



Anesthetic Efficacy and Safety Margins of Crude Leaf Extract from the Ordeal Tree (*Erythrophleum suaveolens*) on African Catfish (*Clarias gariepinus*) Juveniles

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Abstract: The search for safe, affordable, and environmentally friendly anaesthetic agents has intensified due to increasing concerns regarding the use of synthetic chemicals in aquaculture. This study evaluated the anaesthetic efficacy of aqueous crude leaf extract of *Erythrophleum suaveolens* on juvenile *Clarias gariepinus*, with particular emphasis on induction and recovery times, behavioural responses, survival, water quality, and haematological changes. Healthy juveniles of *C. gariepinus* were randomly assigned to six treatments consisting of a control (0.00 g L⁻¹) and five concentrations of aqueous crude leaf extract (2.00, 3.00, 4.00, 5.00, and 6.00 g L⁻¹). Fish were observed for behavioural responses, induction time, recovery time, and survival, while water quality parameters (dissolved oxygen, temperature, pH, and free carbon dioxide) and haematological indices were determined using standard laboratory procedures. Data were analysed using one-way analysis of variance (ANOVA) at a 5% level of significance. The results showed that dissolved oxygen and pH decreased significantly ($P < 0.05$) with increasing extract concentration, whereas free carbon dioxide increased significantly. Water temperature remained relatively stable and did not differ significantly ($P > 0.05$) among treatments. Induction time decreased progressively with increasing extract concentration, while recovery time increased from approximately 1 to 5 minutes. Behavioural responses, including reduced swimming activity, loss of equilibrium, and complete anaesthesia, were concentration dependent. The highest mortality (100%) was recorded at 2.00 g L⁻¹ under the experimental conditions because of prolonged induction time and extended exposure. Haematological analysis revealed significant changes ($P < 0.05$) in white blood cell count, mean corpuscular volume, and platelet distribution width, whereas red blood cell count, haemoglobin concentration, haematocrit, mean corpuscular haemoglobin concentration, platelet count, and mean platelet volume were not significantly affected. The study demonstrates that aqueous crude leaf extract of *Erythrophleum suaveolens* possesses anaesthetic properties capable of inducing anaesthesia in juvenile *Clarias gariepinus*. However, the observed mortality at lower concentrations indicates that careful optimisation of exposure time and dosage is necessary before practical application. Further studies involving phytochemical characterisation, toxicity evaluation, histopathological assessment, and residue analysis are recommended to establish the safety and suitability of the extract as a botanical anaesthetic for sustainable aquaculture.

Keywords: *Clarias gariepinus*; *Erythrophleum suaveolens*; botanical anaesthetic; aquaculture; induction time; recovery time; haematology; water quality.

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1. Introduction

Fish handling and routine aquaculture operations such as grading, transportation, vaccination, biometric measurements, artificial propagation, tagging, and harvesting expose fish to considerable physiological stress. Excessive stress disrupts homeostasis, elevates cortisol secretion, impairs immune function, alters respiration, and increases susceptibility to disease and mortality. Consequently, the use of anaesthetic agents has become an essential component of modern aquaculture because they reduce struggling, minimize tissue damage, improve fish welfare, and enhance survival during routine management procedures (Fayaz et al., 2026; Jia et al., 2025). An ideal fish anaesthetic should induce rapid sedation, provide sufficient muscle relaxation, permit quick recovery without residual physiological impairment, exhibit a wide safety margin, be non-toxic to fish handlers and consumers, leave negligible tissue residues, be environmentally safe, and remain economically affordable. Conventional anaesthetics such as tricaine methane sulfonate (MS-222), benzocaine, 2-phenoxyethanol, metomidate, quinaldine, and eugenol have been extensively used in commercial aquaculture. However, concerns regarding residue accumulation, withdrawal periods, environmental contamination, regulatory restrictions, and relatively high costs have stimulated increasing interest in plant-derived alternatives (Fayaz et al., 2026; Jia et al., 2025). During the past decade, research has increasingly shifted from synthetic anaesthetics to botanical products because of their biodegradability, lower toxicity, availability, and compatibility with sustainable aquaculture. Essential oils and plant extracts rich in eugenol, thymol, linalool, menthol, and other bioactive phytochemicals have demonstrated promising sedative and anaesthetic properties in several cultured fish species. Recent bibliometric analyses further indicate that fish welfare and environmentally friendly anaesthetic agents have become major research priorities in global aquaculture (Minaz & Félix, 2025). Plant-derived anaesthetics reduce behavioural stress, suppress excessive metabolic activity, decrease oxygen consumption during transport, and shorten handling time while maintaining satisfactory induction and recovery periods. In addition to improving operational efficiency, many medicinal plants possess antioxidant, antimicrobial, anti-inflammatory, and immunostimulatory properties that may contribute to improved fish health during stressful husbandry procedures (Fayaz et al., 2026).

Erythrophleum suaveolens (Guill. & Perr.) Brenan, commonly known as the ordeal tree or sasswood, is an indigenous African medicinal plant widely distributed across tropical forests. The species contains numerous biologically active phytochemicals including alkaloids, flavonoids, tannins, saponins, terpenoids, glycosides, and phenolic compounds that exhibit diverse pharmacological

activities. Although the plant has been investigated for antimicrobial, pesticidal, and medicinal applications, limited information exists regarding its suitability as a botanical anaesthetic for cultured fish. Determining its efficacy and safety could provide an inexpensive and locally available alternative to imported commercial anaesthetic agents.

The African catfish (*Clarias gariepinus*) is one of the most economically important freshwater fish species cultured throughout Africa because of its rapid growth rate, high feed conversion efficiency, resistance to disease, tolerance of poor water quality, air-breathing capability, and strong consumer acceptance. These characteristics make the species an excellent experimental model for evaluating new anaesthetic agents under aquaculture conditions. Nevertheless, because *C. gariepinus* frequently undergoes intensive handling during hatchery and grow-out operations, identifying safe, effective, and affordable anaesthetic agents remains an important research priority. Despite growing interest in plant-based anaesthetics, information regarding the anaesthetic efficacy, safety margins, behavioral responses, and haematological effects of *E. suaveolens* leaf extract in *Clarias gariepinus* juveniles remains scarce. This study therefore evaluated the anaesthetic efficacy of aqueous crude leaf extract of *E. suaveolens* by determining induction and recovery characteristics, behavioural responses, survival, water quality changes, and haematological responses in juvenile African catfish. The findings are expected to contribute to the development of sustainable, affordable, and environmentally friendly botanical anaesthetics for aquaculture.

2. Materials and Methods

2.1 Study Area and Collection of Plant Materials

Fresh leaves of *Erythrophleum suaveolens* (Guill. & Perr.) Brenan were collected from Gindiri, Mangu Local Government Area, Plateau State, Nigeria. Botanical identification and authentication were conducted by a qualified taxonomist, and a voucher specimen was deposited in the institutional herbarium for future reference. The collected leaves were washed thoroughly with distilled water to remove adhering dust and debris before being shade-dried at ambient laboratory temperature (25–28 °C) until a constant weight was attained. The dried leaves were pulverised using a laboratory grinder and sieved through a 0.5-mm mesh to obtain a uniform powder suitable for extraction (Félix et al., 2023; Fayaz et al., 2026).

2.2 Preparation of Aqueous Leaf Extract

The powdered leaves were weighed according to the desired experimental concentrations and soaked in distilled water at a ratio of 1:10 (w/v) for 24 h at room temperature with intermittent stirring to facilitate extraction of water-soluble phytochemicals. The mixture was filtered through double-

layer muslin cloth followed by Whatman No. 1 filter paper to obtain a clear aqueous extract. Fresh extract was prepared immediately before each experiment to minimise degradation of bioactive constituents (Minaz & Félix, 2026).

2.3 Experimental Fish and Acclimation

Healthy juveniles of *Clarias gariepinus* were obtained from the Hydrobiology and Fisheries Unit, University of Jos, Nigeria. Fish were transported in aerated containers to the laboratory and acclimated for two weeks before experimentation. During acclimation, fish were maintained in dechlorinated freshwater under continuous aeration and a natural photoperiod. They were fed a commercial diet (Coppens®) twice daily at approximately 3% body weight, and feeding was discontinued 24 h before exposure to eliminate post-prandial metabolic variation (Bronstad, 2022; Fayaz et al., 2026).

Only healthy fish showing normal swimming behaviour, feeding response, and external appearance were selected for the anaesthesia experiment.

2.4 Experimental Design

The experiment employed a completely randomised design comprising six treatment groups, including one control (0.00 g L⁻¹) and five concentrations (2.00, 3.00, 4.00, 5.00 and 6.00 g L⁻¹) of aqueous crude leaf extract of *E. suaveolens*. Each treatment was conducted in duplicate using glass aquaria (40 × 25 × 23 cm) containing 10 L of dechlorinated water stocked with ten juvenile fish. Fish were individually observed throughout exposure for behavioural responses, induction time, loss of equilibrium, total anaesthesia, recovery time, and survival (Fayaz et al., 2026; Martino et al., 2026).

2.5 Range-Finding Test

A preliminary range-finding test was conducted to determine the effective concentration range capable of inducing anaesthesia without causing immediate mortality. The definitive concentrations selected for the main experiment were based on the behavioural responses observed during the preliminary trial and published recommendations for fish anaesthetic evaluation (Fayaz et al., 2026; Köhler & Valentim, 2022).

2.6 Monitoring of Water Quality

Water quality variables including temperature, dissolved oxygen, pH, and free carbon dioxide were measured every 24 h throughout the experiment using calibrated laboratory instruments. Water-quality assessment followed the procedures described in the *Standard Methods for the Examination of Water and Wastewater* (24th ed.) published by the American Public Health Association (APHA, 2023). Water quality was maintained within acceptable limits for

juvenile African catfish to minimise confounding environmental effects (Jia et al., 2025).

2.7 Anaesthesia Procedure

Fish were transferred individually into treatment aquaria containing the appropriate concentration of aqueous *E. suaveolens* extract. Behavioural changes were continuously monitored from the onset of exposure until complete anaesthesia was achieved. Anaesthetic stages were assessed according to internationally accepted fish anaesthesia criteria, including normal swimming, light sedation, deep sedation, partial loss of equilibrium, total loss of equilibrium, complete anaesthesia (loss of reflex), and recovery (Bronstad, 2022; Fayaz et al., 2026). Immediately after reaching complete anaesthesia, each fish was transferred into clean, aerated freshwater for recovery. Induction time (time from immersion to complete anaesthesia) and recovery time (time required to regain normal swimming and equilibrium) were recorded using a digital stopwatch.

2.8 Haematological Analysis

Following recovery, blood samples were collected from representative fish in each treatment using sterile syringes containing EDTA as an anticoagulant. Standard haematological indices including red blood cell count (RBC), white blood cell count (WBC), haemoglobin concentration (Hb), packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular haemoglobin concentration (MCHC), platelet count (PLT), platelet distribution width (PDW), and mean platelet volume (MPV) were analysed using standard laboratory procedures (Fayaz et al., 2026; Jia et al., 2025).

3.9 Statistical Analysis

Data were expressed as mean ± standard deviation. Differences among treatment means were analysed using one-way analysis of variance (ANOVA). Where significant differences were detected ($P < 0.05$), Tukey's multiple comparison test was applied to separate treatment means. Statistical analyses were performed using appropriate statistical software (Fayaz et al., 2026).

3.0 Results

3.1 Water Quality Dynamics

3.1 Water Quality Parameters During Anaesthesia of *Clarias gariepinus* Juveniles

The mean water quality parameters recorded during the anaesthesia of *Clarias gariepinus* juveniles using aqueous crude leaf extract of *Erythrophleum suaveolens* are presented in Table 4.1. Water quality assessment followed standard procedures for aquaculture toxicological and anaesthetic studies as described by the American Public Health Association (APHA, 2023).

Dissolved oxygen (DO) exhibited a concentration-dependent decline with increasing concentrations of the aqueous crude leaf extract. The highest mean DO concentration ($4.58 \pm 0.01 \text{ mg L}^{-1}$) was recorded in the control treatment (0.00 g L^{-1}). This value decreased to $2.45 \pm 0.05 \text{ mg L}^{-1}$ at 2.00 g L^{-1} , $2.10 \pm 0.10 \text{ mg L}^{-1}$ at 3.00 g L^{-1} , $1.36 \pm 0.06 \text{ mg L}^{-1}$ at 4.00 g L^{-1} , $1.10 \pm 0.10 \text{ mg L}^{-1}$ at 5.00 g L^{-1} , and reached the lowest value ($1.05 \pm 0.05 \text{ mg L}^{-1}$) at 6.00 g L^{-1} . Statistical analysis revealed significant differences ($P < 0.05$) in dissolved oxygen among all treatment groups compared with the control.

Water temperature showed only slight variation among treatments. The highest mean temperature ($23.15 \pm 0.15 \text{ }^{\circ}\text{C}$) was recorded at 6.00 g L^{-1} , while the lowest ($23.00 \pm 0.00 \text{ }^{\circ}\text{C}$) occurred at 3.00 g L^{-1} . No significant differences ($P > 0.05$) were observed in water temperature among the treatments and the control. Temperature control is essential in fish anaesthetic studies because it influences metabolic rate and anaesthetic uptake (Bronstad, 2022).

The pH values decreased progressively from the control to 4.00 g L^{-1} , with mean values of 6.71 ± 0.01 , 6.58 ± 0.03 , 6.55 ± 0.05 , and 6.40 ± 0.00 , respectively. A slight increase in pH was observed at 5.00 g L^{-1} (6.43 ± 0.03) and 6.00 g L^{-1} (6.42 ± 0.02) relative to the value obtained at 4.00 g L^{-1} .

Nevertheless, pH differed significantly ($P < 0.05$) between the treatment groups and the control. Maintenance of near-neutral pH is important in fish exposure studies as it influences ion balance and physiological stability (Fayaz et al., 2026).

The concentration of free carbon dioxide (CO_2) generally increased with increasing concentrations of *E. suaveolens* extract. The lowest mean CO_2 concentration ($5.10 \pm 0.10 \text{ mg L}^{-1}$) was recorded in the control treatment, whereas the highest value ($15.00 \pm 0.00 \text{ mg L}^{-1}$) occurred at 6.00 g L^{-1} . An exception was observed at 4.00 g L^{-1} , where the mean CO_2 concentration ($12.90 \pm 0.01 \text{ mg L}^{-1}$) was slightly lower than that recorded at 3.00 g L^{-1} . Statistical analysis indicated significant differences ($P < 0.05$) in free CO_2 concentrations among the treatments relative to the control. Elevated CO_2 levels in aquatic systems are commonly associated with increased organic load and respiratory activity in confined exposure media (Minaz & Félix, 2026).

Overall, increasing concentrations of aqueous crude leaf extract of *Erythrophleum suaveolens* resulted in a progressive reduction in dissolved oxygen and pH, an increase in free carbon dioxide concentration, and minimal variation in water temperature throughout the experimental period.

Table 1. Mean Water Quality Parameters of Experimental Tanks during Anaesthesia of *Clarias gariepinus* Juveniles with Different Concentrations of Aqueous Crude Leaves Extract of *Erythrophleum suaveolens*

Parameters	Concentrations (g/L)						P-values
	0.00	2.00	3.00	4.00	5.00	6.00	
Do (mg/L)	4.58 ± 0.01	2.45 ± 0.05	2.10 ± 0.10	1.36 ± 0.06	1.10 ± 0.10	1.05 ± 0.05	0.00
Temperature ($^{\circ}\text{C}$)	23.01 ± 0.01	23.01 ± 0.01	23.00 ± 0.00	23.05 ± 0.05	23.01 ± 0.01	23.15 ± 0.15	0.58
pH	6.71 ± 0.01	6.58 ± 0.03	6.55 ± 0.05	6.40 ± 0.00	6.43 ± 0.03	6.42 ± 0.02	0.00
Free CO_2 (mg/L)	5.10 ± 0.10	8.00 ± 0.00	13.05 ± 0.05	13.05 ± 0.05	12.90 ± 0.01	15.00 ± 0.00	0.00

3.2 Behavioural Responses, Induction, Recovery, and Survival of *Clarias gariepinus* Juveniles Exposed to Aqueous Crude Leaf Extract of *Erythrophleum suaveolens*

The average behavioural responses, induction time, recovery time, and survival rate of *Clarias gariepinus* juveniles exposed to aqueous crude leaf extract of *Erythrophleum suaveolens* are presented in Table 4.2. The behavioural responses of the fish varied with both the concentration of the plant extract and the duration of exposure, consistent with established patterns in fish anaesthesia studies (Fayaz et al., 2026; Minaz & Félix, 2026).

The induction time decreased progressively with increasing concentrations of the aqueous crude leaf extract. Fish exposed to the lowest concentration (2.00 g L^{-1} , Tank A)

required the longest induction time, whereas those exposed to the highest concentration (6.00 g L^{-1} , Tank E) exhibited the shortest induction time. This trend indicates that increasing extract concentration resulted in more rapid induction of anaesthesia, a response commonly reported in plant-based anaesthetic agents due to dose-dependent physiological depression of the central nervous system in fish (Félix et al., 2023; Fayaz et al., 2026).

In contrast, recovery time increased with increasing concentrations of the extract. Recovery times ranged from 1 to 5 minutes across the treatments. Fish exposed to 2.00 g L^{-1} recovered within 1 minute, while those exposed to 6.00 g L^{-1} required approximately 5 minutes to regain normal swimming behaviour and equilibrium. Similar dose-dependent recovery patterns have been reported in fish

exposed to botanical anaesthetics, where higher concentrations prolong metabolic clearance and neuromuscular recovery (Martino et al., 2026; Köhler & Valentim, 2022).

Survival varied among the treatment groups. The highest mortality rate (100%) was recorded in fish exposed to the lowest concentration (2.00 g L⁻¹). Under the experimental conditions, these fish remained exposed to the extract for a longer period due to prolonged induction time, resulting in complete mortality. Variations in survival rates following

anaesthetic exposure have been linked to stress duration and physiological imbalance in fish (Jia et al., 2025; Minaz & Félix, 2026).

Overall, the results demonstrate that the behavioural responses, induction time, recovery time, and survival of *C. gariepinus* juveniles were influenced by the concentration of the aqueous crude leaf extract of *Erythrophleum suaveolens*, consistent with findings on plant-derived anaesthetics in aquaculture systems (Fayaz et al., 2026; Félix et al., 2023).

Table 2. Mean Behaviour and Survival Rate of *Clarias gariepinus* Juveniles during Anaesthesia with Aqueous Crude Leaves Extract of *Erythrophleum suaveolens*

Tank	Conc. (g/L)	No. of Fish	Induction Time (Mins)	Recovery Time (Time)	No. of Mortality	No. of Survival	Mortality Rate (%)	Survival Rate (%)
A	2.00	10	45	1	10	0	100	0
B	3.00	10	39	3	4	6	40	60
C	4.00	10	25	3	9	1	90	10
D	5.00	10	15	4	6	4	60	40
E	6.00	10	14	5	5	5	50	50

3.3 Effect of Anaesthetic Concentrations of Aqueous Crude Leaf Extract of *Erythrophleum suaveolens* on the Haematology of *Clarias gariepinus* Juveniles

The effects of aqueous crude leaf extract of *Erythrophleum suaveolens* at concentrations of 2.00, 3.00, 4.00, 5.00, and 6.00 g L⁻¹, together with the control (0.00 g L⁻¹), on the haematological parameters of *Clarias gariepinus* juveniles are presented in Table 4.3. Haematological analysis was conducted using standard laboratory procedures for fish health assessment (D’Angelo & de Girolamo, 2022; Adeyemi et al., 2023).

The mean white blood cell (WBC) count increased progressively with increasing concentrations of the aqueous crude leaf extract from the control to 4.00 g L⁻¹, after which a decline was observed at 5.00 and 6.00 g L⁻¹. The highest mean WBC count ($99.25 \pm 0.26 \times 10^9$ L⁻¹) was recorded at 4.00 g L⁻¹, whereas the lowest value ($85.05 \pm 1.95 \times 10^9$ L⁻¹) occurred in the control group. Statistical analysis indicated significant differences ($P < 0.05$) in WBC counts between the treatment groups and the control. Platelet distribution width (PDW) also differed significantly ($P < 0.05$) among treatments, whereas the remaining haematological parameters showed no significant differences ($P > 0.05$). Similar haematological responses have been reported in fish exposed to plant-derived anaesthetics and toxic extracts (Omitoyin et al., 2021; Nwani et al., 2022).

The mean lymphocyte (LYM) count did not exhibit a concentration-dependent trend but fluctuated across the

treatments. The highest mean lymphocyte count ($73.44 \pm 43.91\%$) was recorded at 3.00 g L⁻¹, while the lowest ($16.01 \pm 0.23\%$) occurred at 2.00 g L⁻¹. No significant differences ($P > 0.05$) were observed between the treatment groups and the control, consistent with findings in fish exposed to botanical anaesthetics where lymphocyte variation is often irregular (Gabriel et al., 2020; Akinrotimi et al., 2023).

The red blood cell (RBC) count showed a general decline with increasing extract concentration, although fluctuations occurred among treatments. The highest mean RBC count ($2.35 \pm 0.05 \times 10^{12}$ L⁻¹) was recorded in the control group, while the lowest ($1.32 \pm 0.43 \times 10^{12}$ L⁻¹) occurred at 6.00 g L⁻¹. Mean RBC counts of 2.15 ± 0.10 , 1.40 ± 0.83 , 1.41 ± 0.47 , and $1.58 \pm 0.37 \times 10^{12}$ L⁻¹ were recorded at 2.00, 3.00, 4.00, and 5.00 g L⁻¹, respectively. Despite these variations, no significant differences ($P > 0.05$) were observed between the treatment groups and the control. Similar reductions in erythrocyte indices have been associated with exposure to plant-based toxicants in fish (Fafioye et al., 2021; Ololade & Oginni, 2022).

Similarly, haemoglobin concentration (HGB), haematocrit (HCT), and mean corpuscular haemoglobin concentration (MCHC) did not differ significantly ($P > 0.05$) among the treatment groups. In contrast, mean corpuscular volume (MCV) showed significant differences ($P < 0.05$) across the concentrations when compared with the control, indicating possible alterations in erythrocyte morphology under extract exposure (Eyo et al., 2024).

The platelet (PLT) count, like the lymphocyte and RBC counts, did not follow a concentration-dependent pattern. The highest mean platelet count ($137.00 \pm 28.00 \times 10^9 \text{ L}^{-1}$) was recorded at 3.00 g L^{-1} , whereas the lowest ($59.00 \pm 33.00 \times 10^9 \text{ L}^{-1}$) occurred at 6.00 g L^{-1} . No significant differences ($P > 0.05$) were observed in PLT counts or mean platelet volume (MPV) between the treatment groups and the control. However, platelet distribution width (PDW) differed significantly ($P < 0.05$) across all treatment concentrations relative to the control, suggesting stress-related hematopoietic responses (Adewolu et al., 2022).

Overall, exposure of *Clarias gariepinus* juveniles to aqueous crude leaf extract of *Erythrophleum suaveolens* resulted in significant changes in WBC, MCV, and PDW, whereas the remaining haematological parameters showed no statistically significant differences compared with the control. These findings are consistent with reported haematological alterations in fish exposed to plant-derived anaesthetic and toxic compounds (Nwani et al., 2022; Akinrotimi et al., 2023).

4. Discussion

The present study demonstrated that the anaesthetic efficacy of aqueous leaf extract of *Erythrophleum suaveolens* was concentration dependent. Increasing extract concentration significantly reduced induction time while prolonging recovery time, indicating that greater concentrations enhanced the absorption and pharmacological activity of the plant's bioactive constituents. Similar concentration-dependent responses have been consistently reported for botanical anaesthetics including clove oil, eugenol, essential oils and monoterpenes used in fish anaesthesia (Félix et al., 2023; Minaz & Félix, 2026). Recent reviews indicate that plant-derived anaesthetics generally produce faster induction but delayed recovery as concentration increases because of increased uptake across the gill epithelium and slower elimination from body tissues (Fayaz et al., 2026).

The reduction in dissolved oxygen observed with increasing concentrations of *E. suaveolens* extract may be attributed to the elevated oxygen demand associated with organic plant material and reduced gaseous exchange in the exposure medium. Although dissolved oxygen declined during exposure, water temperature remained relatively constant throughout the experiment, suggesting that temperature did not confound the observed anaesthetic responses. Maintenance of stable water temperature is important because temperature strongly influences fish metabolism, anaesthetic uptake and recovery (Bronstad, 2022). Similar observations have been reported in experimental evaluations of botanical anaesthetics in cultured fish (Jia et al., 2025).

The progressive decrease in induction time with increasing concentrations confirms that *E. suaveolens* possesses active phytochemicals capable of depressing the central nervous

system of juvenile *Clarias gariepinus*. Numerous medicinal plants containing alkaloids, flavonoids, tannins, saponins and terpenoids have demonstrated sedative activity in fish through modulation of neuronal signalling and reduction of spontaneous swimming activity (Fayaz et al., 2026). Recent studies indicate that research has increasingly shifted towards plant-derived anaesthetics because they are biodegradable, readily available and compatible with sustainable aquaculture practices (Minaz & Félix, 2026).

Recovery time increased progressively with increasing extract concentration. This finding agrees with previous studies showing that although higher anaesthetic concentrations shorten induction time, they usually prolong recovery because greater quantities of active compounds accumulate in fish tissues before elimination (Félix et al., 2023). Rapid recovery is desirable during routine aquaculture procedures; therefore, selecting the lowest concentration capable of producing effective anaesthesia remains essential for maintaining fish welfare (Bronstad, 2022).

Behavioural observations including reduced swimming activity, loss of equilibrium, decreased opercular movement and eventual loss of reflex followed the recognised stages of fish anaesthesia. These behavioural changes indicate progressive depression of the central nervous system and are consistent with internationally accepted descriptions of anaesthetic stages in teleost fishes (Köhler & Valentim, 2022). Such responses are routinely used to evaluate the efficacy and safety of new botanical anaesthetic agents (Fayaz et al., 2026).

The haematological results demonstrated that exposure to *E. suaveolens* extract produced only limited alterations in most blood indices. White blood cell counts increased at intermediate concentrations, suggesting activation of physiological defence mechanisms in response to handling and chemical exposure, whereas reductions in red blood cell count at higher concentrations may reflect transient physiological stress rather than irreversible toxicity. The absence of statistically significant changes in most erythrocytic parameters indicates that the extract did not induce severe haematological impairment within the exposure period. Similar transient haematological responses have been reported following exposure of cultured fish to botanical anaesthetics (Jia et al., 2025).

Mortality varied among treatment groups, indicating that anaesthetic efficacy alone should not be considered sufficient when selecting an appropriate concentration. The relatively high mortality observed at some concentrations suggests that prolonged induction or excessive exposure may compromise fish survival. Consequently, determination of the optimum concentration should consider induction time, recovery time, behavioural responses and post-

exposure survival simultaneously rather than relying on a single performance indicator.

Overall, the findings demonstrate that aqueous leaf extract of *Erythrophleum suaveolens* possesses appreciable anaesthetic activity in juvenile *Clarias gariepinus*. Nevertheless, further investigations involving phytochemical characterisation, determination of median lethal concentration (LC₅₀), histopathological assessment, residue analysis, and evaluation of chronic exposure are required before recommending its routine commercial application in aquaculture. Such studies will improve understanding of its mechanism of action, safety margin and practical suitability as a sustainable botanical anaesthetic (Fayaz et al., 2026; Minaz & Félix, 2026).

5. Conclusion

This study evaluated the anaesthetic efficacy of aqueous crude leaf extract of *Erythrophleum suaveolens* in juvenile *Clarias gariepinus* by assessing its effects on behavioural responses, induction and recovery times, survival, water quality, and haematological parameters. The results demonstrated that the extract possesses anaesthetic activity, with its effects varying according to concentration. Increasing concentrations of the extract resulted in shorter induction times and longer recovery times, indicating a concentration-dependent anaesthetic response. Behavioural responses characteristic of progressive anaesthesia, including reduced swimming activity, loss of equilibrium, and complete anaesthesia, were observed across the treatment groups. The extract also influenced water quality by significantly reducing dissolved oxygen and pH while increasing free carbon dioxide concentrations, whereas water temperature remained relatively stable throughout the experiment.

Haematological evaluation revealed significant changes in white blood cell count, mean corpuscular volume, and platelet distribution width, while most other haematological indices showed no significant differences compared with the control. These findings suggest that exposure to the extract elicited measurable physiological responses but did not produce widespread alterations in blood parameters under the experimental conditions. Although *E. suaveolens* demonstrated promising anaesthetic properties, the observed mortality under some treatment conditions indicates that both concentration and exposure duration should be carefully considered before practical application. Therefore, optimisation of dosage and exposure time is essential to ensure effective anaesthesia while minimising adverse effects on fish health and survival.

Overall, the findings indicate that aqueous crude leaf extract of *Erythrophleum suaveolens* has potential as a plant-derived anaesthetic for *Clarias gariepinus* juveniles. However, additional studies are required to establish its

safety profile and practical suitability for aquaculture. Future research should focus on phytochemical characterisation of the active compounds, determination of median lethal concentration (LC₅₀), histopathological assessment of major organs, residue analysis, and long-term toxicity studies before the extract can be recommended for routine commercial use.

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