

Effect of Yellow oleander (*Thevetia neriifolia* Tuss.) Seed powder on Hematology and Serum biochemistry in wild female African Giant Rat (*Cricetomys gambianus* W.)

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ABSTRACT

Rodents are known to cause economic damage to crops. One of the most destructive rodent pest species known is African giant rat (AGR). Controlling them with chemicals usually causes environmental pollution due to residues of the chemical used. *Thevetia neriifolia* seed has been discovered to have rodenticidal potential in the laboratory rodents. However, its humaneness as a rodenticide has not been evaluated in wild rodent species. Therefore, this study was aimed at evaluating effect of *Thevetia neriifolia* seed powder on hematology and serum biochemistry in wild female AGR. Twenty wild female AGR were acclimatized for 4 weeks and randomly allocated into 4 groups (A, B, C, and D) (5 animals/group) including control. The *T. neriifolia* seed was sundried, blended into powder, and mixed with commercial feed at 20%, 40%, 60%, and 0% (control), and then turned into pellet. The formulated feeds were administered to the animals for 8 weeks. At termination, the blood samples of the animals were collected for hematology and serum biochemistry analysis. Data were analyzed using ANOVA and means separated using DMRT at significance level of 0.05. The results showed no behavioral changes between treated group and control. All the hematological parameters showed no significant difference except red blood cell and haemoglobin. There was significant difference in Na^+ , HCO_3^- , urea, and albumin among the groups compared with the control ($p < 0.05$). *Thevetia neriifolia* seed powder did not seriously affect the hematology and serum biochemistry of the wild female AGR within the exposure time.

Keyword: African giant rat, *Thevetia neriifolia*, Rodents, Economic damage, hematology, serum biochemistry

Introduction

Rodent species are vertebrate species which belong to the order Rodentia. Some of the species

have been reported to cause economic problem due to the damage they inflict on agricultural crops (Almelda *et al.*, 2013). Some cause environmental problem as a result of the chemical

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5004

rodenticides used for their control while some pose social problem due to their proximity to human habitation (Luis *et al.*, 2013). There are some species that cause health problem as they are vectors of zoonotic diseases (Meerburg *et al.*, 2009).

However, rodent species also play ecological roles in the ecosystem. Some of the ecosystem services they render include aiding in soil mixing and aeration, some serve as dispersal agents, some species aid in the enhancement of organic matter composition, and they serve as prey for predatory vertebrates (Witmer, 2018). In addition, it has been reported that some rodent species serve as indicators of ecosystem health. (Witmer, 2018)

Rodent species exhibit various lifestyles as some are terrestrial (land dwellers), aquatic (water dwellers), arboreal (tree climbing species), and fossorial (borrowing species) (Witmer, 2007). They have been reported to have well developed sense of smell, hearing, and taste. Most of the species are regarded as small mammals whose adult body weights do not exceed 5kg while some species can weigh up to 70kg (Meritt, 2010; Kingdon *et al.*, 2013). African giant rat is said to be one of the rodents that cause the most damage to crops. They are nocturnal omnivores that feed on vegetation and small animals (Ajayi *et al.*, 1978; Ewer, 2010).

Rodents, like other vertebrate pest serve as an important part in the ecosystem but they have been implicated for being the most tenacious and destructive species on the planet. Unfortunately, few studies evaluate the effect of this animals on livestock. They have eradicated numerous native species on islands where the rodents have few or no predators (Engemen *et al.*, 2006).

African giant rats (*Cricetomys gambianus*) are example of rodent that poses a threat to agricultural crops. They shifted from being a domestic rat to invasive species after a suspected release by a pet breeder (Perry *et al.* 2006). They

are fossorial species considered as pests inflicting damage mostly to tuber crops such as cassava and yam (Badmus and Alarape, 2022; Kingdon *et al.*, 2013)

The African giant rat is the most destructive vertebrate pest of agricultural produce on farm and in storage. They are nocturnal animals and because of their large size they pose serious threat to native species (particularly nesting species) and agricultural crops (Fieldler and Fall, 1994). They also transmit disease and were implicated as facilitator of monkey pox disease (Enserink, 2003).

Thevetia neriifolia is a plant that contains toxic substances. They belong to the family of Apocynacea. The plant contains cardiac glycosides which include peruvocides and neriifolin (Oluwaniyi and Ibiyemi, 2007). Chemical and pharmacological studies demonstrated that the plant especially the seed contained potentially toxic cardiac glycosides (Fayinminu *et al.*, 2017). A small amount of the plant has toxic effect. It is an essential source of bioactive compounds with great potential in the manufacturing of rodenticides (Orji and Okafor, 2000; Fayinminnu *et al.*, 2017). These toxic attributes of *Thevetia neriifolia* are yet to be adequately tested for rodents which have remained one of the most destructive pests of agriculture.

Conventional method of rodent control remains the use of chemical poison to achieve lethality. However, there has been attendant problem as a result of the use of chemical rodenticides which include but not limited to the problems of bait shyness, secondary poisoning of non-target species, and resistance. So, there is need to explore some alternative approaches to achieving lethality of the small mammal species which could be environment-friendly and more humane method of rodent control. Some plant parts have been considered to have some rodenticidal properties in laboratory rats. One of such plant

parts is the seed of yellow oleander (*Thevetia neriifolia*) (Fayinminnu *et al.*, 2017). Meanwhile, its effects on hematology and serum biochemistry have not been evaluated in wild rodent pest species. Therefore, this study was aimed at evaluating effect of *Thevetia neriifolia* seed powder on hematology and serum biochemistry in wild female AGR.

Materials and Methods

Study location

The study was carried out in Ecology Laboratory, Department of crop protection and environmental biology, Faculty of agriculture. University of Ibadan, Ibadan, Nigeria.

Collection of Ethical approval

Ethical approval letter was collected from Animal Care and Use Research Ethics Committee (ACUREC), Department of Veterinary Pathology, Faculty of Veterinary Medicine, University of Ibadan, Ibadan, Oyo State. The Number assigned was UI/19/0136.

Collection of experimental animals

Twenty sexually matured female African giant rats (*Cricetomys gambianus*) were wildy captured with single-capture live traps. They were weighed and placed in metal cage with each in a separate housing unit which has been properly prepared and sanitized. The cages were appropriately organized and fitted with drinkers which the rat could easily get access to when filled with water. Feeders were properly fixed to eliminate feed spillage.

Acclimatisation and Treatment of experimental animals

Acclimatization of the experimental animals was for a period of four weeks (before experimentation) with 12 hours light: 12 hours dark cycle and relative humidity of 80-90%. Feed and water were given to the rats *ad libitum*.

During acclimatization, the animals were treated worm expeller against helminthe parasites like *Hymenolepis nana*, *Taenia sp.* cyst and *Strongyloides sp.* that can affect them and inhibit food utilization and also to prevent them from probable infected disease from the wild. In order to treat them for severe cestodiasis, 0.6mls of Shana-zole ® (an Albendazole which is a veterinary worm expeller) was orally administered (per kilogram of the animal) for one day using bread as the vehicle. During the treatment period, all other foods were withdrawn from them so as to ensure that the bread was consumed by them.

Based on the veterinary expert advice, deworming of the animals was repeated after fifteen (15) days of the first treatment in order to get rid of the newly matured cestodes which could have been at the egg stage in the subcutaneous tissues of the animals as at the time of the first treatment.

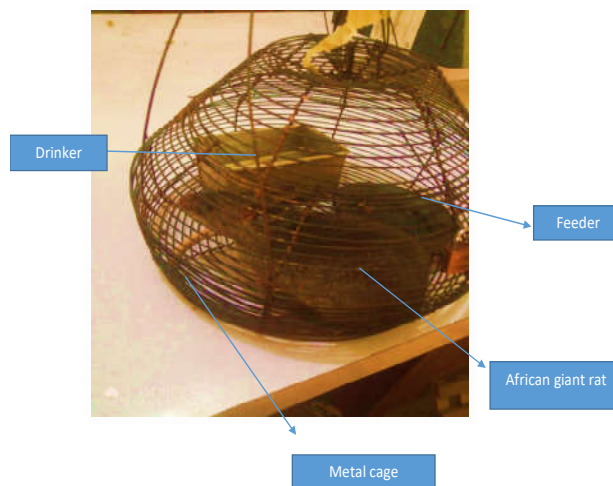


Plate 1: Acclimatized *C. gambianus* in a metal cage

Experimental Procedures

Collection, Identification, and drying of Yellow Oleander (*Thevetia neriifolia*) seed

The plant material used for this experiment was *Thevetia neriifolia*. The plant part of interest was

5006

the seed which was collected early in the morning around 7: 00am within the University of Ibadan premises. It was taken to the Department of Botany Herbarium where it was identified and allocated voucher number: UIH - 23176. *Thevetia neriifolia* seed collected was then sun-dried for ten (10) days in the Department of Crop Protection and Environmental Biology. The dried seed was then ground into powder using milling machine.

Formulation of Experimental feed

Commercially available rat feeds were used in combination with the *Thevetia neriifolia* seed

Group A: 80% of Commercial rat feed + 20% of *T. neriifolia* seed powder

Group B: 60% of Commercial rat feed + 40% of *T. neriifolia* seed powder

Group C: 20% of Commercial rat feed + 80% of *T. neriifolia* seed powder

Group D: 100% of Commercial rat feed + 0% of *T. neriifolia* seed powder

Each of the concentrations was then converted into feed pellet and labelled accordingly.

Administration of experimental feed

At the end of the acclimatization period, the animals were weighed and randomly allocated into four treatment groups A, B, C, and D including control with each treatment group having five animals. 40g of experimental feed was appropriately supplied to each of the rats every morning between 7am and 8am and water was provided *ad libitum*. They were continuously fed for the period of two (2) months.

Collection of blood samples for Hematological and Serum Biochemistry Analyses

The experimental animals were anaesthetized using chloroform and blood samples of each of the animals were collected through ocular

puncture using heparinized capillary tube. Blood samples (2mls and 3mls) of were collected in EDTA bottle and plain bottle respectively for hematology and serum biochemistry analyses. They were stored at 4°C and taken to Trudiag Medical Laboratory, Adeoyo State Hospital, Off Ring Road, Ibadan.

Packed cell volume (PCV) was determined with microhaematocrit method. Hemoglobin was determined using portable hemoglobin photometer. Red blood cell count (RBC) was by improved Neubauer hemocytometer. White blood cell count (WBC) and platelets were determined by the improved Neubauer. The leucocyte differentials (monocytes, lymphocytes and neutrophils) were determined by scanning Giemsa's-stained slides in the classic manner.

Alkaline Phosphatase (ALP), Alanine Aminotransferase (ALT), Aspartate Aminotransferase (AST), Urea, Sodium ion (Na⁺), Potassium ion (K⁺), Chlorine ion (Cl⁻), Bicarbonate (HCO₃⁻) and Creatinine in the serum were obtained using standard method.

The data collected were analyzed using descriptive statistics and ANOVA. Means were separated using Duncan Multiple Range Test (DMRT) at level of significance (α) of 0.05.

Results

Effect of T. neriifolia seed powder on Hematology parameter of the female African giant rats per group during the experimental period

The result of the present study shows that there were variations in the mean PCV (%) values across the experimental groups (Table 1a). The group that received the mid concentration of the experimental feed had the highest mean PCV (45.06±4.50) while the group that received the lowest concentration recorded lowest mean PCV (40.50±4.50) (Table 1a). However, there was no significant difference across the treatment groups

5007

and control ($F = 0.996$, $df = 19$, $p > 0.05$). Similar trend was observed for mean WBC (%) and PLT (%) values. The group that received the mid concentration of the experimental feed recorded the highest mean WBC (5829.20 ± 18.36) and mean PLT (392000.00 ± 5830.95) values (Table 1a). There was no significant difference across the experimental groups and in comparison with the control ($F = 1.223$, $df = 19$, $p > 0.05$).

Variations were observed in the mean values of RBC (%) across the treatment groups (Table 1a). The experimental group that received the mid concentration of experimental feed recorded the highest mean RBC (9749.80 ± 61.70) while the group that received the highest concentration of the feed had the lowest mean RBC (5696.20 ± 1213.02) (Table 1a). The difference recorded across the treatment group in comparison with the control was statistically significant ($F = 2.047$, $df = 19$, $p < 0.05$).

There were observed variations in the mean Hemoglobin (Hb) (g/L) across the experimental groups (Table 1b). The treatment group that received the mid concentration of experimental feed recorded the highest mean Hemoglobin (Hb) value (14.74 ± 0.07) while group that received the lowest concentration of fed has the lowest mean Hb 12.28 ± 0.93 value (Table 1b). There was no significant difference in the mean Hb between the group that received the highest concentration of the experimental feed and the control group. However, there was statistical significant difference in the mean Hb across the treatment groups including the control ($F = 3.398$, $df = 19$, $p < 0.05$).

For Neutrophil (NEUT) (%), the group fed with the lowest concentration of experimental feed recorded the highest mean NEUT value (60.60 ± 4.67) while the group fed with the mid concentration of the feed had the lowest mean NEUT (58.60 ± 2.85) (Table 1b). Statistically, however, there was no significant difference in

the mean NEUT across the treatment groups including the control ($F = 1.54$, $df = 19$, $p > 0.05$).

For Lymphocytes (LYM) (%), the treatment group that received the mid concentration of the experimental feed recorded the highest mean LYM (37.80 ± 3.84) while the group fed with the lowest concentration had the lowest mean LYM (34.00 ± 1.76) (Table 1b). Meanwhile, there was no statistically significant difference in the mean LYM values across the treatment groups including the control ($F = 1.54$, $df = 19$, $p > 0.05$).

Table 1a: Mean Hematology parameters of the female African giant rats per group during the experimental period

GROUP	PCV (%)	RBC (cells/mm ³)	WBC (cells/mm ³)	PLT (cells/mm ³)
A	43.00 $\pm 2.05a$	6238.80 ± 1 383.35ab	5811.00 ± 6 51.395a	377800.00 $\pm$ 28406.68a
B	45.06 $\pm$ 0.40 a	8749.80 ± 6 1.70b	5829.20 ± 2 18.368a	392000.00 $\pm$ 5830.95a
C	40.50 $\pm$ 4.50a	5696.20 ± 1 213.02a	4439.00 ± 7 78.104a	322600.00 $\pm$ 22925.09a
D (control)	39.40 $\pm$ 2.13a	7082.00 ± 2 91.829ab	4531.40 ± 4 08.96a	356620.00 $\pm$ 40134.08a

Table 1b: Mean Haematology parameters of the female African giant rats per group during the experimental period

GROUPS	Hb (g/L)	NEUT (%)	LYM (%)
A	13.48±0.74ab	66.00±3.27a	34.00±1.76a
B	14.74±0.07b	58.60±2.85a	37.80±3.84a
C	12.28±0.93a	60.60±4.67a	36.20±3.34a
D (control)	12.12±0.57a	67.00±1.61a	29.60±1.96a

Means having the same alphabets across the column are not significantly different ($p > 0.05$) Group 1 (80% of Commercial rat feed + 20% of *T. neriifolia* seed powder); Group 2 (60% of Commercial rat feed + 40% of *T. neriifolia* seed powder); Group 3 (20% of Commercial rat feed + 80% of *T. neriifolia* seed powder); Group 4 (Control: Only Commercial rat feed)

Table 2: Mean Serum Electrolytes of the female African giant rats per group during the experimental period

GROU P	Na ⁺ (mmol/L)	K ⁺ (mmol/L)	Cl ⁻ (mmol/L)	HCO ₃ ⁻ (mmol/L)
A	137.20±0.8 0a	3.82±0.07a	102.20±1.36a	23.60±0.92b
B	139.60±0.75ab	3.76±0.12a	107.00±1.05a	22.40±2.07ab
C	139.20±1.99ab	3.64±0.09a	103.00±1.27a	23.60±0.51b
D (contr ol)	142.80±1.39b	4.28±0.73a	105.60±2.32a	20.40±0.60a

Means having the same alphabets across the column are not significantly different ($p > 0.05$) Group 1 (80% of Commercial rat feed + 20% of *T. neriifolia* seed powder); Group 2 (60% of Commercial rat feed + 40% of *T. neriifolia* seed powder); Group 3 (20% of Commercial rat feed + 80% of *T. neriifolia* seed powder); Group 4 (Control: Only Commercial rat feed)

Effect of T. neriifolia seed powder on Serum Electrolytes of the female African giant rat CB of the female African giant rat

The result shows that there was variation in the mean Urea, Creatinine (Cr), Total Bilirubin (TB), and Conjugated bilirubin (CB) across the treatment groups of the female African giant rats (Table 3).

For Urea (mg/dl), the group that received the mid concentration of the experimental feed had the highest mean value (35.00±1.34) while the group fed with the highest concentration of the feed had the lowest mean (28.60±1.37) (Table 3). The difference in the mean Urea (mg/dl) recorded across the treatment groups with the control was statistically significant ($F = 4.941$, $df = 19$, $p < 0.05$). The mean Cr (mg/dl) recorded in the group fed with the mid concentration of the experimental feed was the highest (0.70±0.06) while the lowest was recorded in the group that received the highest concentration of the feed (0.58±0.05) (Table 3). However, there was no statistical significant difference in the mean Cr recorded across the treatment groups with the control ($F = 0.745$, $df = 19$, $p > 0.05$).

The mean TB (mg/dL) recorded in the group fed with the mid concentration of the experimental feed was the highest (0.62±0.03) which was the same as that recorded in the group fed with highest concentration of the feed. Whereas, the lowest was recorded in the group that received the lowest concentration of the feed (0.54±0.08) (Table 3). However, there was no statistical significant difference in the mean TB recorded across the treatment groups with the control ($F = 1.657$, $df = 19$, $p > 0.05$). The mean CB (mg/dl) recorded in the group fed with the highest concentration of the experimental feed was the highest (0.34±0.05) while the lowest was recorded in the group that received the lowest concentration of the feed (0.28±0.58) which was the same as that recorded in the group that received the mid concentration of the feed (Table 3). However,

there was no statistical significant difference in the mean CB recorded across the treatment groups with the control ($F = 3.845$, $df = 19$, $p > 0.05$).

Table 3: Mean Serum biochemistry parameters of the female African giant rats per group during the experimental period

GROUP	Urea (mg/dl)	Cr (mg/dl)	TB (mg/dl)	CB (mg/dl)
A	31.80±1.72 ab	0.66±0.0 5a	0.54±0. 08a	0.28±0.5 8a
B	35.00±1.34 ab	0.70±0.0 6a	0.62±0. 03a	0.28±0.5 8a
C	28.60±1.37 a	0.58±0.0 5a	0.62±0. 03a	0.34±0.0 5a
D (control)	37.00±2.12 b	0.66±0.0 7a	0.66±0. 12a	0.50±0.0 7a

Means having the same alphabets across the column are not significantly different ($p > 0.05$) Group 1 (80% of Commercial rat feed + 20% of *T. neriifolia* seed powder); Group 2 (60% of Commercial rat feed + 40% of *T. neriifolia* seed powder); Group 3 (20% of Commercial rat feed + 80% of *T. neriifolia* seed powder); Group 4 (Control: Only Commercial rat feed)

Effect of *T. neriifolia* seed powder on Serum protein and enzyme of the female African giant rat

The result of the present study shows that the group that was fed with mid concentration of the experimental feed had the highest mean TP value (7.26 ± 0.09) mg/dl while the group that received the highest concentration of the experimental feed recorded the lowest mean TP value (6.86 ± 0.13) mg/dL (Table 4). In comparison with the control group, there was no significant difference in the mean TP values across the treatment groups ($F = 1.657$, $df = 19$, $p > 0.05$).

There was variation in the mean values of ALB (mg/dl) across the treatment groups with the control. The group that received the mid concentration of experimental feed had the highest mean ALB value (4.28 ± 0.15) while the group that received the lowest concentration of the experimental feed had the lowest mean value

(3.84 ± 0.84) (Table 4). There was statistical significant difference in the mean ALB recorded across the experimental groups with the control ($F = 3.845$, $df = 19$, $p < 0.05$).

The group that received the highest concentration of experimental feed had the highest mean Aspartate Aminotransferase (AST) (15.00 ± 0.63) mg/dL while the group that received the lowest concentration recorded the lowest mean value (14.2 ± 0.82) mg/dL (Table 4). However, there was no statistical significant difference in the mean AST recorded across the experimental groups with the control ($F = 0.405$, $df = 19$, $p > 0.05$).

Similarly, for Alanine Aminotransferase (ALT), the group that received the highest concentration of experimental feed recorded the highest mean (ALT) (12.40 ± 0.51) mg/dL while the group that received the lowest concentration recorded the lowest mean value (10.80 ± 0.86) mg/dL (Table 4). However, there was no statistical significant difference in the mean ALT recorded across the experimental groups with the control ($F = 3.00$, $df = 19$, $p > 0.05$). Meanwhile, for Alkaline Phosphatase (ALP), the group that received the mid concentration of the experimental feed recorded the highest mean (ALP) (59.40 ± 2.44) mg/dL while the group that received the lowest concentration recorded the lowest mean value (56.00 ± 4.16) mg/dL (Table 4). However, there was no statistical significant difference in the mean ALP recorded across the experimental groups with the control ($F = 1.761$, $df = 19$, $p > 0.05$).

Table 4: Mean Serum proteins and enzymes of the female African giant rats per group during the experimental period

GRO UP	TP (mg/dl)	ALB (mg/dl)	AST (IU/L)	ALT (IU/L)	ALP (IU/L)
A	6.96±0.06a	3.84±0.08a	14.2±0.80a	10.80±0.86a	56.00±4.16a
B	7.26±0.09a	4.28±0.15b	14.40±0.68a	12.00±0.71a	59.40±2.44a
C	6.86±0.13a	3.88±0.09ab	15.00±0.63a	12.40±0.51a	58.00±3.36a
D (control)	7.06±0.21a	3.88±0.06ab	15.40±0.93a	12.40±0.51a	50.00±2.09a

Means having the same alphabets across the column are not significantly different ($p > 0.05$) Group 1 (80% of Commercial rat feed + 20% of *T. neriifolia* seed powder); Group 2 (60% of Commercial rat feed + 40% of *T. neriifolia* seed powder); Group 3 (20% of Commercial rat feed + 80% of *T. neriifolia* seed powder); Group 4 (Control: Only Commercial rat feed)

Discussion

The present study revealed that of all the hematological parameters, only the red blood cell and hemoglobin showed significant difference among the treatment groups. Red blood cell functions mainly in the transport of oxygen from the lungs to all parts of the body. It is able to perform this function due to the fact that it contains hemoglobin with which oxygen binds to become oxy-hemoglobin. In addition, it transports carbon dioxide back to the lungs to be exhaled (Onuoha and Ala, 2020). All other hematological parameters as revealed from the results showed no significant changes that could cause loss in weight or mortality of the female African giant rats used in the present study. This is indicative of the fact that the plant material incorporated into the animal's feed had little or no adverse effect on the hematology of the experimental animal.

It was revealed from the result of the present study that all the serum biochemical parameters including the liver enzymes did not show

significant changes except urea both at lowest and highest concentration of the experimental feed administration. This could mean that the yellow oleander seed powder included in the feed had no serious adverse effect on the serum biochemistry of female *C. gambianus* used for this study. This is presumably because of the concentration of the feed and the animal used in this particular study. Concentration higher than those used in the present study could have effect on the serum biochemistry of some other rodent species. Urea serves an important role in the metabolism of nitrogen-containing compounds by animals. The body makes use of it in the excretion of nitrogen (Onuoha and Ala, 2020). In other words, urea is the main nitrogen-containing substance in the urine of mammals. It is a colourless, odourless solid that is highly soluble in water and practically non-toxic (Onuoha and Ala, 2020). Similar report was given by Odimegwu and Olabisi (2021) who stated that that *T. neriifolia* administered to Wistar rat on a single dose of 1000mg/kg, 2500mg/kg and 5000mg/kg did not result in any toxic signs or mortality in the acute toxicity. There was, however, previous report by Umakanth (2017) that yellow oleander seed caused health poisoning even to human in the northern and southern part of Sri Lanka because it contains highly toxic cardiac glycosides including *Thevetia* A and B. It was regarded as a method of suicide and women are mostly vulnerable. Cardiac effect was observed especially among the women and a few death was recorded.

In addition, tremor, restlessness, muscular relaxation, urinary retention, generalized seizure and death were signs displayed by farm rats when fed with *Thevetia* seeds as observed by Enriquez *et al.* (2002) within 24 hours of feeding the rat with the seed. There was bladder distention which result to micturition decrease prior to death. In the present research findings carried out on female AGR, it was observed that after 24 hours of feeding them with the seeds, they were restless,

and urinary retention was also noticed. This report was in agreement with the earlier report by Enriquez *et al.* (2002). However, no mortality was recorded throughout the study period.

5011 Conclusion

Yellow oleander seed powder did not have effect on hematological parameters of the experimental animals. It had no effect on serum biochemical parameters of the experimental animals. Therefore, the formulated feed had humane and environment-friendly rodent pest management properties.

References

- Ajayi S.S., Tewe O.O., and Faturoti E.O. (2007). Behavioural changes in the African giant rat (*Cricetomys gambianus* Waterhouse) under domestication. *European-African Wildlife Journal*. 16:137-143
- Almeida A., Corrigan R., and Sarno R. (2013). The economic impact of commensal rodents on small businesses in Manhattan's Chinatown: trends and possible causes. *Suburban Sustainability*, 1(1): 1-12. <http://dx.doi.org/10.5038/2164-0866.1.1.2>
- Badmus H.A. and Alarape, A.A. (2022). People's Perception about Plant-based Formulated Diets as a Non-chemical Method of Rodent Population Control in Nigeria. *Journal of Experimental Agriculture International*. 44(11): 212-225
- Engeman R., Woolard J., Perry N., Witmer G., Hardin S., Brashears L., Smith H., Muiznieks B., and Constantin B. (2006). Rapid assessment for a new invasive species threat: The case of the Gambian giant pouched rat in Florida. *Wildlife Research*. 33, 439–448.
- Enriquez M.E.M., Luis A.M.R., Manuel L.R., Gil A.M.G., Abigail A. C. and Alfonso E. C. S. (2002). Acute Toxicity of *Thevetia peruviana* in Rodents. *Proc. West. Pharmacol. Soc.* 45: 131-133
- Enserink M. (2003). U.S. monkey pox outbreak traced to Wisconsin pet dealer. *Science* 300: 1639.
- Ewer R. F. (2010). The Behaviour of the African Giant Rat (*Cricetomys gambianus* Waterhouse). *From the Zoology Department, University of Ghana*. 6-79.
- Fayinminnu O. O., Ogunwale O. A., and Gbemilade T. A. (2017). Evaluation of the Effects of Drying Methods on Phytochemicals in *Thevetia neriifolia* Parts as a Potential Rodenticide. *Biotechnology Journal International* 17(2): 1-11
- Fiedler L.A. and Fall M.W. (1994). Rodent control in practice: tropical field crops. Pages 313- 338 in A.P. Buckle and R.H. Smith, eds. *Rodent Pests and Their Control*. CAB International, Wallingford, Oxon, UK.
- Kingdon J., Happold D., Butynski T., and Happold M. (2013). *Mammals of Africa. Choice Reviews Online* (Vol. 50). <https://doi.org/10.5860/choice.50-4188>
- Luis A.D., Hayman D.T.S., O'Shea T.J., Cryan P., Gilbert A.T., Pulliam J.R.C., Mills J.N., Timonin M.E., Willis C.K.R., Cunningham A.A., Fooks A.R., Rupprecht C.E., Wood J.L.N. and Webb C.T (2013). A comparison of bats and rodents as reservoirs of zoonotic viruses: Are bats special? *Proc Biol Sci*. 280 (1756):20122753.
- Meerburg B., Singleton, G., and Kijlstra, A. (2009). Rodent-borne diseases and their risk to public health. *Crit. Rev. Microbiol.* 35, 221–270. doi: [10.1080/10408410902989837](https://doi.org/10.1080/10408410902989837)
- Merritt J. F. (2010). *The biology of small mammals*. The Johns Hopkins University Press. Baltimore, Maryland.
- Odimegwu J. I. and Olabisi F. O. (2021). Anti-arthralgic activity of the n-hexane extract (HTp) of yellow oleander seeds; *Thevetia peruviana* (Pers.) K. Schum. doi: <https://doi.org/10.1101/2021.07.27.453963>
- Oji O. and Okafor Q.E. (2000). Toxicological Studies on Stem Bark, Leaf and Seed

5012

- Kernel of Yellow Oleander (*Thevetia peruviana*). *Phytother. Res.* 14, 133–135
- Oluwaniyi O.O. and Ibiyemi S.A. (2007). Extractability of *Thevetia peruviana* glycosides with alcohol mixture. *African Journal of Biotechnology*. Vol. 6 (18), pp. 2166-2170.
- Onuoha, C. H. and Ala, A. A. (2020). Effects of aqueous leaf extracts of *Tithonia diversifolia* and *Moringa oleifera* on haematological, biochemical and histopathological parameters in albino rats. *Journal of Medicinal Plants Research* 14.7:331–342.
<https://doi.org/10.5897/JMPR2020.6927>
- Perry N.D.; Hanson B., Hobgood W., Lopez R.L., Okraska C.R., Karem K., Damon I.K., and Carroll D.S. (2006). New invasive species in southern Florida: Gambian rat (*Cricetomys gambianus*). *Journal of Mammalogy*. 87: 262-264.
- Umakanth, M. (2017). Prevalence of yellow oleander (*Thevetia peruviana*) poisoning in eastern part of Srilanka. *Saudi Journal of Medical and pharmaceutical sciences*. 3 (10B): 1097-1100
- Witmer G. (2007). The ecology of vertebrate pests and integrated pest management (IPM). *Perspectives in Ecological Theory and Integrated Pest Management* 393–410.
<https://doi.org/10.1017/CBO9780511752353.013>
- Witmer G. (2018). Perspectives on existing and potential new alternatives to anticoagulant rodenticides and implications for integrated pest management. In *Anticoagulants and Wildlife*; van den Brink, N., Elliot, J., Shore, R., Rattner, B., Eds.; Springer: Cham, Switzerland