support recording the feed formulation and form and feed expenditure but do not validate the historic FCR values reported here.It emphasises the importance of recording feed composition, quantity, price, and biomass change in future cycles.

4. Grow-out productivity and farm-level financial indicators

After-adoption R/C across the five financial summaries ranged from 1.28 to 1.35, an observed nominal accounting difference associated with nursery-integrated practice rather than evidence of a causal profit effect, given the unverified linkage between the six nursery records and the five financial summaries and the differing accounting periods involved. A survey of 28 nursery farmers in Subang reported R/C of 2.15 for small-seed production over 4–5 week cycles and the enterprise, product and cycle length differ from the 40–50 g juveniles (Martono et al., 2024). Further, The studies presented here do not provide a directly comparable financial benchmark for a nursery stage producing 40–50 g juveniles, which highlights the need for nursery-specific cost records. Comparisons across farming systems are also subject to caution. Mansour et al. (2021) studied growth, productivity and financial revenue of monoculture and different proportions of striped catfish-Nile tilapia polyculture. These comparisons are relevant to a different management question than the direct grow-out versus nursery-integrated grow-out comparison.

The Kota Karang summaries showed larger increases in revenue (13.21–28.00%) than the Tangkit Baru summaries (0–4.06%). A resource-based accounting approach, recording the quantities and costs of land, water, energy, labour, management and capital (Kumar et al., 2023), would allow future evaluations to separate an accounting margin from a fuller economic return, and to test whether feed and fish prices shown to be significant determinants of profitability (Saha et al., 2022) explain some of the observed variation.

5. Practical implications

A practical next step is to have a standardised pond-cycle ledger with separate sections for nursery and grow-out recording pond and group identifiers, stocking and harvest dates, fish numbers, mean weights, feed purchases and use, water-management expenditures and sales, with quantities and unit prices recorded separately so that changes in physical performance can be distinguished from changes in input or output prices. It would also allow comparisons per kilogram harvested, per surviving juvenile and per unit time of pond occupation. The water-supply planning before stocking, the joint monitoring of growth and survival, and the cycle-specific cost recording identified as priorities to improve future monitoring.

CONCLUSION

Three groups met the 40–50 g/fish target across six historical nursery records, one exceeded it, and two fell below it under the highest recorded density and water-supply constraints, without establishing causation. Separate grow-out accounts showed positive margins and higher nominal revenue-to-cost ratios post-adoption (1.28–1.35), but do not show nursery-specific profitability or causal benefits. Small, aggregated, unlinked datasets, different observation periods, lack of management and water-quality data, unadjusted inflation, and no evidence of sustained adoption constrain interpretation. Future evaluations should link stocking to pond volume and seasonal water availability, monitor repeated cycles, distinguish nursery and grow-out accounts, and use consistent pond and business identifiers.

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