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Evaluation of Ecotoxicological Impacts of *Datura metel*, *Rauvolfia vomitoria*, and *Pentodon pentandrous* Piscicides on *Tilapia guineensis*

Lawson-Jack, T*., Abbey, S.D., Wokem, G.N. and Ollor, O.A.
Department of Medical Microbiology, Faculty of Medical Laboratory Sciences,
Rivers State University, Port Harcourt, Nigeria.
***Corresponding Author:** *token.lawson-jack1@ust.edu.ng*

ABSTRACT

The increasing use of plant-derived toxicants in fisheries management and aquaculture has necessitated the evaluation of their effects on non-target aquatic organisms. This study investigated the acute toxicity of leaf extracts of *Datura metel*, *Rauvolfia vomitoria*, and *Pentodon pentandrus* on *Tilapia guineensis* under controlled laboratory conditions. *Tilapia guineensis* was obtained from Sombreiro River and leaf extract were obtained using standard procedures. Fish were exposed to varying concentrations (0, 0.25, 0.5, and 0.75 ml/l) of each plant extract and mortality was monitored at specific time intervals over a 24-hour exposure period. Results showed that no mortality occurred in the control groups throughout the experimental period and exposure to *Datura metel* produced no mortality at any concentration tested. In contrast, both *Rauvolfia vomitoria* and *Pentodon pentandrous* extracts caused significant mortality that increased with concentration and exposure time. For *Rauvolfia vomitoria*, mortality commenced between 20 and 40 minutes of exposure, with higher concentrations producing earlier deaths. At 0.75ml/l, mortality was observed within 20 minutes, while lower concentrations required longer exposure periods before lethal effects occurred. *Pentodon pentandrous* exhibited the highest toxicity among the extracts tested. Mortality occurred as early as 20 minutes at concentrations of 0.5 and 0.75 ml/l, and the highest concentration resulted in the greatest number of deaths within the shortest time. No additional mortality was recorded after the first hour of exposure for either extract. The result shows differences in piscicidal activities, with *Pentodon pentandrous* showing strongest toxic effect, followed by *Rauvolfia vomitoria*, while *Datura metel* was non-toxic at the concentrations evaluated. Caution should be exercised in the use of *Pentodon pentandrous* and *Rauvolfia vomitoria* in aquatic environments due to their significant toxic effects on fish.

Keywords: *Tilapia guineensis*, acute toxicity, *Datura metel*, *Rauvolfia vomitoria*, *Pentodon pentandrous*.

Introduction

Pesticides are widely applied in intensive agricultural and aquaculture settings to manage pest populations such as insects, weeds, mollusks and microbial pathogens. Pesticides can enter aquatic environments through direct applications or through several indirect mechanisms including runoff, drainage and wind drift (Öruc, 2010), eventually affecting non-target aquatic organisms such as fish and crustaceans, thereby having considerable ecological and economic impacts (Adhikari *et al*., 2004).

Since conventional piscicides are often synthetic chemicals that may persist in aquatic environments and adversely affect non-target organisms, increasing concerns about environmental pollution, bioaccumulation, and ecosystem degradation have stimulated interest in plant-based piscicides as environmentally friendly alternatives. Plant-derived piscicides, also known as botanical or herbal piscicides, are natural products obtained from various plant parts, including leaves, roots, seeds, bark, and fruits, that contain biologically active compounds capable of disrupting physiological processes in fish (Das *et al*., 2018). These natural products are generally considered biodegradable, locally available, and less persistent in aquatic ecosystems than many synthetic chemicals.

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Traditional fishing communities have utilized extracts from toxic plants to stun or kill fish, thereby facilitating their capture. The toxic effects of these plants are attributed to secondary metabolites such as alkaloids, saponins, tannins, flavonoids, terpenoids, glycosides, and rotenoids, which interfere with respiration, nervous system function, osmoregulation, or cellular metabolism in fish (Narzary *et al*., 2023). These compounds may enter the fish through the gills and rapidly induce physiological stress, loss of equilibrium, respiratory distress, and eventual mortality.

In aquaculture, plant-based piscicides are commonly applied during pond preparation to eradicate predatory, weed, or unwanted fish species before stocking cultured fish. Their use has gained prominence because many botanical toxins degrade naturally and may have reduced long-term environmental impacts compared with synthetic piscicides. Several studies have reported the effectiveness of plant products in controlling unwanted fish populations while offering economic advantages due to their local availability and low cost (Debnath & Sahoo, 2024; Das *et al*., 2018). Among the numerous piscicidal plants investigated, *Datura metel*, *Rauvolfia vomitoria*, and *Pentodon pentandrous* have attracted attention because of their rich phytochemical composition and biological activity. *Datura metel* contains tropane alkaloids such as atropine, hyoscyamine, and scopolamine, which possess potent neurotoxic properties capable of affecting nervous system function in both target and non-target organisms (Islam *et al*., 2023). These compounds can induce physiological disturbances, behavioral abnormalities, and mortality in aquatic organisms when present at sufficient concentrations. Thus the study aimed at the evaluation of the ecotoxicological impacts of various concentrations of leaf extraxts of *Datura metel*, *Rauvolfia vomitoria*, and *Pentodon pentandrous* Piscicides on *Tilapia guineensis*.

Materials and Methods

Source of *Tilapia guineensis*

A total of 30 fish were obtained from Nigerian Institute for Oceanography and Marine Research's (NIOMR) Africa Regional Aquaculture Center (ARAC), Buguma, Rivers State-Nigeria and transported to fishery Department of Rivers State University. The fish were transported in open separate tanks in order to reduced stock density; reduce stress and mortality **(**Luz & Favero (2024). A pinch of sodium chloride (NaCl) was added to the water in the tank and the tanks were filled with one-third of clean water. The fish weight ranges from 11 – 44.8g and standard length ranges from 10 – 17.5cm.

Source of Plant and Taxonomic Identification

Plants used were *Datura metel, Ravovia vomitatarius* obtained from the botanical Garden of the Rivers State University, Port Harcourt-Nigeria and *Pentodon pentandrous was obtained from* local fishermen that utilise it for killing fish in Abua Odual Local Government Area of Rivers State. The taxonomic identification of the three plants was done by Professor Benjamin. A. Ekeke of the Department of Plant Science and Biotechnology, Rivers State University, Port Harcourt- Nigeria.

Phytochemical Analyses

Extractions of the plants for phytochemical analyses were carried out in consonance with ISO17025 (2017) Soxhlet extractor was used in extracting the phytochemical of the leaf extract with the aid of a polar and non-polar extracting solvent (Hexane, Diethyl ether and Methanol). Phytochemical constituents of interest were determined using UV visible scan analysis with wavelength 200 – 1100nm and compared with standard phytochemical constituents ISO17025 (2017). Phytochemical constituents analyzed were Tannin, Alkaloids, Saponins, Oxalate and Total phenol content.

Preparation of Plant Extract

Leaves were weighed at different grams and pounded using mortar and pestle soaked in 500ml of distilled water which serves as the stock. Five (5ml) milliters, 10ml and 15ml of the plant extract was added to 20 litres of borehole water singly in glass aquarium tank and allowed to stay for 24hrs and the toxicity test treatments were carriedout in triplicates.
The concentrations were determined using the formula:
$C = n/v$
C = concentratration
n = quantity of solute
v = volume of solution

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Histopathological Analysis

Histopathogical analysis was done through processes such as Dehydration, Clearing, Embedding, Block making, Sectioning, Staining and Microscopy. Histological process begins with the careful collection of fresh tissue (gill), followed by fixation—using 10% neutral buffered formalin—to prevent autolysis and preserve cellular architecture (Bancroft & Gamble, 2019; Kiernan, 2015). The fixed tissues (gill) are then processed through dehydration, clearing, and paraffin wax infiltration before being embedded to provide structural support for sectioning (Slaoui & Fiette, 2011). The thin tissue (gill) sections produced using a microtome was mounted on glass slides, and stained, with hematoxylin and eosin (H&E), to enhance the visibility of cellular and tissue structures (Young et al., 2014; Bancroft & Gamble, 2019). The stained sections were subsequently mounted with a coverslip and examined under a light microscope to evaluate normal histological features or pathological changes.

Results

The phytochemical composition of the leaves as shown in Table 1, revealed that *Raufolvia vormitaria* has the highest percentage of flavonoid (8.6%) compared to other plants while *Pentodon pentandrous* has the highest percentage of alkaloids (15.72%) compared to other leaf species.

Table 1: Phytochemical Compositions of the Leaves of *Datura, Revoulvia*, and *Pentdrus* species

Phytochemicals	*Pentondon pentadrus* %	*Raufolvia vormitaria* %	*Datura metel* %
Flavonoids	7.56	8.6	0
Tannins	0	0	0.20
Phenols	1.24	0.32	0
Alkaloids	15.72	3.16	6.40
Irredoids	0	0	1.80
Terpenes	0	0	0
Saponins	5.99	4.8	4.20
Tropane-Alkaloids	0.8	0.17	6.01

As shown in Tables 2, the mortality rate of the various concentrations of the plant extracts on *Tilapia* indicates that *Pentodon pentandrous* shows a high mortality rate compared to other plants.

The histopathological result is shown in Table 3 indicating an acute toxicity of the plant extract on the fish (*Tilapia*).

Table 2: Mortality Rates of *Tilapia* on Exposure to Different Concentrations of *Datura metel, Rauvolfia vomitaria,* and *Pentodon pentandrous* Leaf Extracts

Exposure Time	Plant Extract (Toxicant)/Concentration (ml/l)											
	Datura metel				*Rauvolfia vomitaria*				*Pentodon pentandrous*			
	0	**0.25**	**0.5**	**0.75**	**0**	**0.25**	**0.5**	**0.75**	**0**	**0.25**	**0.5**	**0.75**
5 Mins	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	2	3	0	0	2	5
40	0	0	0	0	0	2	3	2	0	4	3	0

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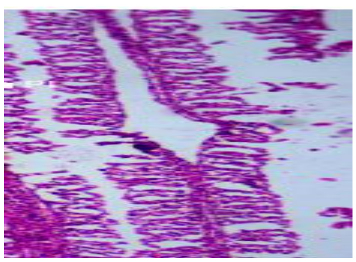
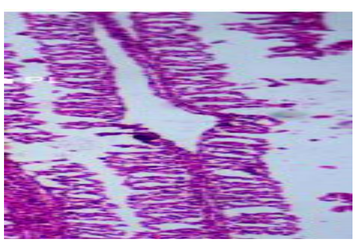
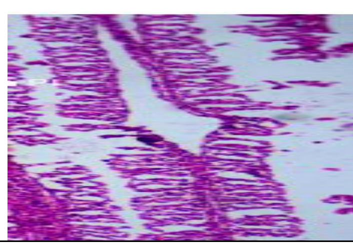
60	0	0	0	0	0	3	0	0	0	1	0	0
2 hr	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0

Table 3: Histopathological Changes in the Gills of *Tilapia guinensis* after Exposure to *Datura metel, Rauvolfia vomitaria,* and *Pentodon pentandrous*

S/N	Toxicant (15mg/l)	Photomicrographs	Histopathological effect on fish gill	Remarks
1	*Datura metel*		Moderate epithelial lifting of primary and secondary lamella, and visible blood showing evidence of life in the gills	Mild histopathological effects. This could be because the fish may have developed tolerance to the phytochemicals present the leaves of the test plant
2	*Rauvolfia vomitaria*		Moderate epithelial lifting of primary and secondary lamella, and visible blood showing evidence of life in the gills	Mild histopathological effects. This could be because the fish may have developed tolerance to the phytochemicals present the leaves of the test plant
3	*Pentodon pentandrous*		Moderate epithelial lifting of primary and secondary lamella, and visible blood showing evidence of life in the gills	Mild histopathological effects. This could be because the fish may have developed tolerance to the phytochemicals present the leaves of the test plant.

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Discussion

The phytochemical composition of the leaves of *Pentodon pentandrous*, *Rauvolfia vormitaria*, and *Datura metel*, (Table 1) revealed clear interspecific variations in the presence and concentrations of bioactive compounds. These phytochemicals—such as flavonoids, alkaloids, tannins, phenols, saponins, and terpenoid derivatives—are known to contribute significantly to the medicinal and ecological functions of plants (Isah, 2019). Flavonoids were most abundant in *Rauvolfia vormitaria* (8.6%), followed closely by *Pentodon pentandrous* (7.56%), while they were completely absent in *Datura metel*. This suggests that *Rauvolfia vormitaria* and *Pentodon pentandrous* may possess stronger antioxidant potentials, as flavonoids are widely reported to scavenge free radicals and reduce oxidative stress (Kumar *et al*., 2023). The absence of flavonoids in *Datura metel* may indicate a different phytochemical defense strategy or biosynthetic pathway. Tannins were only detected in *Datura metel* (0.20%), albeit at a low concentration, and were absent in the other two species. Tannins are associated with antimicrobial and anti-herbivory properties, suggesting that *Datura metel* may rely, even minimally, on tannin-mediated defense mechanisms (Adeyemi & Ogunleye, 2024). Similarly, phenols were present only in *Pentodon pentandrous* (1.24%) and *Rauvolfia vormitaria* (0.32%), with *Pentodon pentandrous* showing a comparatively higher concentration, indicating a potentially greater role in antioxidative and anti-inflammatory activities.

Alkaloids were the most dominant phytochemical across all three species, particularly in *Pentodon pentandrous* (15.72%), followed by *Datura metel* (6.40%) and *Rauvolfia vormitaria* (3.16%). This high alkaloid content highlights the pharmacological relevance of these plants, as alkaloids are known for their potent biological activities, including analgesic, antimalarial, and anticancer effects (Okeke *et al*., 2025). The significantly higher alkaloid concentration in *Pentodon pentandrous* suggests that it may have stronger therapeutic potential compared to the other species. Iridoids were exclusively found in *Datura metel* (1.80%), indicating species-specific biosynthesis. Iridoids are known for their anti-inflammatory and hepatoprotective properties, which may contribute to the medicinal value of *Datura metel* (Singh et al., 2023).

Terpenes, however, were absent in all three plant species, which is somewhat unexpected given their widespread occurrence in medicinal plants, and may suggest either low concentrations below detection limits or methodological limitations during analysis.

Saponins were present in all three species, with *Pentodon pentandrous* (5.99%) having the highest concentration, followed by *Rauvolfia vormitaria* (4.8%) and *Datura metel* (4.20%). This indicates that all three plants may possess similar capabilities in terms of antimicrobial and cholesterol-lowering activities, as saponins are known to exhibit such biological effects (Eze et al., 2024). Tropane alkaloids were notably highest in *Datura metel* (6.01%), while *Pentodon pentandrous* (0.8%) and *Rauvolfia vormitaria* (0.17%) contained much lower amounts. This finding aligns with existing knowledge that *Datura metel* is rich in tropane alkaloids such as atropine and scopolamine, which are responsible for its well-documented pharmacological and toxicological properties (Sharma & Verma, 2025). The results demonstrates that *Pentodon pentandrous* is particularly rich in alkaloids, flavonoids, and saponins, suggesting strong pharmacological potential (Sofowora, 2008). *Rauvolfia vormitaria* shows a balanced composition with high flavonoids and moderate saponins, while *Datura metel* is characterized by the presence of unique compounds such as iridoids and high tropane alkaloids. These variations underscore the importance of species-specific phytochemical profiling in determining the medicinal applications of plants.

The mortality pattern in the toxicological responses of *Tilapia* exposed to three plant extracts (*Datura metel*, *Rauvolfia vomitoria*, and *Pentodon pentandrous*) showed marked variation in the toxicological responses of *Tilapia* exposed to the three plant extracts. These differences reflect variations in phytochemical composition, bioavailability, and physiological effects on aquatic organisms. For *Datura metel*, no mortality was recorded across all tested concentrations (0 – 0.75ml/l) and throughout the exposure period (5 minutes to 24 hours). This suggests that the extract exhibited no acute toxicity under the conditions of this study. Although *Datura metel* is known to contain potent tropane alkaloids, its toxicity depends strongly on concentration, extraction method, and organismal susceptibility.

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Similar observations were reported by Islam *et al*. (2023)**,** who noted that the toxicological effects of *Datura metel* are highly dose-dependent and may not manifest at lower concentrations. The absence of mortality in this study therefore implies that the applied concentrations were below the lethal threshold for *Tilapia.*

In contrast, *Rauvolfia vomitoria* exhibited moderate toxicity with delayed onset of mortality. At concentrations of 0.25–0.75ml/l, no mortality occurred within the first 15 minutes; however, deaths began between 20 and 60 minutes, with mortality counts ranging from 2 to 3 individuals. No further mortality was observed beyond this period up to 24 hours. This pattern suggests an acute but time-limited toxic effect. The observed response aligns with findings by Adomefa *et al*. (2024)**,** who reported that *Rauvolfia vomitoria* contains bioactive alkaloids capable of inducing physiological stress and toxicity, particularly at moderate to high concentrations. The stabilization of mortality after 60 minutes may indicate physiological adaptation or rapid degradation of active compounds in the aquatic environment. *Pentodon pentandrous* demonstrated the highest toxicity among the three extracts. Mortality occurred earlier and was more pronounced, particularly at higher concentrations. At 0.25 ml/l, mortality peaked between 40 and 60 minutes (4 & 1 individuals), while at 0.5 and 0.75ml/l, deaths began as early as 20 minutes, reaching up to 5 individuals. As with *Rauvolfia vomitoria*, no additional mortality occurred after 60 minutes. This rapid onset of mortality suggests a strong acute toxic effect, likely mediated through disruption of respiratory or nervous system functions. The concentration-dependent increase in mortality observed is consistent with general ecotoxicological trends. Comparable findings were reported by Omitoyin *et al*. (2023), who demonstrated that plant-derived piscicides induce rapid mortality in fish, particularly at higher concentrations.

Similarly, Oladipo *et al*. (2024) emphasized that many medicinal plant extracts possess significant acute toxicity that manifests within short exposure durations. The results indicate a clear toxicity gradient: *Pentodon pentandrous*> *Rauvolfia vomitoria* > *Datura metel*. The absence of mortality beyond 60 minutes across all treatments suggests that the toxic effects were primarily acute rather than chronic.

It is also likely that the most susceptible individuals succumbed early; leaving more resistant fish that survived prolonged exposure. This observation is consistent with established toxicological principles regarding acute exposure and organismal tolerance.

The histopathological responses in the gills of *Tilapia guineensis* (Table 3) following exposure to *Pentodon pentandrous*, *Rauvolfia vomitoria* and *Datura metel* leaf extracts at a concentration of 15mg/l demonstrated varying degrees of tissue damage, reflecting differences in toxicity and the adaptive capacity of the fish to these substances. Moderate epithelial lifting and visible blood congestion were observed in fish exposed to plant-derived toxicants such as *Datura*, *Rauvolfia*, and *Pentodon*. These changes indicate sub-lethal stress, where the gill structure is compromised but not completely destroyed. Epithelial lifting is often interpreted as a defense mechanism that increases the diffusion distance between water and blood, thereby limiting toxin entry.

The presence of blood in the lamellae suggests that the gills remain functional, albeit under stress. Studies by Bello *et al*. (2023) have shown that phytochemicals can induce moderate histological alterations in fish tissues, depending on concentration and exposure duration. Similarly, Mensah *et al*. (2024) noted that plant extracts containing alkaloids and flavonoids can cause reversible gill damage. The pattern of histopathological changes observed in this study highlights a clear gradient of toxicity among the tested xenobiotics. Plant-based toxicants induced moderate, potentially reversible damage. These findings underscore the importance of considering both the type of toxicant and the exposure history of aquatic organisms when assessing environmental risk.

Conclusion

The occurrence of alkaloids, flavonoids, saponins, phenols, tannins, iridoids, and tropane alkaloids supports the view that these plants possess diverse biochemical mechanisms for defense and biological activity. These phytochemicals are associated with antimicrobial, antioxidant, anti-inflammatory, insecticidal, and piscicidal properties, making the plants valuable candidates for use in traditional medicine and environmentally friendly pest and fisheries management strategies.

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The high alkaloid and tropane alkaloid contents observed, particularly in *Pentodon pentandrous* and *Datura metel*, may account for their effectiveness as botanical toxicants against aquatic organisms. Although plant-based piscicides remain valuable tools in fisheries management, their application requires careful ecological risk assessment. The assumption that botanical origin guarantees environmental safety is no longer supported by contemporary evidence. Instead, their use should be guided by integrated ecotoxicological evaluations that consider acute and chronic toxicity, species sensitivity (including non-target organisms such as *Tilapia guineensis*), and ecosystem-level consequences. Future management strategies should prioritize controlled application, dose optimization, and monitoring of ecological recovery to ensure that piscicide use does not compromise aquatic biodiversity and ecosystem integrity.

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