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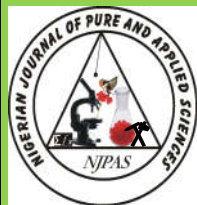
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Full Length Research Paper

Antimalarial Potentials of Aqueous root and Leaf extracts of *Axonopus compressus* in *Plasmodium berghei* infected mice

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ABSTRACT

Aqueous extracts of *Axonopus compressus* was studied as an antimalarial herbal medication in *Plasmodium berghei* infected mice. Sixty-five adult albino mice were randomly selected into eight groups (A-I). The control group (A) was not infected and received distilled water for ten days. Group (B) was infected but not treated. Group C rats were infected but treated with chloroquine. Mice in groups D, E and F were administered with 31.25, 62.5 and 125 mg/kg body weight leaf aqueous extract of *Axonopus compressus* respectively, while mice in groups GH and I received 31.25, 62.5 and 125 mg/kg body weight aqueous root extract of *Axonopus compressus* respectively upon infection with *plasmodium berghei*. Parasitaemia and chemosuppression levels in all the groups of infected mice were determined. The mice were then sacrificed ten days after the last administration and blood was collected into heparinized tube for hematological study. The results showed a significant decrease ($P < 0.05$) in the parasitaemia level and an increase in the chemosuppression in the 31.25 mg/kg b.wt leaf extract as well as 62.5 mg/kg b.wt root extract comparable to the reference drug (Chloroquine). There was also a significant increase ($P < 0.05$) in the white blood cells (WBC) and a decrease in the Red blood cell, packed cell volume (PCV), heamoglobin and lymphocyte in all the infected animal groups relative to control, extract treated groups and the chloroquine treated groups. These results therefore, suggest that the aqueous extract of *Axonopus compressus* leaf possesses antimalarial activity without causing any adverse effect on the hematological parameters.

Key words: *Axonopus compressus*, antimalarial potential, haematological parameters

Introduction

Malaria is a mosquito-borne infectious disease caused by a eukaryotic protist of the genus *Plasmodium*. It is widespread in tropical and subtropical regions, including parts of the Americas, Asia and Africa. Each year, there are approximately 350-500 million cases of malaria cases killing between one and three million people, the majority of whom are young children in sub-Saharan Africa (Snow *et al.*, 2005).

Ninety percent of malaria related deaths occur in sub-Saharan Africa. Malaria is commonly associated with poverty and can indeed be a cause of poverty and a major hindrance to economic development. Five species of the *Plasmodium* parasite can infect humans; the most serious forms of the disease are caused by *Plasmodium falciparum*. Malaria caused by *Plasmodium vivax*, *Plasmodium ovale* and *Plasmodium malariae* are milder in humans and not generally fatal. A fifth species, *Plasmodium knowlesi*, is a zoonosis that causes malaria in macaques but also infects humans (Cox-Singh, 2008).

Malaria is naturally transmitted by the bite of female anopheles mosquito. When a mosquito bites an infected person, a small amount of blood is taken, which contains malaria parasites. These develop within the mosquito and about one week later, when the mosquito takes its next blood meal, the parasites are injected with the saliva of the mosquito into the person being bitten. After a period of between two weeks and several months (occasionally years) spent in the liver, the malaria parasites start to multiply within red blood cells, causing symptoms that include

fever and headache. In severe cases the disease worsens leading to hallucinations, coma and death (Cox-Singh, 2008).

A wide variety of anti-malarial drugs are available to treat malaria. In the last 5 years, treatment of *P. falciparum* infections in endemic countries has been transformed by the use of combinations of drugs containing artemisinin derivative. Severe malaria is treated with intravenous or intramuscular quinine or increasingly, the artemisinin derivative (Dondorp *et al.*, 2007). Several drugs are also available to prevent malaria in travelers to malaria-endemic countries (prophylaxis). Resistance has developed to several anti-malarial drugs, most notably chloroquine (WHO, 2012). Malaria transmission can be reduced by preventing mosquito bites by distribution of inexpensive mosquito nets and insect repellents, or by mosquito control measures such as spraying insecticides in houses and draining stagnant waters where mosquitoes lay their eggs.

Although many are under development, the challenge of producing a widely available vaccine that provides a high level of protection for a sustained period is still to be met (Kilama, 2009). The development of resistance by malaria parasite against first line and second line anti-malarial drugs has underscored the importance to develop new drugs and pharmacophores to treat the disease. The absence of a vaccine for protection and the discovery of new drugs such as artemisinin have increased the support for malaria research. The chances of a variety of drug target and candidate molecule becoming a drug is very low and it does become necessary

to start with a large basket, identified on a rational basis.

Axonopus compressus (Carpet grass) has been known to possess some therapeutic and healing properties. For example, the plant has been used to help to stop bleeding (including bleeding from the mucous membranes) and to control excess menstrual flow. It has also been used to relieve colitis, hemorrhoids, diarrhoea, dysentery, vomiting and bed wetting in children and incontinence in the aged (Wunsch et al., 2005)[6]. Ethnobotanical survey shows that decoction of the plant is used in the treatment of malaria locally. However, there has not been any publication of any research work that has been carried out so far on its antiplasmodial properties, hence this study.

Therefore, this study aims to focus on the antimalarial potential of *Axonopus compressus* leaf and root extracts in *Plasmodium berghei* infected mice as well as the effect on hematological parameters in the blood.

Materials and Methods

Plant materials

Samples of *Axonopus compressus* plant were collected from the bushy environment of University of Ilorin, Ilorin, Nigeria and it was authenticated at the herbarium unit of the Department of Plant Biology, University of Ilorin, Ilorin, Nigeria and assigned voucher number UILH/001/1221. A voucher specimens was equally deposited in the Department of Plant Biology. The plant was washed and the leaf separated from roots by cutting with knife.

Animals

The forty-five (45) albino mice with an average weight of 19 ± 2 g used for this study were obtained from the small animal holding unit of the Department of Biochemistry, University of Ilorin, Ilorin, Nigeria. They were maintained in standard conditions of temperature, relative humidity and light/night cycles. They were allowed free access to commercial pelleted rat chow (Bendel Feeds Ltd, Ewu, Nigeria) and water *ad libitum*.

Drugs and Reagents

Chloroquine diphosphate was a product of May and Baker Pharmaceutical company Limited, Nigeria, while Giemsa stain (stock solution) and immersion oil were products of Anosantec Laboratories, UK and Panzonal Laboratory supplies, Button road, Canada respectively. Hematocytometer was a product of Super Main Field, Germany. All other reagents used were of analytical grade and were prepared in all-glass distilled water.

Malaria parasites

A chloroquine sensitive strain of *Plasmodium berghei* (NK-65) was obtained from the Institute for Advanced Medical Research and Training (IAMRAT), College of Medicine, University of Ibadan, Oyo state. Parasites were maintained through weekly blood passage in mice.

Methods

Preparation of aqueous root and leaf extract of *Axonopus compressus* plant

Axonopus compressus root and leaf were air dried to a constant weight and milled into powder with electric milling machine. 200g of the extract were extracted in 1.6 litres of

distilled water for 48 hours. This was then filtered using Whatman No. 1 filter paper and the filtrate was freeze dried at Landmark University, Omu-Aran, Kwara state. The sample was reconstituted in distilled to give the 31.25, 62.5 and 125 mg/kg b. wt of the extract for both the leaf and the root that was used for the experiment.

Secondary metabolites screening

The secondary metabolites of *Axonopus compressus* root and leaf extract were determined using standard procedures described by Harbone (1973); Sofowora (1993), Trease and Evans (1989).

Animal groupings and treatments

The ten (10) day suppressive test was carried out according to the procedure described by David et al. (2006). Forty-five (45) mice were randomly assigned into nine groups of five each (n = 5) as follows:

Group A (Control): Not infected and administered with distilled water

Group B: Infected with *Plasmodium berghei* (NK-65) and administered with distilled H₂O

Group C: Infected and administered 20 mg/kg body weight of Chloroquine.

Group D: Infected with *Plasmodium berghei* (NK-65) and administered 31.25 mg/kg body weight aqueous leaf extracts of *Axonopus compressus* plant

Group E: Infected with *Plasmodium berghei* (NK-65) and administered 62.5 mg/kg body weight aqueous leaf extracts of *Axonopus compressus* plant

Group F: Infected with *Plasmodium berghei* (NK-65) and administered 125 mg/kg body weight aqueous leaf extracts of *Axonopus compressus* plant

Group G: Infected with *Plasmodium berghei* (NK-65) and administered 31.25 mg/kg body weight aqueous root extracts of *Axonopus compressus* plant

Group H: Infected with *Plasmodium berghei* (NK-65) and administered 62.5 mg/kg body weight aqueous root extracts of *Axonopus compressus* plant

Group I: Infected with *Plasmodium berghei* (NK-65) and administered 125 mg/kg body weight aqueous leaf extracts of *Axonopus compressus* plant.

Thin blood smear was prepared from the tail vein of the infected mice on the fifth day after treatment. The blood smears were fixed with methanol, stained with 10% Giemsa for 15 minutes and rinsed with distilled water.

Number of parasitized and non-parasitized erythrocytes were counted through the oil immersion objective (x 100) light microscope from which percentage Parasitaemia and percentage chemosuppression was computed as described by (Okokkon et al., 2005) using the following expressions:

$$\% \text{ Parasitaemia} = \frac{\text{Parasitized Red Blood Cell}}{\text{Parasitized Red Blood Cell} + \text{Non-Parasitized Red Blood Cell}} \times 100$$

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$$\% \text{ Suppression} = \frac{\text{Parasitaemia in negative control} - \text{Parasitaemia in study group}}{\text{Parasitaemia in negative control}} \times 100$$

$$\text{Average percentage Suppression} = \frac{\text{Parasitaemia of control} - \text{Parasitaemia of test group}}{\text{Parasitaemia of control}} \times 100$$

After the experimental period of ten days, animals were sacrificed and venous blood was collected into sample bottles containing anticoagulant as earlier reported (Adebayo *et al.*, 2003) for haematology study.

Statistical analysis

The Statistical analysis was carried out by one-way analysis of variance and Duncan Multiple Range test. P values <0.05 were considered significant.

Result and Discussion

The secondary metabolites detected in *Axonopus compressus* aqueous leaf and root extracts were Alkaloids Saponins, Phenolics, Cardiac glycosides, Tannins, Phlobatannins, and steroids (Table 1). The leaf extract has appreciable amount of Saponins and Phenolics and a moderate amount of Flavonoids and Alkaloids while the root extracts shows an appreciable amount of Alkaloids, Saponins and Flavonoids and a moderate amount of Tannins, Phenolics, while cardiac glycosides is present in trace amount.

Table 1: Secondary metabolite contents of the leaf and root of aqueous extract of *Axonopus compressus* plant

Secondary parameters	metabolite	Concentration (mg/dl) Leaf	Concentration (mg/dl) Root
Alkaloids		15.50 ± 0.01	34.23 ± 0.03
Saponins		35.50 ± 0.01	36.14 ± 0.01
Tannin		13.30 ± 0.02	16.12 ± 0.02
Anthraquinones		0.00 ± 0.00	0.00 ± 0.00
Steroids		0.20 ± 0.02	0.12 ± 0.01
Cardinolides		0.00 ± 0.00	0.00 ± 0.00
Terpenes		0.00 ± 0.00	0.00 ± 0.00
Phenolics		29.70 ± 0.01	14.38 ± 0.15
Cardiac Glycosides		1.70 ± 0.01	12.48 ± 0.03
Phlobatannins		1.40 ± 0.01	1.86 ± 0.01
Flavonoids		12.35 ± 0.03	37.21 ± 0.05
Chalcones		0.00 ± 0.00	0.00 ± 0.00

The secondary metabolite screening results above reveals that the plant is quite rich in phytochemicals with Saponins been the most abundant

Table 2: Percentage Parasitaemia and Chemosuppression in Mice treated with aqueous extracts *Axonopus compressus*

Groups	% Parasitaemia (% Chemosuppression)				Remarks
	Day 4	Day 6	Day 8	Day 10	
B (Infected untreated)	3.52 (0)	4.52 (0)	4.72 (0)	5.06 (0)	
C (Infected and treated with Chloroquine)	0.30 (91.4)	0.25 (94.4)	0.11 (97.6)	0.09 (98.2)	
D (Infected and treated with 31.25mg/kg b.wt of root extract)	2.79 (20.74)	3.33 (26.3)	3.67 (22.2)	3.67 (27)	Not effective for treatment
E (Infected and treated with **62.5mg/kg b.wt of root extract)	0.50 (85.7)	0.48 (89.3)	0.26 (94.4)	0.22 (95.6)	Effective for treatment
F (Infected and treated with **125mg/kg b.wt of root extract)	2.98 (8.30)	3.21 (28.9)	2.74 (41.9)	3.52 (30.8)	Not effective for treatment
G (Infected and treated with 31.25mg/kg b.wt of leaf extract)	0.45 (86.1)	0.42 (90.7)	0.24 (94.4)	0.15 (97.0)	Effective for treatment
H (Infected and treated with 62.5 mg/kg b.wt of leaf extract)	3.41 (3.12)	3.12 (30.9)	3.58 (24.1)	3.58 (29.2)	Not effective for treatment
I (Infected and treated with 125mg/kg b.wt of leaf extracts)	2.88 (18.18)	2.69 (40.4)	2.98 (36.8)	4.23 (16.48)	Not effective for treatment

Values are average counts of five mice

****Not safe: About 50% of the Swiss albino mice in these groups died**

The percentage parasitaemia count (Table 2) in infected untreated mice, infected mice treated with 31.25, 62.5 and 125 mg/kg of *Axonopus compressus* leaf and root extracts and infected mice treated with 20 mg/kg chloroquine diphosphate for days 4, 6, 8 and 10. It also shows the percentage chemosuppression caused by various doses of the *Axonopus compressus* root and leaf

plant extracts and 20 mg/kg body weight of chloroquine for 4,6, 8 and 10 days respectively. Groups E and G showed the highest percentage chemosuppression (Table 3) on day 4,6, 8 and day 10 among the other extract treated groups. Therefore, 62.5 mg/kg body weight of the root extract and 31.25 mg/kg body weight leaf extract are the most effective doses.

Table 3: Hemoglobin indicators of Mice treated with the aqueous extracts of *Axonopus compressus*

GROUPS	PCV (%)	Hb (g/L)	RBC (x 10 ¹² /L)	MCV (fl)	MCH (pg)	MCHC (g/dl)
Control	42.25 ± 0.75 ^{bc}	12.55 ± 0.47 ^b	7.50 ± 0.32 ^b	52.75 ± 1.97 ^a	17.75 ± 0.75 ^a	29.75 ± 0.63 ^a
Infected+standard drug	25.75 ± 1.32 ^a	7.60 ± 0.32 ^a	4.50 ± 0.25 ^a	52.00 ± 1.35 ^a	20.75 ± 1.65 ^b	32.00 ± 0.71 ^a
Infected+31.25mg/kg b.wt of Root extract	44.75 ± 0.85 ^{bc}	13.32 ± 0.35 ^{bc}	8.55 ± 0.12 ^{bc}	51.25 ± 0.63 ^a	15.25 ± 0.25 ^a	30.00 ± 0.41 ^a
Infected+62.5mg/kg b.wt of Root extracts	48.00 ± 0.41 ^c	14.32 ± 0.16 ^c	8.72 ± 0.23 ^c	52.00 ± 0.82 ^a	16.00 ± 0.41 ^a	30.50 ± 0.50 ^a
Infected+125mg/kg b.wt of Root extracts	46.50 ± 1.9 ^{bc}	13.86 ± 0.56 ^{bc}	8.68 ± 0.18 ^c	52.50 ± 0.43 ^a	15.75 ± 0.48 ^a	29.50 ± 0.289 ^a
Infected+31.25mg/kg b.wt of leaf extracts	44.00 ± 4.34 ^{bc}	13.90 ± 0.51 ^{bc}	8.23 ± 0.28 ^{bc}	52.25 ± 0.11 ^a	15.75 ± 0.48 ^a	29.75 ± 0.25 ^a
Infected+62.5mg/kg b.wt of leaf extracts	47.25 ± 0.85 ^{bc}	14.00 ± 0.33 ^{bc}	7.65 ± 0.41 ^b	51.50 ± 0.30 ^a	15.50 ± 0.29 ^a	30.75 ± 0.75 ^a
Infected+125mg/kg b.wt of leaf extracts	41.00 ± 2.35 ^b	12.73 ± 0.69 ^b	7.64 ± 0.41 ^b	52.50 ± 0.43 ^a	18.00 ± 1.29 ^a	30.25 ± 0.21 ^a

Results are means of 5 determinations ± SEM. Means along the same column with different superscript letters are significantly different (P<0.05).

PCV: Packed Cell Volume, Hb: Heamoglobin, RBC: Red Blood Cell, MCV: Mean Corpuscular Volume, MCH: Mean Corpuscular Heamoglobin, MCHC: Mean Corpuscular Heamoglobin Concentration

Table 4: White blood cell and platelet counts in mice treated with the aqueous extracts of *Axonopus compressus*

GROUPS	WBC ($\times 10^3/L$)	Platelets ($\times 10^5/L$)	Neutrophils (%)	Lymphocytes (%)
Control	4.53 ± 0.023^a	6.41 ± 0.32^c	22.00 ± 3.90^a	70.00 ± 5.28^b
Infected+standard drug	12.500 ± 0.83^d	1.48 ± 0.47^a	50.50 ± 2.02^b	41.10 ± 3.12^a
Infected+31.25mg/kg b.wt of root extracts	6.65 ± 0.53^c	4.57 ± 0.60^b	59.75 ± 3.68^b	31.75 ± 2.84^a
Infected+62.5mg/kg b.wt of root extracts	6.2 ± 0.30^c	4.88 ± 0.16^b	53.25 ± 2.50^b	37.25 ± 2.59^a
Infected+125mg/kg b.wt of root extracts	6.43 ± 0.18^c	4.40 ± 0.12^b	51.50 ± 1.94^b	38.50 ± 2.90^a
Infected+31.25mg/kg b.wt of leaf extracts	6.30 ± 0.22^c	4.36 ± 0.07^b	56.75 ± 3.28^b	36.00 ± 3.11^a
Infected+62.5mg/kg b.wt of leaf extracts	5.90 ± 0.25^b	4.53 ± 0.12^b	58.25 ± 1.11^b	35.50 ± 2.63^a
Infected+125mg/kg b.wt of leaf extracts	0.01 ± 0.24^a	6.22 ± 0.47^c	19.00 ± 3.49^a	75.50 ± 3.02^b

Results are means of 5 determinations $\pm$ SEM. Means along the same column with different superscript letters are significantly different ($P < 0.05$).

WBC: White Blood Cell

There was a significant increase ($P < 0.05$) in the white blood cells (WBC) of the infected animals compared to control, extract treated groups and chloroquine treated group. There is also a decrease in packed cell volume (PCV) and hemoglobin in all the infected animal groups when compared with control, extract treated groups and chloroquine treated group. Lymphocyte level significantly decreased ($P < 0.05$) in infected untreated mice as well

as all the extract infected treated groups and chloroquine, while there was the same level of significant increase ($P < 0.05$) in both control and the 125 mg/kg b. wt of leaf. Neutrophils level also showed significant increase ($P < 0.05$) in infected untreated group, all the extract infected treated groups and chloroquine treated group and a significant decrease ($P < 0.05$) in control. Platelet level showed a significant increase in infected untreated group, all extract infected treated groups and chloroquine

treated group while control and 125mg/Kg b. wt group showed the same level of significant decrease ($P < 0.05$). There was no significant difference ($P > 0.05$) in the levels of MCH, MCV, MCHC between the chloroquine treated group and control animals. There was also no significant difference ($P < 0.05$) in MCH, MCV and MCHC among all the extract treated groups and control as shown in (Table 3 and 4).

Discussion

Plant secondary metabolites have been linked to the therapeutic activity of medicinal plants (Adimoelja, 2000). The secondary metabolites screening of *Axonopus compressus* plant root and leaf have revealed the bioactive agent(s) alkaloids, phenolics, saponins, cardiac glycosides, tannins, anthraquinones, steroids and phlobatannins. These non-nutritive plant-derived substances act as precursors for chemo-pharmaceutical semi-synthesis and are known to elicit different pharmacological and toxicological effects in man and animal (Bernhoft, 2010). The antiparasmodial activity of crude plant extracts has been attributed to secondary metabolites of diverse chemical structures belonging to the classes of alkaloids, terpenes, flavonoids, xanthenes, quinines, limonoids, chalcones, coumarins, and related compounds (Batista *et al.*, 2009). Several plant-derived chemical compounds

pertaining to these secondary metabolites have been isolated and their antiparasmodial/antimalarial activity tested on different parasite strains *in vitro* and *in vivo* (Batista *et al.*, 2009). Alkaloids are the most efficient therapeutically significant plant metabolite. Pure isolated alkaloids and the synthetic derivatives are used as antiparasmodial (Njoku and Akumefula, 2007). The presence of phlobatannins may suggest diuretic property of the plant extract (Awoyinka *et al.*, 2007). The steroid content of the plant extract may serve as anti-inflammatory and analgesic agent (Singh, 2006). Anthraquinones have wide applications as immunosuppressive, immunostimulant, anti-ulcer, antioxidant (Sun *et al.*, 2000) and anti-microbial activity (Wang and Chung, 1997). It is also involved in the induction of water and electrolyte secretion and as well as peristalsis in colon (Bernhoft, 2010).

The determination of percentage inhibition of parasitaemia is the most reliable parameter in standard test for antiparasmodial screening. Mean group parasitaemia level of less than or equal to 90 percent of the control animals usually indicate that the test plant extract is active (Peter and Anantoli, 1998). The parasite strain used for the study was chloroquine sensitive hence chloroquine was adopted as the reference drug. When standard antimalarial drug is used in mice infected

with *P. berghei*, it suppresses parasitaemia to a non-detectable level (Keiseko *et al.*, 2000); this was in agreement with the effect of chloroquine in this study. The two extract at the three doses tested, significantly decreased percentage parasitaemia in a dose-independent manner, most active at the 31.25mg/kg body weight for the leaf and 62.5mg/kg body weight for the root and significantly compare with chloroquine. Secondary metabolites such as alkaloids, tannins, Phenolics and Anthraquinones and their related compounds have been implicated in the antiplasmodial activity of crude plant extracts (Batista *et al.*, 2009 Kaur *et al.*, 2009). Alkaloids from different plants have been isolated and their antiplasmodial activity reported (Adebayo and Krettli, 2011; Kaur *et al.*, 2009). They are believed to block protein synthesis in the parasite's apicoplast ribosome via structure-related interaction (Abdullelah and Zainab-abidin, 2007). Steroid saponins have also been found to be detrimental to several infectious protozoans such as *Plasmodium berghei* (Nafiu *et al.*, 2015)

Therefore, the reduction in parasitaemia level by the aqueous root and leaf extract of *Axonopus compressus* plant at all the doses tested might be due to the presence of secondary metabolites such as alkaloids, tannins, Saponins, Phenolics and Anthraquinones interacting together to form a therapeutic unit and thereby eliciting its

antiplasmodial activity, hence, its usage for the treatment of malaria in folk medicine. The antiplasmodial mechanism of action of *Axonopus compressus* plant might include one or more of the following; (i) inhibition of haemozoin polymerization in the parasite (ii) intercalation with the parasite DNA, (iii) inhibition of parasite's glycolytic lactate dehydrogenase for energy generation (iv) alkylation (v) interference with the formation of mitotic spindles and the assembly of microtubules into typical axonemes in gametes, thus inhibiting the formation of mobile microgametes; (vi) inhibition of proteolytic processing of circumsporozoite protein by a parasite-derived cysteine protease, thereby preventing sporozoite invasion of host cells (Adebayo and Krettli, 2011, Karou *et al.*, 2007). The reduction in parasitaemia by the extract was not dose dependent as higher doses failed to produce less parasitaemia level. This might be possibly due to the toxic effect of the plant extract associated with other metabolites of the extract. Also, the metabolism of alkaloids can generate reactive intermediates which on the negative side, produce reactive species capable of eliciting damage to cells, organs etc. and consequently, their toxicological effects.

Similarly, the chemo-suppression of parasite multiplication by the extract was best at the lowest dose in the leaf extracts when compared with that of the chloroquine.

This might be due to the synergistic role of the plant secondary metabolites interacting to form phytocomplex (Bernhoft, 2010), reported that *Eurycoma longifolia* and *Ardisia crispa* exhibited potent anti-malarial activities with 80 percent parasitaemia inhibition at 10mg/kg. The observed antiplasmodial activity of the aqueous extract of *Axonopus compressus* root and leaf plant is consistent with the traditional use of the plant as herbal medication against malaria as claimed (Asase, *et al.*, 2010).

Assessment of haematological parameters can be used to determine the extent of deleterious effect of foreign compound on the blood. It can also be used to explain blood relating functions of biochemical compound (Yakubu *et al.*, 2007). Haematological parameters can also be used to investigate and determine blood diseases that affect the production of blood and its components such as PCV, RBC, WBC, Neutrophils, Lymphocytes and so on. Aneamia is a fairly common problem encountered in malaria. This is evidenced by the decrease in the levels of red blood cells (RBCs), PCV and heamoglobin in all the infected untreated animal group (Table 3). The observed decreases can be due to multiple causes. Repeated haemolysis of infected red cells is the most important cause for the reduction in heamoglobin levels. Massive destruction of red cells account for rapid development of anaemia in

P. falciparum malaria. Decrease in Hb might also be an indication of reduction in RBC size, impaired biosynthesis of human in the bone marrow and reduction in production of RBC (Sturrock *et al.*, 1996). However, the root and the leaf extracts tend to ameliorate the effects observed in the infected-untreated group. Consequently, the infected and extract treated groups shows an increase in the RBC, PCV and heamoglobin concentration with much of the increase seen at 62.5mg/kg b.wt of the group administered with the root extracts and that of the 31.25 mg/kg b.wt of the group administered with the leaf extract.

The non-significant difference ($P < 0.05$) of the indices relating to RBC of the extract treated groups at various doses suggest that the extract level had no effect on the average size of RBC (microcytes) and also in the haemoglobin weight per RBC (Table 4).

There was an observed significant increase ($P < 0.05$) in the level of WBC in the infected group (Table 4). White blood cells function mainly to fight infection, defend the body by phagocytosis against invasion of foreign organisms, and to produce, transport and distribute antibodies in the immune response. The observed increase in the level of white blood cells in the infected animal groups may be as a result of stimulation of immune system of the animals to fight the

antimalarial parasites. There was a significant decrease in the level of white blood cells in all the infected – extract treated groups at various doses and infected – chlorine treated group. This may imply a reduction in the ability of the body to respond to infection due to the infection (Yakubu *et al.*, 2006).

The observed low lymphocyte in all the infected extract treated groups and chloroquine infected treated group compared with control and most effective group is an indication that inhibition of T and B lymphocyte in the mice through the blocking of amino acid uptake stimulated lymphocyte (Nahas *et al.*, 1974). Lymphocytes are also the main effector cells of the immune system.

Decreased platelet (thrombocytopenia) is also fairly common in malaria. This may be related to the sequestration of the platelets in the spleen (Kakkilaya, 2006). The infected extract treated groups and infected chloroquine treated groups also showed an increase in the levels of platelets. The observed significant increase in the level of platelets in uninfected-extract treated group (most effective group) showed a reversible trend with a significant decrease comparing

favourably with the normal control (Table 4).

Conclusion

From this study, there is evidence in support of the use of the leaf extract in treating malaria as used traditionally. However, the presence of cardiac glycosides in the root extract may account for its toxicity despite the antimalarial activity.

Declaration of interest

Authors declare that there is no conflict of interests.

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