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Nephro- and Hepato-TOXICITY of Common Household Insecticides Used in Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author AIA conceptualized and designed the study and also wrote the manuscript. Author ACN managed the analyses of the study. Author KON managed the literature searches. Author JAE wrote the protocol while author AUM performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Background: The use of household insecticides for the eradication of insects especially mosquitoes in Nigeria is increasing. These insecticides are used without consideration of their adverse effect on human health.
Aim: This study sought to investigate the effect of common household insecticides used in Nigeria on renal and hepatic indices of Wistar rats.
Methodology: Thirty male Wistar rats were divided into five groups of six each and kept in different rooms. Rats in group 1 were exposed to Rambo, those in group 2 were exposed to Mortein, those in group 3 were exposed to Raid, those in group 4 were exposed to Baygon while those in group 5 were not exposed to any insecticide and served as the control group. The exposure was done twice a day via inhalation route. Throughout the experiment, animals were fed *ad libitum* with standard

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feed and drinking water. After twenty-one days of exposure, they were sacrificed after an overnight fast under diethyl ether as anesthesia. Blood samples were collected by cardiac puncture. Renal and hepatic indices were determined using standard methods.
Results: All the insecticides used in this study significantly increased renal and hepatic indices when compared with those of their respectively control at $P < 0.05$.
Conclusion: The result of this study showed that common household insecticides used in Nigeria have the propensity to induce nephro- and hepato-toxicity in Wistar rats.

Keywords: Household insecticides; nephrotoxicity; hepatotoxicity.

1. INTRODUCTION

Insecticides are substances used to kill, repel or mitigate one or more species of insects. They also include ovicides and larvicides used against insect eggs and larvae, respectively [1]. Insecticides are used in agriculture, healthcare, industry and by individuals. Insecticides have been reported to be a major factor behind the increase in the 20th century's agricultural productivity [2]. Nearly all insecticides have the potential to significantly alter ecosystems; many are toxic to humans and/or animals; some are accumulate in the body and bio-magnify as they pass along the food chain [2].

Insecticides can be classified into two major groups: systemic insecticides, which have residual or long term activity; and contact insecticides, which have no residual activity. The mode of action describes how the pesticide kills or inactivates a pest. It provides another way of classifying insecticides [1]. Mode of action can be important in understanding whether an insecticide will be toxic to unrelated species, such as fish, birds and mammals. Insecticides may be repellent or non-repellent. Social insects such as ants cannot detect non-repellents and readily crawl through them. As they return to the nest they take insecticide with them and transfer it to their nestmates. Over time, this eliminates all of the ants including the queen. This is slower than some other methods, but usually completely eradicates the ant colony [3]. Insecticides are distinct from non-insecticidal repellents, which repel but do not kill. The common household insecticides used in Nigeria are systemic insecticides. They include Rambo produced by Gongoin and Co, Mortein produced by Reckitt Benckiser, Raid and Baygon both produced by S.C. Johnson and Co. People use these insecticides without consideration of their adverse effect on health. Airaodion et al. [4] has previously reported that these insecticides had adverse effect on male reproductive hormones. This present study therefore sought to investigates the effect of these insecticides on renal and hepatic indices in Wistar rats.

2. MATERIALS AND METHODS

2.1 Collection of Insecticides

Baygon, Raid and Mortein insecticides were purchased from 'Pinnacle' Supermarket while Rambo was purchased from 'Medhelp' Pharmacy both in Ibadan, Nigeria. They were kept at room temperature before and during the experiment.

2.2 Experimental Design and Animal Treatment

Thirty male Wistar rats weighing between 220 and 245 g were used for this study. They were acclimatized for seven (7) days to laboratory conditions before the commencement of the experiment. During this period, they were fed *ad libitum* with standard feed and drinking water and were housed in clean cages placed in well-ventilated housing conditions (under humid tropical conditions) throughout the experiment. All the animals received humane care according to the criteria outlined in the 'Guide for the Care and Use of Laboratory Animals' prepared by the National Academy of Science and published by the National Institute of Health. They were randomly divided into five groups of six rats each and kept in different rooms. Rats in group 1 were exposed to Rambo insecticide, those in group 2 were exposed to Mortein insecticide, those in group 3 were exposed to Raid insecticide, those in group 4 were exposed to Baygon insecticide while those in group 5 were not exposed to any insecticide and served as the control group. The exposure was done twice a day *via* inhalation route. Throughout the experiment, they were fed *ad libitum* with standard feed and drinking water. After twenty-one days of exposure, the rats were sacrificed after an overnight fast under diethyl ether as anesthesia. Blood samples were collected *via* cardiac puncture.

2.3 Determination of Hepatic Indices

Aspartate Aminotransferase (AST) and Alanine Aminotransferase (ALT) activities were determined using Randox commercial Enzyme kits according to the method of Reitman and Frankel [5]. Alkaline Phosphatase (ALP) activity was determined by Phenolphthalein Mono-phosphate method described by Babson et al. [6].

2.4 Determination of Renal Indices

Creatinine concentration was determined using Jaffe reaction described by Toora and Rejagopal [7]. Urea concentration was determined using a Randox Commercial Kit based on the methods of Fesus et al. [8].

2.5 Statistical Analysis

Data were subjected to analysis using Analysis of Variance (ANOVA) with the aid of graph pad prism. Data from each parameter was expressed as mean value ± standard error of the mean (SEM). Data were considered to be significantly different at 95% confidence level ($P < 0.05$).

3. RESULTS

The results of the effect of common household insecticides used in Nigeria ALT, AST, ALP, creatinine and urea are presented in Figs.1-5 respectively.

4. DISCUSSION

The liver is the main metabolic organ in the body and is considered a viable defense system against environmental toxicants (xenobiotics) and metabolic toxins [9]. All the insecticides used in this study were observed to significantly increase the activity of AST when compared to those in control animals at $P < 0.05$ (Fig. 1). This might be due to degeneration and necrosis of hepatocytes by the insecticides, which attributes an increased permeability of the cell membrane that results in the release of transaminases into the blood stream [10,11]. This is contrary to the findings of Manfo et al. [12] who reported a nonsignificant difference in the activity of AST when they evaluated the effects of agro pesticides use on liver and kidney function in farmers from Buea, Cameroon. Similarly, the activity of ALT was significantly increased in animals treated with Rambo, Raid and Baygon when compared with those in control animals (Fig. 2). ALT is a cytosolic enzyme mainly expressed by the hepatocytes, and increased activity in serum of animals treated with Rambo, Raid and Baygon might implies lysis of the liver cells and leakage of the enzyme into the blood, and therefore a cytotoxic effect of the insecticides on the liver [12]. The increase in the activities of ALT and AST is indicative of liver alteration. AST is also found in other organs such as the heart and skeletal muscle, while ALT has low concentrations in the skeletal muscle and kidney, and is chiefly produced in the hepatocytes [13,14]. This is further sustained by exclusive localization of the ALT in cellular cytoplasm in the liver, unlike AST which is both cytosolic (20% of total activity) and mitochondrial (80% of total activity) [14]. The result of this study is in agreement with the findings of El-Nahhal [15], who reported liver alterations in farmers from Gaza following occupational exposure to pesticides. Other investigations from Shahzad et al. [16], Araoud et al. [17], and Jamal et al. [18] have also demonstrated increased ALT activity following pesticides exposure. Moreover, Khan et al. [19] observed a positive correlation between ALT activity and exposure to the pesticides cypermethrin, methomyl, and imidacloprid. Observation in this present study further supports the deleterious effect of insecticides on hepatic enzymes. A similar observation was made for ethoprophos, an insecticide that has been shown to induce hepatotoxicity in mice [20]. However, Mortein had no significant effect on the activity of ALT when compared with those in control group (Fig. 2).This might be an indication that Mortein has less hepatotoxic effect when compared with other insecticides used in this study.

Exposure of animals to insecticides in this study was observed to significantly ($P < 0.05$) increase the activity of alkaline phosphatase (ALP) when compared to those in control group (Fig. 3). ALP is a marker enzyme for the plasma membrane and endoplasmic reticulum of the tissues [21]. It is often employed to assess the integrity of the plasma membrane, since it is localized predominantly in the microvilli in the bile canaliculli, located in the plasma membrane [22]. Since ALP hydrolyses phosphate monoesters, its significant increase in animals exposed to insecticides could constitute a threat to the life of the cells that are dependent on a variety of phosphate esters for their vital process as it may lead to indiscriminate hydrolysis of phosphate ester metabolite of the liver [23]. Consequently this may adversely affect the facilitation of the

transfer of metabolites across the cell membrane of animals exposed to common household insecticides used in Nigeria.

The kidneys are mainly involved in excretion of xenobiotics and related metabolites into urine. They are especially vulnerable to damage by xenobiotics such as insecticides [24]. In this study, the integrity of the kidneys was assessed through serum creatinine and urea levels. All the insecticides used in this study significantly increased the concentrations of creatinine and urea when compared with those of animals in the control group (Figs. 4 and 5 respectively).Creatinine is derived mainly from the catabolism of creatine found in muscle tissue and its catabolism to creatinine occurs at a steady rate. Severe kidney damage will lead to increased creatinine levels. Serum creatinine is a measure of the glomerular filtration rate and is used as an index of renal function in clinical practice [25]. The elevated level of serum creatinine in this study sequel to exposure to insecticides might be an indication that the integrity of the kidney has been compromised. Hyperuricemia has also been acknowledged as

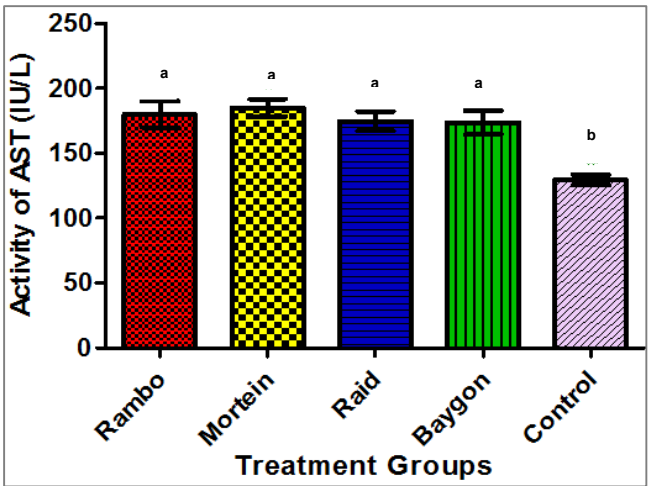

Fig. 1. Effect of household insecticides on the Activity of Aspartate Aminotransferase (AST) in animals after 21 days exposure

Results are presented as mean ± SEM with n = 6. Bars with different letters are significantly different at P<0.05

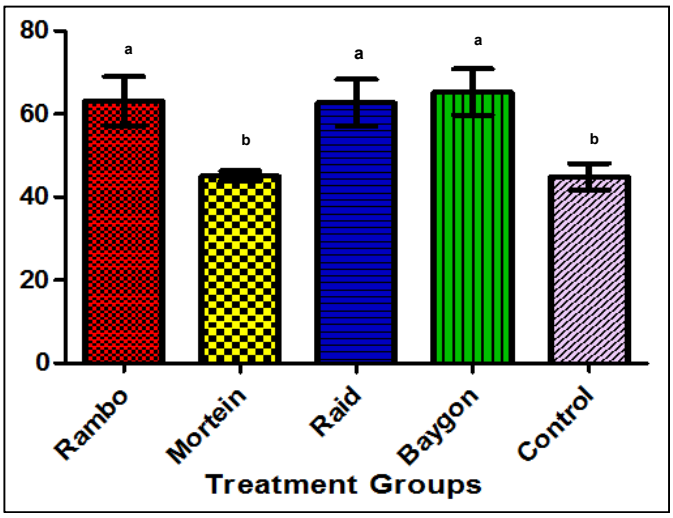

Fig. 2. Effect of household insecticides on the Activity of Alanine Aminotransferase (ALT) in animals after 21 days exposure

Results are presented as mean ± SEM with n = 6. Bars with different letters are significantly different at P<0.05

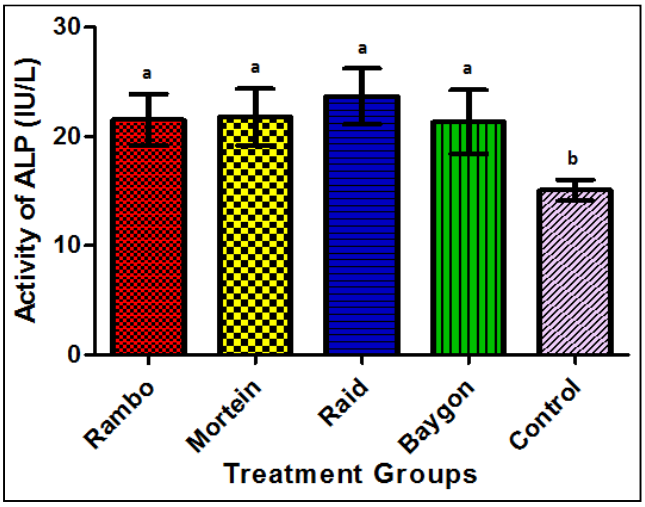

Fig. 3. Effect of household insecticides on the Activity of Alkaline Phosphatase (ALP) in animals after 21 days exposure

Results are presented as mean ± SEM with n = 6
Bars with different letters are significantly different at P<0.05

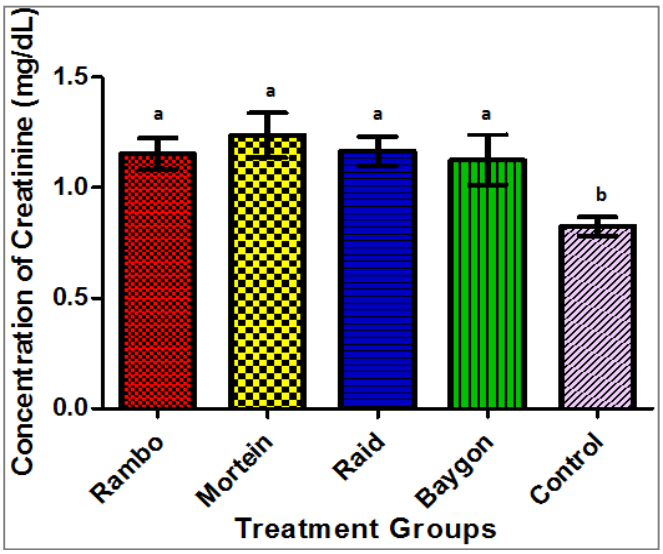

Fig. 4. Effect of Household Insecticides on the Concentration of Creatinine in Animals after 21 Days Exposure

Results are presented as mean ± SEM with n = 6
Bars with different letters are significantly different at P<0.05

an independent predictor for kidney injury [26,27]. This result is consistent with the findings of El-Nahhal [15], Jamal et al. [18] and Tanga et al. [28] who separately reported elevation in creatinine and urea levels following exposure to pesticides. This was further emphasized by Ghosh et al. [29], who elucidated a positive correlation between increased levels of pesticides in biological fluids and development of chronic kidney disease. However, the result of this study contradicts the findings of Manfo *et al.* [12] who reported a nonsignificant difference in the levels of creatinine and urea when they evaluated the effects of agro pesticides use on liver and kidney function in farmers from Buea, Cameroon.

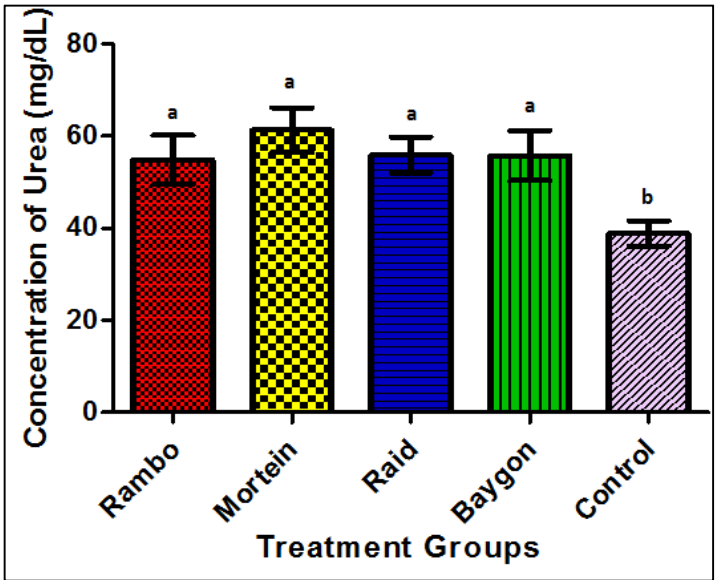

Fig. 5. Effect of household insecticides on the concentration of urea in animals after 21 days exposure

Results are presented as mean ± SEM with n = 6
Bars with different letters are significantly different at P<0.05

5. CONCLUSION

Results of this study showed that common household insecticides used in Nigeria are potential nephron- and hepatotoxic agents. Staying in a room fumigated with these insecticides when the effect has not completely subsided should be discouraged.

DISCLAIMER

The products used for this research are commonly and predominantly used products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

It is not applicable.

ETHICAL APPROVAL

As per international standard written ethical permission has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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