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MOLLUSCICIDAL POTENTIAL OF *Tetrapleura tetraptera* AND *Spondias mombin* AGAINST *Bulinus globosus*

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ABSTRACT

Background: Schistosomiasis is a neglected tropical disease of major global concern. Resistance to praziquantel, the primary drug used for schistosomiasis control, has been reported in endemic regions, highlighting the need for alternative strategies such as snail vector control.

Objectives: This study evaluated the molluscicidal activity of cold water, hot water, and methanolic extracts of *Spondias mombin* and *Tetrapleura tetraptera* against *Bulinus globosus*, the intermediate host of urinary schistosomiasis.

Methods: Snails were exposed to varying extract concentrations (10–250 mg/L) for 24 hours.

Results: Results showed that all extracts of *T. tetraptera* exhibited significant molluscicidal activity, with LC_{50} values as low as 10 mg/L and LC_{90} values between 50 and 100 mg/L. In contrast, *S. mombin* showed moderate activity only at higher concentrations (150–250 mg/L), with LC_{50} and LC_{90} values of 150 mg/L and 200 mg/L, respectively.

Conclusion: Based on World Health Organization (WHO) guidelines, *T. tetraptera* meets the criteria for an effective plant-based molluscicide and could serve as a locally available alternative to synthetic agents such as niclosamide.

Keywords: *Bulinus globosus*, molluscicidal, plant extracts, *Tetrapleura tetraptera*, *Spondias mombin*

INTRODUCTION

Schistosomiasis is a neglected tropical disease (NTD) and the second most common socio-economically devastating parasitic disease after malaria (Akinneye *et al.,* 2018), that affect about 240 million residents of developing countries. It is an acute and chronic disease caused by blood flukes (trematode worms) of the genus S*chistosoma*. Mujumbusi *et al*. (2023) reported that schistosomiasis is a serious global-health problem with over 230 million people requiring treatment, of which the majority live in Africa. The disease usually affects people living in regions like the Middle East, Corsica (France) and Africa (WHO, 2023). It is regarded as disease of poverty because it particularly affects poor communities that lack clean water, adequate sanitation and readily-available medical treatment (Mutsaka-Makuvaza *et al.,* 2020).

The adverse effects of this disease are considered to cause more disabilities than killing its victims (WHO, 2023), as it usually results into anaemia, slow growth and reduction in the learning ability of children. These can later degenerate to chronic case and may lead to people's inability to work and can even lead to death in some cases (WHO, 2022). It is estimated that at least 90% of those requiring treatment for schistosomiasis live in Africa, Deol *et al*., (2019), while Lackey and Horrall (2021) described *S. haematobium* as a recognized carcinogen and the second leading cause of bladder cancer worldwide. Santos *et al*. (2021) described urinary schitosomiasis as a factor responsible for female genital schistosomiasis leading to infertility and higher risk of human immunodeficiency virus (HIV) transmission.

The life cycle of schistosomes is complex and involves both snail belonging to the genus *Bulinus* and human hosts, typically a human (Aula *et al*., 2021). In human, infection is initiated by the penetration of *S. haematobium* cercariae through intact skin that is in contact with infested fresh water. The cercariae penetration of unbroken human skin is brought about by the help of their glandular secretions. Obare *et al.* (2016) highlighted that schistosomiasis transmission can be interrupted at four distinct points: sanitation; broadly-snail control; reduction of water contact; mass or targeted chemotherapy. In addition, Maguire (2020) posited that transmission of schistosomiasis in endemic communities can be interrupted by provision of sanitation and safe water supplies and elimination of snail intermediate hosts or their habitats, hence the persons with safe water and adequate sanitation are at lower risk of infection.

Snail management can be helpful because it reduces the number of intermediate snail hosts and this can be achieved through the application of molluscicide. Vaccine could have been the best alternative to prevent schistosomiasis but it was reported by Nelwan (2019) that there was no schistosomiasis vaccines available as at the time of his report. In addition, Molehin *et al*. (2022) revealed that a large number of vaccine candidates have been identified but very few have made it to clinical trials, and that they may not provide the level of protective immunity that might be required.

However, the use of plant materials in the treatment of various diseases is an age long practice, in which different plant parts have been used in the management of one ailment or another. The different parts used are; leaves, stem, back, fruits, flower, roots and sap. Studies have been carried out globally to verify their efficacy and some of the findings have led to the production of plant-based medicines. Medicinal plants play vital roles in disease prevention, their promotion and use fit into all existing prevention strategies (Sofowora, *et al.,* 2013). The usage cut across all the continents of the world and Africa is not left out. According to Okoye *et al*. (2014), about 80% of the world's population still depends solely on traditional or herbal medicine for treatment of diseases, mostly in Africa and other developing nations while Adeneye (2014) reported that herbal medicine provides for about 30% of many rural populations globally.

Among the plants use for treatment of ailments are *Spondias mombin*, which is also known as yellow mombin and *Tetrapleura tetraptera. S. mombin* Linn (*Anacardiacea*) (Maria *et al.,* 2022), has been documented for its antimicrobial and molluscicidal phenolic acids health care needs (Corthout *et al*., 1994). It is a plant with versatile folklore uses and is reputed, among other claims, to be effective in the treatment of inflammatory conditions, wounds, and infections (Nworu *et al.,* 2011). The juice of the crushed leaves and the powder of dried leaves are used as dressings on wounds and sites of inflammation, Faluyi (2021).

Informations on the ethnopharmacological and nutritional value of *Tetrapleura tetraptera* have been documented by (Akintola *et al*., 2015; Adesina *et al*., 2016). The stem, back, leaf and fruit of *T. tetraptera* have been exploited for their potentials as anti-inflamatory, antimicrobial, molluscicidal agents and all these have been documented by different authors. The anti-inflammatory and hypoglycemic activity of *T. tetraptera* was documented by Ojewole and Adewunmi (2004). Aderibigbe *et al*. (2007) confirms the anticonvulsant, analgesic and hypothermic effects of the plant. Its use in the management of diseases like leprosy, convulsion, inflammation, dermatological problems, hypertension, diabetes, asthma, post-partum care, wound healing etc was reported by Faluyi (2020).

However, since re-infection with schistososme's cercariae is the major challenge in schistosomiasis, there is the need to break the infection cycle by getting rid of the snail intermediate host, the *Bulinus globosus.* This can be achieved by the use of plant materials and some chemicals. In view of the above, this study aimed at determining the molluscicidal activity of the two selected plants: *S. mombin* and *T. tetraptera.*

MATERIALS AND METHODS

Collection and Preparation of Plant Extracts

The leaves of *Spondias mombin* were harvested from a community in Akure metropolis while the fruits of *Tetrapluera tetraptera* were bought from the Oba's Market (Oja Oba) in Akure. All the plant materials were identified and authenticated at the Herbarium of the Department of Plant Science, Ekiti State University Ado-Ekiti. The leaves of *S. mombin* were air dried for about two weeks, then ground into powder (Ogbeide *et al*. 2020) using mechanical grinder and the resultant powder was packed and stored in plastic containers. The fruits of *T. tetraptera* were cut into smaller bits, blended into paste and also stored in plastic containers for further use.

The marceration method as described by Abubakar and Haque (2020) was used for the extraction of the plant materials with the aid of three solvents (cold water, hot water and methanol) in plant/solvent ratio of 1:10 (w/v). For cold water extraction, 300g of the powdered plant sample was introduced into 3 L of cold water at the ratio of 1:10, and left for 72 h with occasional agitation. So also for hot water extraction, 300g of the plant powder was mixed with 3 L of water at the same ratio 1:10 (w/v) and was brought to boil for 10 mins. The same ratio was repeated for methanol extraction as the plant powders were immersed in the analytical grade of each solvent and left for 72 h with occasional agitation. Thereafter, the mixtures were filtered using sterile muslin clothes that have been double folded. The filtrates were concentrated using vacuum rotary evaporator (RE -52A, PEC MODEL USA) and the concentrated extracts were stored in refrigerator (4 ^{O}C) for further use.

Collection of Snails (*Bulinus globosus*)

The snails**,** *Bulinus globosus* which is the intermediate host of urinary schistosomiasis were collected from six different contact sites along river Awo which happened to be their natural habitat in Ita-Oniyan with the aid of scoop nets and by hand picking them directly from freshwater vegetation (Falade and Otarigho, 2015) for 30 min - 1 hr. They were taken in plastic containers with net covers to the Biology Laboratory of the Federal University of Technology, Akure for identification and analysis. The snails were identified based on shell morphology using identification key developed by Mandahl-Barth for the identification of East and Central African snails of medical and veterinary importance (Owiny *et al.,* 2019). After sorting the *B. globosus* from other snails, 10 snails were kept in each plastic container containing aged water from the river and were fed with dried lettuce. Thereafter, all the containers with snails were kept in the dark part of the laboratory cupboard for another 3 days in order for them to get acclimatized to their new environment. They were later washed with distilled water, arranged in 2s in each of 100 ml beakers containing fresh distilled water. They were exposed to sunlight for about 2 hr for them to shed cercariae (Owiny *et al*., 2019). Examination for cercariae shedding was done using dissecting microscope as described by Amoani *et al*. (2015).

Moluscicidal Activity of the Plant Extracts

The plants were evaluated for molluscicidal activity on adult *Bulinus globosus* snails by placing a group of 2 snails in a glass beaker holding 50 ml of distilled water. *Snails were exposed to each concentration for 24 hours while being fed with dried lettuce.* Different concentrations; 10 mg/litre, 50mg/litre, 100mg/litre, 150mg/litre, 200mg/litre and 250mg/litre of the hot and cold water and methanol extracts of the four plants were prepared. A 1 mg/litre of niclosamide (98% High Performance Liquid Chromatography (HPLC) produced by AK Scientific Union City CA 94587, USA) according to the method of Kindiki *et al.* (2016) was prepared and used as positive control while a beaker containing only 50 ml distilled water was used as negative control. After the expiration of 24 hrs, all the contents of the beakers were discarded and replaced with 50 ml of the different concentrations of the plant extracts, with positive and negative controls. All these were done in duplicates. The preparations were left for 24 hrs without feeding the snails and at the end of 24 hrs, all the contents of the beakers were discarded and replaced with distilled water. All these were left for another 24 hrs for observation in case of any changes in the snails. The observation was performed by pocking the snails with office pins and lack of motion was taken as the sign that the snail was dead.

Both qualitative and quantitative analysis of phytochemicals like Total flavonoid, glycosides, saponin, steroid and tannin were determined according to the methods of Nkop *et al.* (2020), as reported by Kone *et al*. (2022).

RESULTS

Each snail in the control beaker initially withdrew to its shell but resumed normal movement in the beaker after about 10 minutes and whenever an office pin was applied to its footsole, the snail would retract to its shell. In the beakers containing the treated snails, they were seen initially moving out of the solutions but later became inactive. With higher concentrations of *T. tetraptera*, the snails were seen to be immobile immediately they had contact with the solutions. Another observation was that the snails were salivating and the extracts were coagulating in the solution containing *S. mombin* extracts.

Table 1: Molluscicidal activity of the plant extracts

Treat-ments	Concentration (mg/L) i. e. ppm											
	10		50		100		150		200		250	
S.C	ND	ND	ND	ND	ND	ND	T	H	T	T	T	T
S,H	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
S.M	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
T.C	H	H	T	T	T	T	T	T	T	T	T	T
T.H	ND	ND	H	H	T	T	T	T	T	T	T	T
T.M	H	H	T	T	T	T	T	T	T	T	T	T

KEY: S.M: *Spondias mombin* methanol, S.C: *Spondias mombin* cold water, S.H: *Spondias mombin* hot water, T.C: *Tetrapluera tetraptera* cold water, T.H: *Tetrapluera tetraptera* hot water, T.M: *Tetrapluera tetraptera* methanol, ND; No death, T; 100 % death, H; 50 % death

Table 2: Lethal Dosages of Varying Concentrations of the Extracts

Solvent type	S. mombin		T. tetraptera	
	LC_{50}	LC_{90}	LC_{50}	LC_{90}
Methanol (ppm)	-		10	50
Coldwater(ppm)	150	200	10	50
Hot water(ppm)	-		50	100

Table 3: Results of quantitative analysis of phytochemicals in plant extracts

Ex-tracts	Phytochemicals (mg/g)				
	Flavonoid	Tannin	Steroid	Glycoside	Saponin
S.C	8.16 ± 0.02^{a}	5.39 ± 0.01^{b}	17.80 ± 0.04^{a}	11.51 ± 0.05^{a}	14.36 ± 0.26^{c}
S.H	7.88 ± 0.02^{b}	5.29 ± 0.01^{b}	17.31 ± 0.04^{a}	10.93 ± 0.05^{b}	11.09 ± 0.26^{d}
S.M	3.98 ± 0.13^{c}	6.59 ± 0.52^{a}	10.32 ± 0.78^{b}	1.65 ± 0.14^{c}	51.46 ± 0.85^{a}
T.C	1.94 ± 0.02^{c}	3.24 ± 0.01^{c}	7.21 ± 0.04^{c}	1.35 ± 0.05^{c}	43.45 ± 0.26^{b}
T.H	11.45 ± 0.02^{a}	6.53 ± 0.01^{a}	23.40 ± 0.04^{a}	18.30 ± 0.05^{a}	52.73 ± 0.26^{a}
T.M	7.77 ± 0.02^{b}	5.26 ± 0.01^{b}	17.13 ± 0.034^{b}	10.71 ± 0.05^{b}	9.82 ± 0.26^{c}

KEY: S.M: *Spondias mombin* methanol, S.C: *Spondias mombin* cold water, S,H: *Spondias mombin* hot water, T.C: *Tetrapluera tetraptera* cold water, T.H: *Tetrapluera tetraptera* hot water, T.M: *Tetrapluera tetraptera* methanol

Of the six (6) extracts used at different concentrations, it was discovered that varying concentrations of the cold water (50-250 mg/L), hot water (100-250 mg/L) and methanolic (50-250 mg/L) extracts of *T. tetraptera* possessed molluscicidal activity against *B. globosus*, followed by three high concentrations of the cold water extract of *S. mombin* (150-250 mgL) (Table 1). It was also noticed that the molluscicidal activity increases with the increase in concentration of the extracts. The least concentration (10 mg/L) of cold water and methanolic extracts of *T. tetraptera* was able to exert moluscicidal action on 50 % of the snails.

The positive control, which was 1 mg/L of niclosamide caused the total death of the snails within 5 minutes of exposure to the molluscicide, while the snails in distilled water i.e. the negative control remained intact without any death recorded. Table 2 showed the lethal dosages of the different concentrations of the extracts against the snail host.

The results of the quantitative analysis of the phytochemicals present in the plants extracts were part of the results from a larger study conducted and reported by Kone *et al*. (2022), the results are presented in Table 3.

DISCUSSION

The results of this study demonstrate that *Tetrapleura tetraptera* possesses potent molluscicidal properties, confirming previous findings by Aladesanmi (2007) and Adewunmi *et al*., (1990), which reported similar activity of its aqueous and methanolic extracts against *Bulinus globosus* and *Lymnaea natalensis*. The effectiveness of *T. tetraptera* across all three extract types and concentrations supports its potential as a plant-based molluscicide.

In contrast, the molluscicidal activity of *Spondias mombin* was moderate and only evident at higher concentrations (≥150 mg/L). This finding aligns with the report by Corthout *et al*., (1994), which attributed the molluscicidal action of *S. mombin* to phenolic acids. However, according to WHO guidelines (1983), a plant extract must achieve ≥90% snail mortality at concentrations ≤100 mg/L to be considered an effective molluscicide. Based on this criterion, *S. mombin* does not meet the efficacy threshold, limiting its suitability as a stand-alone control agent.

Phytochemical screening confirmed the presence of flavonoids, saponins, tannins, glycosides, and steroids in both plants, which may contribute synergistically to molluscicidal activity. Notably, the hot water extract of *T. tetraptera* contained the highest levels of these compounds, including saponins and steroids—known bioactive agents with molluscicidal potential. Despite this, the extract did not exhibit complete lethality at the lowest concentrations, suggesting possible antagonistic interactions among the phytochemicals or variable bioavailability depending on the solvent used.

These findings support the traditional use of *T. tetraptera* in disease management and suggest its potential for integration into schistosomiasis control programs, especially in resource-limited settings where synthetic molluscicides are unaffordable or unavailable.

CONCLUSION

This study demonstrates that *Tetrapleura tetraptera* exhibits significant molluscicidal activity against *Bulinus globosus* at concentrations well below the 100 mg/L threshold recommended by the World Health Organization (WHO). In contrast, *Spondias mombin* showed limited molluscicidal activity, only effective at higher concentrations. These findings suggest that *T. tetraptera* could serve as a viable, locally available, and cost-effective plant-based alternative to synthetic molluscicides such as niclosamide. Incorporating *T. tetraptera* into integrated schistosomiasis control strategies may contribute to reducing transmission by targeting the snail intermediate host. Further research is recommended to isolate and characterize the bioactive compounds responsible for the molluscicidal effects and to assess their environmental safety and field efficacy.

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Conflict of interest
The authors declare that there is no conflict.

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