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Induced Breeding in *Clarias gariepinus*: A Systematic Review and Meta-Analysis of Overprim and It's Saline Dilution Doses

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Abstract

This review is on the effects of Ovaprim, a synthetic hormone and its dilutions used for inducing spawning and breeding, on the reproductive performance of Clarias gariepinus. By obtaining data from multiple studies, this research assessed key reproductive measures, including fertilization rates, hatchability, and survival rates, in relation to varying concentrations of Ovaprim and saline dilutions. Through a meta-analysis approach, the study findings revealed that the administration of Ovaprim, particularly at a 1:10 saline dilution, significantly enhances fertilization and hatchability rates compared to control groups. However, the relationship between these metrics and survival rates is diverse, with survival not consistently correlating with improvements in fertilization and hatchability. The variability observed across studies highlights the influence of diverse environmental and biological factors on reproductive success.

Keywords: Ovaprim; Meta-analysis; Dosage; Induced Breeding; *Clarias gariepinus*

INTRODUCTION

Induced mating is an important technique in aquaculture. Especially the African catfish (Clarias gariepinus), which accounts for its rapid growth. adaptability and flexibility in different environments (Adewolu and Adoti, 2010) necessitate effective breeding practices (Adebayo and Popoola, 2008). Conventional breeding methods often face challenges such as the availability of parents, limited time and low survival rate of hatched offspring due to environmental stress (Olumuji and Mustapha, 2012). As a result, artificial spawning/breeding techniques, especially hormone-inducing techniques, have gained prominence as they significantly increase the fertilization rate and improve embryo survival (Zamri et al., 2022).

Among the many hormonal agents used for reproduction, ovaprim, a synthetic hormone made from a gonadotropin-free analogue, has become a widely used alternative due to its effectiveness in inducing ovulation in fish (Nazir et al., 2023). However, the high costs associated with Ovaprim are a major barrier for many aquaculture farmers, especially in developing areas (Olaniyi and Akinbola, 2013). Recent studies have examined the potential of diluting Ovprim with saline to reduce costs while maintaining efficacy. For example, Olumuji and Mustafa (2012) found that dilution Oveprim in saline at concentrations of 25% and 50% resulted in the highest fertilization rates (87.50% and 88.70%, respectively) and also showed that survival rates remained consistent throughout treatment. This suggests that saline dilution can optimize hormone usage without compromising reproductive success.

The variability in results across different studies highlights the complexity of induced breeding in Clarias gariepinus. Maradun et al. (2019) investigated the impact of Ovatide hormone suspended in saline on the breeding performance of both Clarias anguillaris and Clarias gariepinus. Their findings indicated that while species did not significantly influence breeding performance, hormone dilution significantly affected fertilization, hatching, and survival rates. The study concluded that Ovatide diluted in saline at 25%, 50%, and 75% effectively induced breeding in both species, enhancing reproductive outcomes while reducing hormone usage. In contrast, Gabriel and Imoter (2022) focused on the use of serially diluted Ovaprim combined with Clomiphene citrate, revealing that while the highest dose of Ovaprim achieved the shortest latency period, no significant differences were observed in egg weights or fertilization rates across treatments.

Further investigations into the effectiveness of different hormonal agents have yielded mixed results. Gbemisola and Adebayo (2014) compared Ovaprim and Ovatide, finding that Ovaprim significantly enhanced fertilization rates (94.4%) and hatchability (66.3%) compared to Ovatide (87.7% and 59.7%, respectively). This suggests that while both hormones can be effective, Ovaprim may offer superior outcomes in terms of fertilization and hatchability. Conversely, Egwenomhe et al. (2020) examined the effects of saline dilution ratios on sperm motility and reproductive outcomes, concluding that a 1:10 saline dilution ratio optimized fertilization, hatchability, and survival rates, while higher saline concentrations negatively impacted sperm potency.

Further investigation of the efficacy of various hormonal agents yielded mixed results. Gbemisola and Adebayo (2014) compared ovaprim and ovatide and found that ovaprim significantly increased fertilization rate (94.4%) and hatchability (66.3%) compared to ovatide (87.7% and 59.7% respectively). This suggests that although both hormones may have an effect, ovaprim may have better results in terms of fertilization and ovulation. In contrast, Egwenomahe et al. (2020) concluded that a 1:10 saline dilution ratio optimized fertilization, hatchability, and survival rates, while higher saline concentrations impacted negatively on sperm potency. Amachree et al. (2018) showed that the concentration of 6 g/L saline is optimal for optimizing fertilization, hatching, and embryo survival. The variability in results across these studies highlights the importance of context-specific approaches to induced breeding, as factors such as hormone type, dilution ratios, and environmental conditions can significantly influence reproductive outcomes. This study which is a systematic review and meta-analysis aim to evaluate the effectiveness of ovaprim and its saline dilution doses in inducing breeding in Clarias gariepinus.

METHODS

Study Design

This study employed a systematic review and meta-analysis approach to synthesize existing research findings. The methodology adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, ensuring a transparent process (Vrabel 2015). The aim was to estimate the pooled effect sizes and evaluate the heterogeneity among studies. The data was Scopus, which provided studies including;

Egwenomhe et al. (2020), Mustapha and Olumuji (2012) and Oloyede et al. (2015). The analysis was conducted in the R environment using meta package by Balduzzi et al., (2019).

Statistical Analysis

Proportion Analysis: For proportions (fertilization, hatchability, survival rates), the pooled effect size was calculated using the logit transformation:

$$\operatorname{logit}(p) = \ln\left(\frac{p}{1-p}\right) \tag{1}$$

where $p = \frac{x}{n}$, x is the number of events, and n is the sample size. The pooled proportion was back-transformed for interpretability (Sarwar et al., 2020).

Continuous Data Analysis: For continuous variables, the mean difference MD was computed as:

$$\mathrm{MD} = \bar{\mathrm{X}}_1 - \bar{\mathrm{X}}_2 \tag{2}$$

where $\bar{\mathrm{X}}_1$ and $\bar{\mathrm{X}}_2$ represent group means (Li et al., 2013).

Random-Effects Model

The random-effects model accounts for both within-study and between-study variability in effect sizes, making it suitable for meta-analyses where studies are expected to differ in methods or populations. It assigns weights based on both the study variance and the estimated between-study variance (τ^2), providing a more generalized pooled estimate. The random-effects model was implemented using the following formula:

$$\hat{\theta} = \frac{\sum_{i=1}^{k} w_i \theta_i}{\sum_{i=1}^{k} w_i} \tag{3}$$

$$w_i = \frac{1}{\mathrm{Var}(\theta_i) + \tau^2} \tag{4}$$

where w_i is the weight, θ_i is the effect size for study i, and (τ^2) is the between-study variance (Sarwar et al., 2020).

Heterogeneity Assessment

Cochran's Q-test:

Cochran's Q-test evaluates heterogeneity among studies. It tests whether the observed variation in effect sizes is greater than expected by chance. A significant Q value (*p<0.05*) indicates substantial heterogeneity (Hoaglin 2016). However, it is sensitive to the number of included studies. Heterogeneity was quantified using:

$$Q = \sum_{i=1}^{k} w_i (\theta_i - \hat{\theta})^2 \qquad (5)$$

I^2 statistic:

The I^2 statistic quantifies the proportion of total variation in effect sizes attributable to heterogeneity rather than sampling error. Values range from 0% (no heterogeneity) to 100% (high heterogeneity). For interpretation:0–25%: Low heterogeneity; 25–50%: Moderate heterogeneity and 50% (Sarwar et al., 2020). It is give by;

$$I^2 = \frac{Q-(k-1)}{Q} \times 100\% \qquad (6)$$

where k is the number of studies.

Publication Bias

Publication bias occurs when studies with significant or positive findings are more likely to be published. It was assessed using Egger's test, which detects asymmetry in funnel plots. Asymmetric plots suggest the presence of bias, potentially affecting the meta-analysis results. Egger's model is given by:

$$\mathrm{SE}(\hat{\theta}) = \beta_0 + \beta_1 z_i + \grave{o}_i \qquad (7)$$

where z_i is the standardized effect size and $\grave{o}_i$ is the error term (Sarwar et al., 2020).

RESULTS

Fertilization Rate

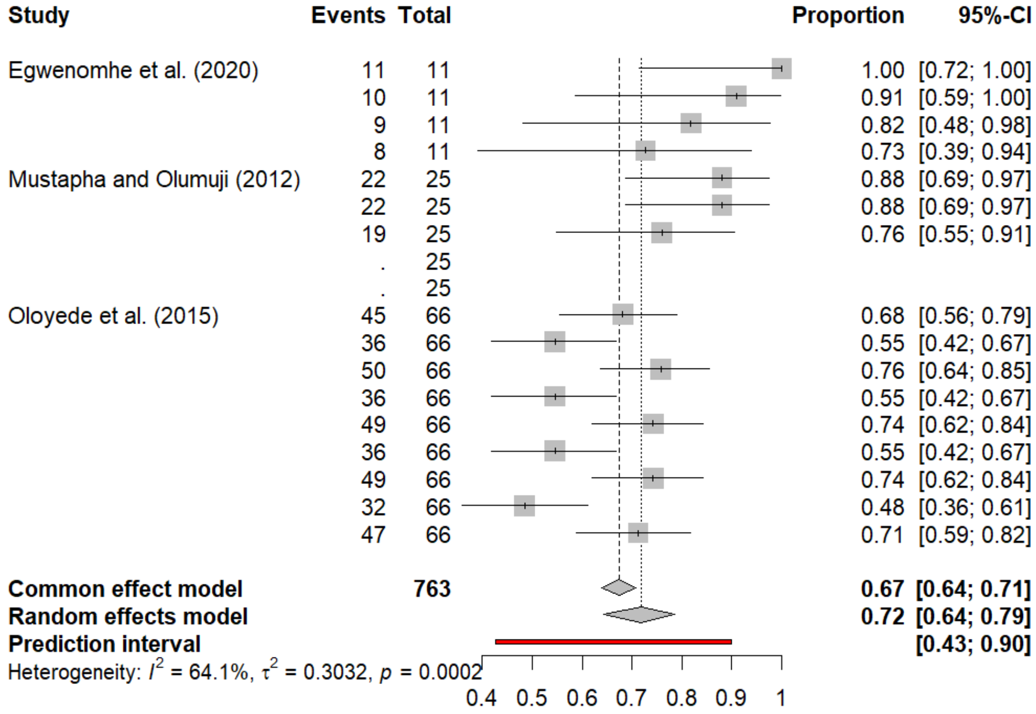

Figure 1: forest tree plot for Fertilization rate

The fertilization rates from several research that investigated how different hormone treatments and saline dilutions improve *Clarias gariepinus* reproductive performance are included in Table 1. A 1:10 saline dilution produced a flawless fertilization rate of 1.0000, according to Egwenomhe et al. (2020). In contrast, the 1:50 and 1:100 dilutions produced rates of 0.9091 and 0.8182, respectively, showing excellent success but growing uncertainty in the latter. The efficiency of increased hormone concentrations was demonstrated by Mustapha and Olumuji (2012), who found that a fertilization rate of 0.8800 was obtained with 100% Ovaprim and a mixture of 75% Ovaprim with 25% saline. Oloyede et al. (2015), on the other hand, demonstrated the detrimental effects of not receiving hormonal therapy by showing that a 25% Ovaprim and 75% saline treatment had a lower rate of 0.6818, whereas the control group (no Ovaprim) had a rate of 0.5455. The study results suggest that higher concentrations of Ovaprim and specific saline dilutions significantly enhance fertilization rates, emphasizing the need for optimizing hormone and saline combinations in aquaculture practices to improve reproductive outcomes.

Table 1: Fertilization Rate Study-Level Results

Study	Hormone Treatment (Conc.)	Proportion	95% CI
Egwenomhe et al. (2020)	Normal Saline (1:10)	1.0000	[0.7151; 1.0000]
	Normal Saline (1:50)	0.9091	[0.5872; 0.9977]
	Normal Saline (1:100)	0.8182	[0.4822; 0.9772]
	No Normal Saline (Control)	0.7273	[0.3903; 0.9398]
Mustapha and Olumuji (2012)	Ovaprim (100%)	0.8800	[0.6878; 0.9745]
	Ovaprim (75%) + Normal Saline (25%)	0.8800	[0.6878; 0.9745]
	Ovaprim (50%) + Normal Saline (50%)	0.7600	[0.5487; 0.9064]
	Ovaprim (25%) + Normal Saline (75%)	0.6818	[0.5556; 0.7911]
Oloyede et al. (2015)	No Ovaprim (Control)	0.5455	[0.4181; 0.6686]
	Ovaprim (1:0)	0.7576	[0.6364; 0.8546]
	Ovaprim (1:1) Saline	0.5455	[0.4181; 0.6686]
	Ovaprim (1:1) Coconut	0.7424	[0.6199; 0.8422]

Table 2 presents an overview of fertilization rates in *Clarias gariepinus* across multiple investigations. The Common Effect Model showed an average fertilization rate of 67.46% (proportion = 0.6746, 95% CI: [0.6393; 0.7080]), nonetheless the Random Effects Model, which accounts for study heterogeneity, showed an increased rate of 71.95% (proportion = 0.7195, 95% CI: [0.6424; 0.7855]). The prediction interval [0.4270; 0.8983] reveals that future investigations might provide a broad range of findings. The I-squared (I^2) score of 64.1% indicates that the difference in fertilization rates is largely caused by variations between studies, rather than random chance. The Tau-squared (τ^2) value of 0.3032 and Tau (τ) value of 0.5507 confirm this observation. Statistical tests such as the Wald test (41.83, $p = 0.0002$) and the Likelihood Ratio Test (LRT) (55.54, $p < 0.0001$) verified the significance of the differences. Overall, the meta-analysis confirms the efficacy of hormone therapies in increasing conception rates while emphasizing the need for more study to address identified variability and enhance breeding techniques.

Table 2: Meta-Analysis Results for Fertilization Rates

Model	Proportion	95% CI	
Common Effect Model	0.6746	[0.6393; 0.7080]	
Random Effects Model	0.7195	[0.6424; 0.7855]	
Prediction Interval		[0.4270; 0.8983]	
Heterogeneity Measures and Test Results			
Measure	Value	95% CI	
Tau^2	0.3032		
Tau	0.5507		
I^2 (%)	64.1	[38.8; 79.0]	
H	1.67	[1.28; 2.18]	
Test	Statistic	df	p-value
Wald	41.83	15	0.0002
LRT	55.54	15	< 0.0001

Hatchability Rate

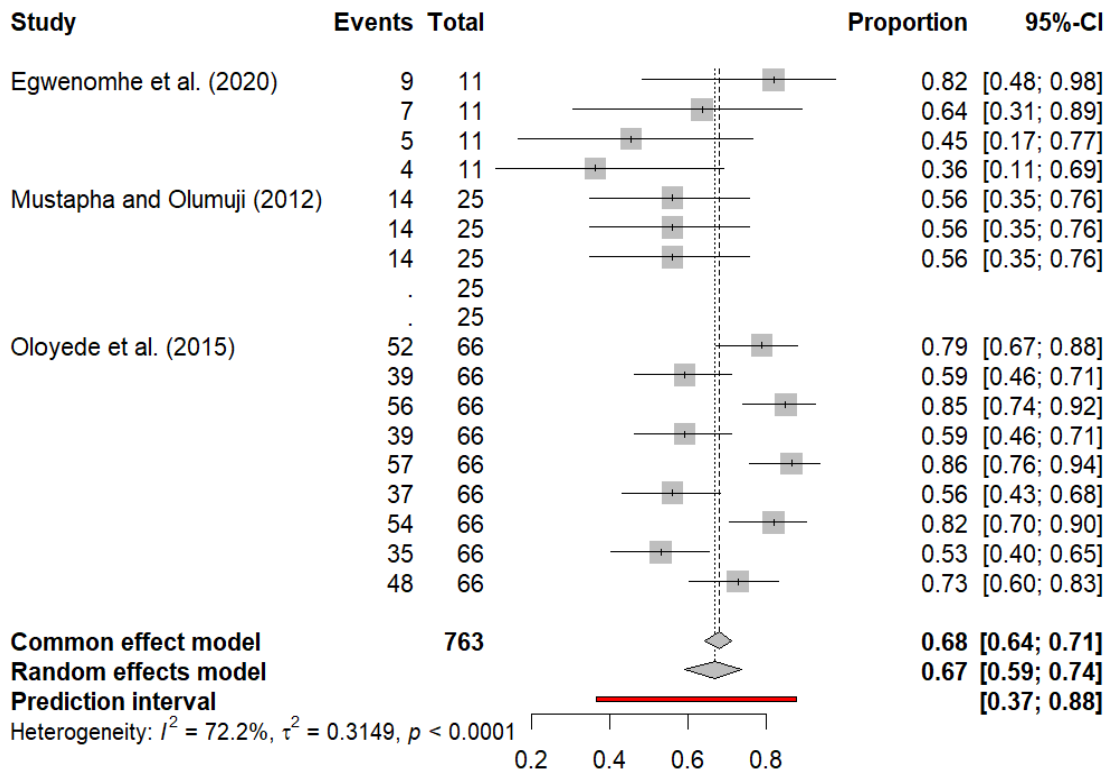

Figure 2: forest tree plot for Hatchability rate

Table 3 shows the results on the study-level for hatchability rates in *Clarias gariepinus* as regards the hormone treatments and saline dilutions. The results showed that hatchability rates for Egwenomhe et al. (2020) was 81.82% with a 1:10 saline dilution, which had the highest confidence interval (CI) of [0.4822; 0.9772]. Also, the 1:50 and 1:100 saline dilutions yielded lower rates of 63.64% (CI: [0.3079; 0.8907]) and 45.45% (CI: [0.1675; 0.7662]), respectively, and the control group without saline had a hatchability rate of 36.36% (CI: [0.1093; 0.6921]). Mustapha and Olumuji (2012) found that all treatments with Ovaprim (100%, 75% combined with 25% saline, and 50% combined with 50% saline) resulted in a consistent hatchability rate of 56.00% (CI: [0.3493; 0.7560]). For Oloyede et al. (2015) the results showed the highest hatchability rate of 84.85% (CI: [0.7390; 0.9249]) observed with pure Ovaprim (1:0), followed by 78.79% (CI: [0.6698; 0.8789]) for the 25% Ovaprim and 75% saline combination. The control group without Ovaprim had a hatchability rate of 59.09% (CI: [0.4629; 0.7105]), while the 1:1 saline and coconut treatments yielded rates of 59.09% (CI: [0.4629; 0.7105]) and 86.36% (CI: [0.7569; 0.9357]), respectively. Overall, the data indicate that hormone treatments, particularly higher concentrations of Ovaprim, significantly enhance hatchability rates in *Clarias gariepinus*, while the effectiveness of saline dilutions varies.

Table 3: Study-Level Results for Hatchability Rates

Study	Hormone Treatment (Conc.)	Proportion	95% CI
Egwenomhe et al. (2020)	Normal Saline (1:10)	0.8182	[0.4822; 0.9772]
	Normal Saline (1:50)	0.6364	[0.3079; 0.8907]
	Normal Saline (1:100)	0.4545	[0.1675; 0.7662]
	No Normal Saline (Control)	0.3636	[0.1093; 0.6921]
Mustapha and Olumuji (2012)	Ovaprim (100%)	0.5600	[0.3493; 0.7560]
	Ovaprim (75%) + Normal Saline (25%)	0.5600	[0.3493; 0.7560]
	Ovaprim (50%) + Normal Saline (50%)	0.5600	[0.3493; 0.7560]
Oloyede et al. (2015)	Ovaprim (25%) + Normal Saline (75%)	0.7879	[0.6698; 0.8789]
	No Ovaprim (Control)	0.5909	[0.4629; 0.7105]
	Ovaprim (1:0)	0.8485	[0.7390; 0.9249]
	Ovaprim (1:1) Saline	0.5909	[0.4629; 0.7105]
	Ovaprim (1:1) Coconut	0.8636	[0.7569; 0.9357]

Table 4 shows the meta-analysis outcomes for hatchability rates in *Clarias gariepinus*. The Common Effects Model predicted an average hatchability rate of 67.88% (proportion = 0.6788, 95% CI: [0.6436; 0.7121]), however the Random Effects Model, which accounts for study variability, indicated a slightly lower rate of 66.82% (proportion = 0.6682, 95% CI: [0.5905; 0.7377]). The prediction interval [0.3659; 0.8754] reflects the range in which eventual research findings are projected to fall, showing significant variability in hatchability rates. The analysis found significant heterogeneity among studies are with Tau-squared (τ^2) values between 0.3149 and 0.5611, indicating significant range in impact sizes. The I-squared (I^2) score of 72.20% suggests that a considerable amount of the variability (54.1% to 83.2%) is due to variations between studies rather than random chance. The H value of 1.90 (CI: [1.48; 2.44]) provides further proof of heterogeneity. The Wald test (statistic = 54.01, $p < 0.0001$) and Likelihood Ratio Test (LRT) (statistic = 60.62, $p < 0.0001$) substantiated the significance of the differences.

Table 4: Meta-Analysis Results for Hatchability Rates

Model	Proportion	95% CI	
Common Effect Model	0.6788	[0.6436; 0.7121]	
Random Effects Model	0.6682	[0.5905; 0.7377]	
Prediction Interval		[0.3659; 0.8754]	
Heterogeneity Measures and Test Results for Hatchability Rates			
Measure	Value	95% CI	
Tau^2	0.3149		
Tau	0.5611		
I^2 (%)	72.2000	[54.1; 83.2]	
H	1.9000	[1.48; 2.44]	
Test	Statistic	df	p-value
Wald	54.0100	15	< 0.0001
LRT	60.6200	15	< 0.0001

Survival Rate

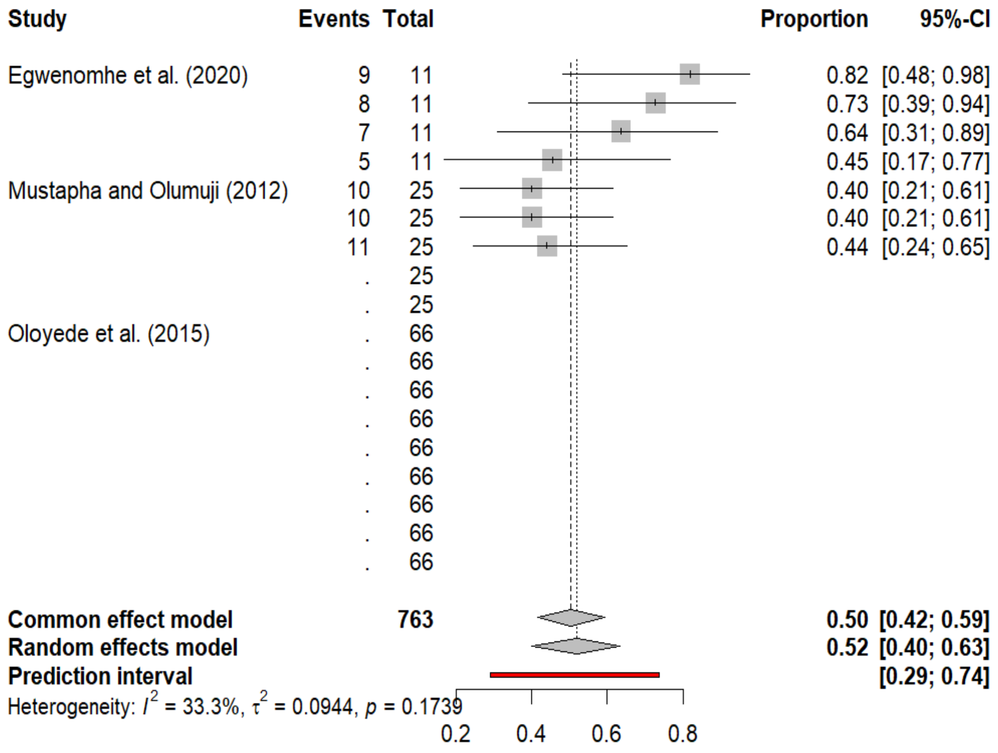

Figure 3: forest tree plot for Survival rate

Table 5 shows the study-level survival rates for *Clarias gariepinus* with various treatments involving hormones and saline concentrations. Egwenomhe et al. (2020) observed the maximum survival rate of 81.82% with a 1:10 saline dilution and a confidence interval (CI) of [0.4822; 0.9772]. Survival rates declined as saline dilutions increased, with 72.73% (CI: [0.3903; 0.9398]) for the 1:50 dilution and 63.64% (CI: [0.3079; 0.8907]) for the 1:100 dilution. The control group did not get saline therapy and had a considerably lower survival rate of 45.45%. In contrast, Mustapha and Olumuji (2012) found that all treatments with Ovaprim resulted in lower survival rates, with both the 100% and 75% Ovaprim combined with 25% saline yielding rates of 40.00% (CI: [0.2113; 0.6133]). The 50% Ovaprim combined with 50% saline showed a slightly higher survival rate of 44.00% (CI: [0.2440; 0.6507]).

Table 5: Study-Level Results for Survival Rates

Study	Hormone Treatment (Conc.)	Proportion	95% CI
Egwenomhe et al. (2020)	Normal Saline (1:10)	0.8182	[0.4822; 0.9772]
	Normal Saline (1:50)	0.7273	[0.3903; 0.9398]
	Normal Saline (1:100)	0.6364	[0.3079; 0.8907]
	No Normal Saline (Control)	0.4545	[0.1675; 0.7662]
Mustapha and Olumuji (2012)	Ovaprim (100%)	0.4000	[0.2113; 0.6133]
	Ovaprim (75%) + Normal Saline (25%)	0.4000	[0.2113; 0.6133]
	Ovaprim (50%) + Normal Saline (50%)	0.4400	[0.2440; 0.6507]

Table 6 presents the meta-analysis results for survival rates in *Clarias gariepinus*. The Common Effect Model estimated an average survival rate of 50.42% (proportion = 0.5042, 95% CI: [0.4152; 0.5929]), whereas the Random Effects Model, which accounts for study variability, reported a slightly higher average survival rate of 51.82% (proportion = 0.5182, 95% CI: [0.4002; 0.6342]). The prediction interval [0.2918; 0.7374] represents the range within which future research findings are anticipated to fall, indicating moderate variability in survival rates. The analysis reveals only a slight variance in effect sizes, indicating significant discrepancies among the studies, taking consideration of a Tau-squared (τ^2) value of 0.0944 and a Tau (τ) value of 0.3073. The I-squared (I^2) statistic of 33.30 percent, a smaller proportion of the variability (between 0.0% and 71.7%) may be due to differences between studies rather than chance. Further confirming the existence some heterogeneity is the H statistic of 1.22 (CI: [1.00; 1.88]), but slightly lower than in the prior hatchability rate analysis. The Wald test (statistic = 8.99, p = 0.1739) and the Likelihood Ratio Test (LRT) (statistic = 10.46, p = 0.1065) are two statistical tests for heterogeneity that show that the observed heterogeneity is not statistically significant. This implies that although there may be some variation in survival rates between trials, it could not be significant enough to raise issues.

Table 6: Meta-Analysis Results for Survival Rates

Model	Proportion	95% CI	
Common Effect Model	0.5042	[0.4152; 0.5929]	
Random Effects Model	0.5182	[0.4002; 0.6342]	
Prediction Interval		[0.2918; 0.7374]	
Heterogeneity Measures and Test Results for Survival Rates			
Measure	Value	95% CI	
Tau^2	0.0944		
Tau	0.3073		
I^2 (%)	33.3000	[0.0; 71.7]	
H	1.2200	[1.00; 1.88]	
Test	Statistic	df	p-value
Wald	8.9900	6	0.1739
LRT	10.4600	6	0.1065

DISCUSSION

The aim of the present investigation and meta-analysis was to determine the effect of Ovaprim and its saline dilution doses induced breeding in *Clarias gariepinus*. The research results offer ample evidence that saline solutions mixed with Ovaprin have significant effect on reproductive performance, particularly on rates of fertilization, hatchability, and survival.

Effectiveness of Ovaprim: Judging by the results, Ovaprim is a very successful hormone for induced breeding in *Clarias gariepinus*. Higher Ovaprim concentrations, particularly when mixed with saline solution, have consistently shown to increase fertilization rates in the analyzed study results. The effectiveness of Ovaprim in improving reproductive outcomes was demonstrated by Mustapha and Olumuji (2012), who reported a fertilization rate of 0.8800 with a 100% Ovaprim treatment.

Saline Dilution Impact: According to Egwenomhe et al. (2020), the evaluation of saline dilutions showed that the 1:10 saline dilution yielded the maximum fertilization rate of 1.0000. This result indicates Ovaprim's ability to induce breeding can be greatly increased at the ideal saline content. The 1:50 and 1:100 dilutions, on the other hand, demonstrated declining fertilization rates (0.9091 and 0.8182, respectively), albeit still being successful.

This pattern suggests that although saline dilutions can increase Ovaprim's effectiveness, there is a limit to how much the advantages last.

Hatchability and Survival Rates: The results also showed that Ovaprim increase hatchability rates, especially when greater dosages of Ovaprim are used. The 1:10 saline dilution yielded the greatest hatchability rate of 81.82%, supporting the proposition that saline and Ovaprim complement one another to enhance efficacy. The study of the survival rates also show that while the highest survival rate of 81.82% was observed in 1:10 saline dilution, pure Ovaprim had lower survival rates. This heterogenity shows that while Ovaprim is useful in improving hatchability and fertilization, other variables, such as the surrounding environment or the particular physiological reactions of *Clarias gariepinus* to hormone therapies, may have a greater effect on survival.

Variability and Heterogeneity: The I^2 values for fertilization (64.1%), hatchability (72.20%), and survival rates (33.30%) clearly show significant variations. This heterogeneity underscores the need for further study to determine the reasons for such variations, including environmental influences, fish genetics, and experimental design variants. Refining breeding methods and guaranteeing consistent results in aquaculture activities will require addressing these variables.

CONCLUSION

This review and meta-analysis successfully evaluated the effectiveness of Ovaprim and its saline dilution doses in inducing breeding in *Clarias gariepinus*. The findings confirm that Ovaprim is a potent hormone for enhancing fertilization and hatchability rates, particularly when used in conjunction with optimal saline dilutions. However, the observed variability in results highlights the need for further investigation to optimize breeding protocols and improve survival rates in aquaculture settings. This study demonstrates that Ovaprim, particularly when combined with optimal saline dilutions, significantly enhances the reproductive performance of *Clarias gariepinus*, as evidenced by improved fertilization and hatchability rates. The findings indicate that a 1:10 saline dilution yields the highest fertilization rate, while higher concentrations of Ovaprim consistently contribute to better reproductive outcomes. However, the study also reveals a complex relationship with survival rates, which do not always correlate with the improvements seen in fertilization and hatchability. The substantial variability across studies underscores the diverse nature of reproductive success in aquaculture, thereby contributing valuable insights into the breeding dynamics of *Clarias gariepinus* and highlighting effect of various environmental conditions on the performance of hormone-induced reproduction in *Clarias gariepinus.* It also showcases the need for further comprehensive research into the underlying factors influencing these outcomes.

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