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In-vitro efficacy of *solanum incanum* on *Rhipicephalus appendiculatus*

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Herbal remedies have a long history of use for tick control. Solanum incanum ripe fruits are locally used to manage ticks. In this study, the effect of S. incanum fruit extracts on egg hatchability, inhibition of oviposition and larval mortality of Rhipicephalus appendiculatus ticks was investigated. The reproductive efficiency of eggs laid by the ticks was determined. The highest number of eggs laid was recorded in the untreated control, whereas the lowest was in the control treated with amitraz. The number of eggs that were laid after treatment with the plant extract increased with increase in the extract concentration, that is, 20, 10 and 5% was 51.0262, 43.774 and 36.901%, respectively. The control treated with amitraz showed higher efficacy of 98.63556% whereas the untreated control had no effect on the ticks. S. incanum 5% showed higher efficacy of 33.49%, than 10 and 20%, which showed 19.405 and 7.833%, respectively. However, there was no significant differences in efficacies between the fruit extract concentrations. In the results obtained from the larval packet test (LPT), the control treated with amitraz was recorded with the highest mortality of 100% whereas the untreated control showed no significant larval mortality. There was high larval mortality recorded in all the three concentrations of S. incanum, of 100, 50 and 25 mg/ml with 97.969, 98.589 and 95.948%, respectively.

Key words: Efficacy, *Solanum incanum*, *Rhipicephalus appendiculatus.*

INTRODUCTION

Ticks are one of the leading vectors of diseases of economic importance to the Animal Industry in Africa. Tick-borne diseases (TBD) mainly theileriosis/East Coast Fever (ECF), babesiosis and anaplasmosis present serious constraints to production and especially of exotic cattle and their crosses (Salih et al., 2015; Vudriko et al., 2016; Mohammed et al., 2017). The aforementioned diseases also account for nearly 90% of total disease control costs and over 60% of total farm inputs and other associated economic losses due to a reduction in meat and milk production, as well as, a devaluation of leather due to skin lesions caused by high infestations (Souza Higa, 2015). To address tick challenge, commercial cattle farmers rely extensively on use of acaricides by chemical control of ticks. This has proved to be an effective strategy for mitigating the tick's economic impact on the Animal Industry; thus, creating a huge demand and market for acaricides in Uganda. The liberalization of the veterinary drug industry in the country has made acaricides even more accessible to farmers. Because of limited regulation, cases of uncontrolled use of acaricides by farmers have been widely reported; wrong dilution,

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application methods and increased acaricide pressure are amongst factors that accelerate development of acaricide resistance. The evolution of acaricide resistance which was first reported in Uganda in 1970 is a cause of grave concern among cattle producers, government agencies and technical personnel (Andreotti et al., 2011).

Acaricide failure places tremendous financial burden on the Ugandan farmers; not only does it lead to a high loss of their cattle to TBD, but the costs of the acaricides themselves account for about 90% of an average farmer's total disease control budget, making non-functional acaricides a major budgetary loss to farmers. Unless new chemical types are introduced, or highly effective alternative therapies are developed, parasites are likely to cause very considerable financial problems and serious issues of welfare in the future Animal Industry.

Alternatively, exploiting plants as sources of effective tick repellents and botanical acaricides is promising. These natural products offer a cheap alternative to synthetic acaricides and are biodegradable (Parte et al., 2014). Moreover, these botanicals are found to contain a mixture of active substances that can delay or prevent the development of resistance by the ticks to herbal products (Ghosh et al., 2015).

Solanum incunum is one of the plants that people use in the local setting for the control of ticks, as it is locally available, cheap, and environmentally friendly and no residual effects in animal products such as milk and meat has been reported. In the various studies conducted, *S. incanum* has been found to have pesticidal activity. According to Mwaura et al. (2014), *S. incanum* is effective for control of cattle ticks when used as water extracted concoction. The whole dry ripe fruits are crushed and extracted in water at 5% w/v for 24 h and this is then sprayed onto cattle (5 L/animal). In the study conducted by Munene et al. (2017), *S. incanum* fruit extract was found out to have nematocidal activity against chili root knot disease. Mukami and Wanzala (2017) showed that *S. incanum* fruit extract has inhibitory effect on the growth of oral microbes.

Considering the aforementioned points in mind, the current study was conducted to evaluate the *in vitro* efficacy of *S. incanum* ripen fruit crude extract on *Rhipicephalus appendiculatus* ticks, its effect on reproductive efficiency and larval mortality.

Problem statement

Ticks harm their animal hosts by sucking blood, thus reducing growth rate and milk yield, causing mechanical damage to hides and skins, introducing toxins and predisposing the animals to myiasis. Theileriosis, cowdriosis and dermatophilosis are the major tick-borne and tick-associated diseases of grazing cattle in Africa. *Rhipicephalus* is one of the tick species that are widely spread in the Uganda, posing a serious threat especially to exotic cattle. TBD particularly ECF is ranked by farmers as the most important constraint to cattle production in Uganda (Vudriko et al., 2016). TBDs' control worldwide has continued to rely heavily on synthetic chemical acaricides (Campos et al., 2010).

Unfortunately, synthetic chemical acaricides have long become unsustainable to use in TBDs' control and management interventions. Such compounds have suffered from a number of drawbacks, including acaricide resistance in ticks, their sky rocketing costs, pollution of the environment and food products (meat, blood, and milk) with toxic residues, deleterious effects on non-target organisms among others. Societal and scientific concerns regarding exclusive dependency upon synthetic chemicals have emphasized the need for the development and introduction of alternatives to acaricides that are consistent with the principles of sustainable agriculture (Wycliffe, 2017).

Exploiting plants as sources of effective tick repellents and botanical acaricides is often promising. *S. incunum* is one of the plants that people use in the local setting for the control of ticks as it is locally available cheap and environmentally friendly without residual effects in animal products such as milk and meat.

Justification

Due to the problems of conventional acaricides, there is need to develop complementary and/or alternative cheap but effective and safe anti-tick plant-derived bioacaricide. Formulation of new botanical acaricides, particularly those based on *S. incanum* extract, is an exciting option for integrated tick management programs, since such plant-derived acaricides have various benefits, including selectivity, greater safety for non-target organisms, and compatibility with biological control organisms. *S. incanum* is also readily available, cheap and has no effect on the environment. Despite the use of the fruits sap of *S. incanum* for the management of ticks by local farmers, there is no scientific documentation in Uganda that shows its effectiveness on the different stages of tick growth.

Hence, the present study was conducted to assess the efficacy of *S. incanum* on *R. appendiculatus* in the laboratory.

Specific objective

(1) To determine the reproductive efficiency of engorged females of *R. appendiculatus* ticks treated with fruit extract of *S. incanum.*

(2) To determine the mortality of *R. appendiculatus* larvae

treated with fruit extract of *S. incanum.*
(3) To compare the acaracidal activity of *S. incanum* and amitraz on *R. appendiculatus.*

Significance of the research

This study aimed at providing alternative botanical acaricide using *S. incanum* crude ripened fruit sap extract, which is safe, cheap, easily available and environmentally friendly. This will form strategies on the development of a phyto-derived botanical acaricides against ticks. Prevention of tick infestation on farm animals by using such botanical acaricides will prevent environmental pollution, contribute to the solution of the growing problems of acaricide resistance by ticks and thus improve food security. More so, this study will increase data source for other researchers with related interests.

Scope

The study was conducted to assess the efficacy of *S. incunum* on *R. appendiculatus*. This was achieved by using compounds in ripe fruits, which was extracted by maceration in portable water at room temperature for 48 h. Treatments were carried out on engorged female ticks and tick larvae. The research was conducted within a period of seven weeks at acarology laboratory in Tororo district. Tororo district is located in eastern Uganda and is bordered by Mbale district to the north, Manafwa district to the northwest, the republic of Kenya to the east. Busia district to the south, Bugiri district to the southwest and Butaleja district to the northwest.

LITERATURE REVIEW

Ticks are obligate ecto parasites of vertebrates (Jongejan and Uilenberg, 1994). Engorged female tick produces a single large batch of eggs and dies. Depending upon the species, tick egg mass deposited can range from 1,000 to 18, 000 eggs (Stafford III, 2007).

Globally, almost 900 species of ticks have been described of which about 700 species are hard ticks and the remainder soft ticks (Stafford, 2001). Approximately 200 Ixodidae and 40 Argasidae tick species are present in the Afro tropical region, but only a small number are of veterinary or human importance. Ticks are very important to man and his domestic animals, and must be controlled if livestock production is to meet world needs for animal protein. Feeding by large numbers of ticks causes direct effect by reduction in live weight, milk production and anemia among domestic animals, while tick bites cause dermatitis and reduce the quality of hides (Jongejan and Uilenberg, 1994). Tick bite paralysis is another effect caused by injection of toxins by certain ticks while feeding for example sweating sickness caused by *Hyalomma truncatum*, tick toxicosis caused by *Rhipicephalus* species and others (Stewart and de Vos, 1984). More so, ticks serve as carriers of pathogens that include bacteria, spirochetes, protozoa, viruses and toxins (Onyango, 2016), transmitting different diseases from host to host during blood sucking (Jongejan and Uilenberg, 1994). The major diseases include babesiosis, anaplasmosis, theileriosis, and heart-water. In addition, other diseases of less importance cause severe economic losses to the livestock industry. Knowledge of the nature and habits of the tick and the disease agents it transmits helps in control (Stewart et al., 1981).

Control measures of ticks

Host resistance, anti-tick vaccine and habitat modification

Host resistance to ticks is one of the measures of tick control whereby acquired resistance to Ixodidae tick has been recognized as a possible biological control method according to Jongejan and Uilenberg (1994). Such resistance, acquired after repeated infestations by ticks, is immunologically mediated. According to Stafford (2001), avoiding camps that are heavily infested with ticks during certain seasons and a grazing strategy reduces number of ticks on pastures (Turton, 2003). Anti-tick vaccines seem to offer partial solution to the problem of acaricide résistance. Similarly, immunization against tick borne diseases can currently be accomplished by using blood vaccines containing infective or attenuated organisms or using infected tick stabilates (Jongejan and Uilenberg, 1994).

Habitat modifications by severe bush fires help to eliminate unwanted vegetation and destroy the habitat of native small vertebrates acting as hosts in the immature stages of certain ticks. Ploughing, constitute additional measures for effective tick control through exposing the soil and thus the surviving ticks to sunshine which has a negative effect on those tick species that depend for their survival on the shade of trees and tall grass.

Ethno-botanical, biological and chemical control

Ticks have relatively few natural enemies, but the use of predators, parasites, and pathogens has been examined for tick control. Guinea fowls, chicken, and application of entomo-pathogenic fungi, is a promising approach for controlling ticks. Plant extracts from different parts of the plant are used as sprays or pour-on to control ticks. Synthetic chemical acaricides are used for tick control as sprays, dipping, and pour-on and injectable acaricides.

Acaricide resistance in Africa

Super resistant ticks that are not responsive to all the molecules of acaricides on market have been identified on 68% of the farms that reported the problem in Western and Central Uganda in July 2016 and are believed to be spreading to other areas. Vudriko et al. (2016), also reported this emergence of multiple acaricide resistant ticks and its implication on tick control in Uganda in January 2016.

Prevention, control, and management of both vector and pathogen have continued to rely heavily on the application of synthetic chemical acaricides on the host since their introduction in 1902 in Sub-Saharan Africa. However, this has proved to be costly and unsustainable in a number of ways. The acaricides can eliminate ticks from the host, but they do not prevent continued re-infestation from the source environment, where ticks spend 90% of their life. For effective management of harmful ticks, an integrated combination of tactics may need to be put in place that controls ticks on individual hosts as well as in the host environment in order to prevent host re-infestation during grazing.

Medicinal plants used for tick control

In Ethiopia, juice of crushed leaves of *Calpurnia aurea* is used for tick control. This plant contains compounds such as alkaloid calpermenin that act as repellants and has acaracidal effects. In addition, *Tephrosia* leaf extract was found to contain tannin and saponins with larvicidal effect on the larvae of *Rhipicephalus, Boophilus microphilus in vitro*. Another most important acaracidal plant is *Azadirachita indica* whereby the extract from its bark acts against adult *B. microphilus* and *Boophilus annulatus* and shows inhibitory effect on vitellogen during oogenesis of arthropods and acceleration of hatching rate and mortality of newly hatched larvae (Abdisa, 2017). Studies show that stylothanthes, a legume pasture is also used in tick control as its leaves and stems are covered with glandular trichomes, which produce sticky secretion, that traps and kill the tick larvae as they try to ascend the plants (Saganuwan, 2017), and many other plants as discussed by various studies (Abebe et al., 2014; Premalatha et al., 2018; Rahuman, 2011; Yanar et al., 2011).

Phytochemical constituents in medicinal plants

Plants contain phytochemical constituents like alkaloids, saponins, solasonines, glycosides and others that serve different functions such as repellants, growth inhibitors and others. The phytochemical screening of latex *Calotropis procera* done by Kawo et al. (2009), revealed the presence of alkaloids, flavonoids, tannins, saponins, and cardiac glycosides with very high content in water extracts. In the study conducted on *Argemone mexicana, Datura metel* and other five medicinal plants, it was also found to contain same constituents as earlier mentioned in extraction of 95% ethanol. Rahuman (2011), discusses different plants. *S. incanum* was found to contain all the aforementioned active ingredients in both extracts of water and ethanol (Tweldesahle and Okbatinsae, 2017; Habtamu and Gebre, 2014).

Uses of Sodom apple

S. incunum is effective for control of cattle ticks when used as water extracted concoction. The whole dry ripe fruits are crushed and extracted in water at 5% w/v for 24 h and this is then sprayed onto cattle 5 L/animal (Onyango, 2016), whereas the fruit pulp is applied directly on the tick infested area to kill ticks. Fruit sap is also used directly by mixing with butter and then smeared on cattle as practiced in Ethiopia (Sahle and Okbatinsae, 2017).

S. incanum fruit extract in ethanol was tested on engorged female ticks and larvae of *R* (*Boophilus*) at different concentrations of 5, 10, 20, and 40% (w/v). Application of the extract led to mortality and reduction in reproductive function of ticks. The 5% *S. incanum* treatments had higher efficacy ratios ($P<0.05$) than the other fruit extract concentrations and the efficacy ratio increased with increase in time of incubation (Madzimure et al., 2013).

Many of the medicinal uses of *S. incunum* are based on its analgesic properties. Throughout tropical Africa a sore throat, angina, stomach-pain, colic, headache, painful menstruation and liver pain are treated with *S. incunum*. For these purposes, leaf, fruit and fruit decoctions are drunk, fruits are chewed and sap swallowed, leaf sap is used for washing painful areas, and ash of burnt plants is mixed with fat and applied externally. Leaves are added to soup to improve the flavor (Sahle and Okbatinsae, 2017). *S. incanum* was also found out to have growth inhibitory effect on the oral microorganism under laboratory control according to (Mukami and Wanzala, 2017).

Importance of Sodom apple in Africa

In Ethiopia, fruit sap is mixed with butter and applied to cattle to control ticks. In the southern part of Ethiopia, Haddiya people use the fruit of the plant to get relief from stomach problem, the fruit is chewed and sap is swallowed (Sahle and Okbatinsae, 2017). The plant is employed in Eastern and Southern Africa for the treatment of skin diseases, general infections, abdominal pains, fever, stomachache and indigestion. In addition, the fruit of *S. incunum* is used for the treatment of dandruff, skin diseases, sores and wounds in Tanzania. Another widespread use of *S. incanum* is in the treatment of venereal diseases. Different plant parts are also used to treat snake bite (Matu, 2008). In Senegal, Kenya, Uganda and Zimbabwe, a decoction of the fruits is drunk, fruits are chewed and sap is swallowed, and young chewed leaves or pulped fresh fruits are applied to the bite wound. In Niger, Sudan, Rwanda and Namibia, the fruits are used as an ingredient of arrow poison and in Mozambique as fish poison (Alamri and Moustafa, 2012).

MATERIALS AND METHODS

Experimental design

Independent variables were manipulated to obtain primary data. Primary data was obtained from treatment of adult engorged female ticks, tick eggs and larvae of *R. appendiculatus* with fruit extract of S. *incanum* at different concentrations.

Source of ticks

R. appendiculatus larvae were obtained from colonies in the Acarology laboratory at NALIRRI in Tororo. Newly emerged adult *R. appendiculatus* ticks were attached onto animals' ears for feeding for a period of 9 days to obtain fully engorged females, which were collected using the ear bags, and then taken to the laboratory. Ticks were then washed with portable water and dried using paper towel (Nyigo et al., 2016) and put in perforated labeled sample bottles for *S. incanum* fruit extract efficacy assays.

Collection and preparation of plant material

The ripe fruits of *S. incanum* were collected from several naturally growing fields around NALRRI in Tororo. The fruits were then washed with water thoroughly to remove the debris. The green viscous juice was obtained from these fruits through incisions on the pericarp (Mukami and Wanzala, 2017). The juice was then diluted using distilled water to come up with concentrations of 5, 10, and 20% (v/v), the solutions were left to stand for 24 h. The extract was used in the treatment of adult engorged females of *R. appendiculatus* ticks to evaluate its inhibitory effect on egg laying.

S. incanum fruit extract that was used for treating larvae and eggs of *R. appendiculatus* ticks was prepared using method described by Kemei et al. (2017) with a few modifications. 20 g/100 ml of the fruit was extracted by macerating in distilled water at room temperature for 48 h. The mixture was thereafter, filtered using Whatmann no. 1 filter paper. The collected filtrate was concentrated in an oven at 60°C into slurry. The slurry was weighed and then dissolved in water to form a stock solution of 100 mg/ml; serial dilutions were made to come up with 50 and 25 mg/ml. solutions, which were stored in a refrigerator at 4°C awaiting bioassays.

Treatment of *R. appendiculatus* adult engorged female ticks with fruit extract

Engorged female ticks were divided into five groups: three treatments of the different fruit extract concentrations, positive control group and the negative control. Each treatment was replicated three times with each replicate having four ticks. Adult immersion test was used in this experiment. Ticks were immersed in 10 ml of fruit extract at different concentrations of 5, 10, and 20% (v/v) for a period of 10 min. Water was used as negative control whereas amitraz at 2 ml/l was used as positive control. Ticks were drained of excess acaricide using paper towel, transferred to Petri dishes for incubation at 28°C and 85 to 90% relative humidity. Eggs laid were weighed on the 15th day after treatment to determine reproductive efficiency (RE) (Abdel-Shafy et al., 2018). Data was recorded in the data collection sheet for determination of reproductive efficiency and percentage inhibition of egg laying following the formulae used by Ghosh et al. (2015).

$$\mathbf{RE} = \frac{\textbf{weight of eggs laid}}{\textbf{weight of engorged female}}$$

$$\textbf{Percentage inhibition of egg laying} = \frac{\textbf{RE control} - \textbf{RE treated}}{\textbf{RE control}} \times \mathbf{100}$$

Treatment of *R. appendiculatus* larvae using S. *incanum* fruit extract

The larval packet test was performed as per FAO (2004) to determine the *in-vitro* acaracidal activity of the *S. incanum* fruit extract. The larvae aged between 14 and 21 days were subjected to larval packet test. Packets made of Whatman filter paper No. 1 were sealed using bulldog clips to prevent larvae from escaping, then placed on the Petri dish. Larvae were treated with 2 ml of each concentration of 25, 50 and 100 mg/ml of the plant extract. After 10 min, the larval packets were dried with rotary evaporator and then incubated at 28°C and 85 to 90% relative humidity for 24 h. Distilled water was used in negative control whereas amitraz at 2 m/L was used for positive control. Larval mortality was assessed after 24 h, whereby all the larvae that were unable to move were considered dead.

The percentage of mortality in all of the experimental batches of larvae was corrected by applying Abbott's formula:

$$\textbf{Corrected percent mortality} = \frac{\textbf{test mortality} - \textbf{\% control mortality}}{\mathbf{100} - \textbf{control mortality}} \times \mathbf{100}$$

Data analysis

Data was collected, collated and analyzed using Microsoft excel spreadsheets. Results generated from the investigation were expressed using descriptive statistics (mean, percentage and graphs). For comparison of the acaracidal efficacy of formulations, statistical analysis of data was performed on arithmetic mean efficacy using ANOVA single factor to compare differences between treatment groups for significance at the $P < 0.05$ level. The results were presented using tables and graphs.

Ethical consideration

An introductory letter was issued to the researcher by the university authority introducing the researcher to the management of the research institute (NaLiRRI) who in turn introduced the researcher to the laboratory personnel.

The study was conducted under the close supervision of

Table 1. Mean reproductive efficiency (R.E) and mean efficacy of *Solanum incanum* fruit extract against engorged female of *Rhipicephalus appendiculatus* ticks.

Treatmens	Mean R.E	Mean efficacy
Amitraz	1.880668	98.63556
Untreated control	55.47174	0.00
Solanum incanum 5%	36.90056	33.4881
Solanum incanum 10%	43.77442	19.40563
Solanum incanum 20%	51.02624	7.83299

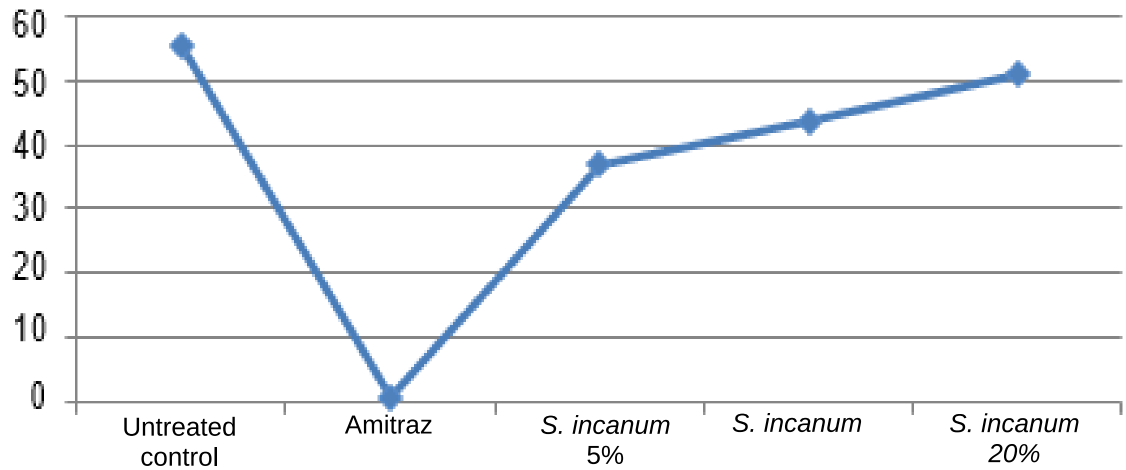

Figure 1. Mean reproductive efficiency of *Rhipicephalus appendiculatus* females treated with *Solanum incanum* fruit extract.

Busitema University to avoid getting involved in activities that would diminish confidence in laboratory, competence, impartiality, judgment or operational integrity of collected data.

RESULTS

The following results were obtained from experimentation using *S. incanum* fruit extract against *R. appendiculatus* with the aim of finding its effect on egg laying, hatchability and larval mortality in comparison with amitraz.

Impact of *S. incanum* extract on efficiency of *R. appendiculatus*

From the Table 1, the highest eggs laid were recorded in the untreated control whereas the lowest was recorded in the positive control treatment with amitraz. The plant extract treatment for 20% concentration had the highest percentage mean of eggs that were laid followed by 10% and lastly 5%. The number of eggs that were laid after treatment with the plant extract increased with increase in the extract concentration Figure 1.

Amitraz showed higher efficacy (98.640%) whereas the untreated control had no effect on the ticks. In plant extract treatments, 5% *S. incanum* showed higher efficacy than 10 and 20% as seen in the table. However, there was no significant difference among the three concentrations of the fruit extract. There was a significant difference (P< 0.05) between *S. incanum* fruit extract treatments and untreated control as well as positive control treatment using amitraz. The efficacy of the plant extract on egg laying was seen to decrease with the increase in the extract concentration. Similar results were recorded in the study conducted by Madzimure et al. (2013) who reported higher tick mortality caused by the lowest concentration 5% of *S. incanum* fruit extract. Onyango (2016) also got related results in his study of the larvicidal activity of *Ipomoea kituiensis* extracts against *Boophilus dicloratus* ticks where mortality was higher in lower plant concentration.

Effect of *S. incanum* fruit extracts on *R. appendiculatus* larvae

From this experiment, amitraz was recorded with the highest mortality of 100% whereas the untreated control

Table 2. Mean efficacies of *Solanum incanum* ripen fruit extract against *Rhipicephalusa ppendiculatus* tick larvae.

Treatment	Mean efficacy (%)
Amitraz	100
Untreated control	0.00
Solanum incanum 100 mg/ml	97.96939
Solanum incanum 50 mg/ml	98.4898
Solanum incanum 25 mg/ml	95.9488

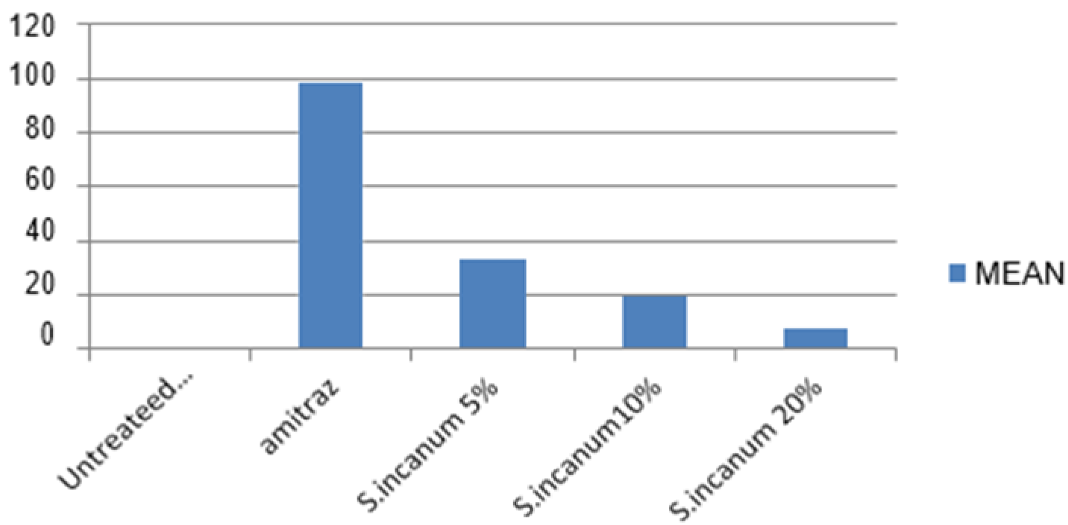

Figure 2. Mean acaracidal efficacy of different treatments.

showed no significant larval mortality (Table 2). From Figure 2, there was high larval mortality recorded in all the three concentrations of *S. incanum*, though they did not show any significant difference in their acaracidal activity. There was a significant difference (P<0.05) between *S. incanum* fruit extract and the untreated control. However, there was no significant difference between the efficacy of the positive control and *S. incanum* fruit extract (Figure 3).

DISCUSSION

Reproductive efficiency of *R. appendiculatus* ticks with *S. incanum* fruit extract

The results of the study demonstrated acaracidal effects of extract of *S. incanum on R. appendiculatus* ticks. These findings agree with the previous studies that have shown that most of the plants of Solanaceae contain alkaloids, tannins, steroids, saponins, as well as reducing sugars (Amadi et al, 2010). The fruit extracts have been identified to have alkaloids, phenols, carbohydrates, tannins, triterpenoids, glycosides, steroids, resins and saponins. Flavonoids and chlorogenic acids have been documented for *S. incanum* (Lin et al, 2000). The observed acaracidal activities of *S. incanum* have been shown to be caused by alkaloids. The Solasodine found in fruits may also be responsible for acaracidal activity.

From the literature, amitraz and *S. incanum* fruit extract revealed that both exhibit acaracidal properties. This is due to alkaloid interference with membranes of the cells and disrupts the integrity of cells up to apoptosis that is the degradation of the cells because they cannot withstand the osmotic forces, as their membranes are destroyed (Rosenkranz and Wink, 2007).

From this study, however, it was revealed that amitraz had higher inhibitory effects on oviposition (P<0.05) than *S. incanum* fruit extract concentrations on *R. appendiculatus* ticks. The three concentrations 5, 10 and 10% of the fruit extract showed no significant difference in their inhibitory effect on oviposition. These results are

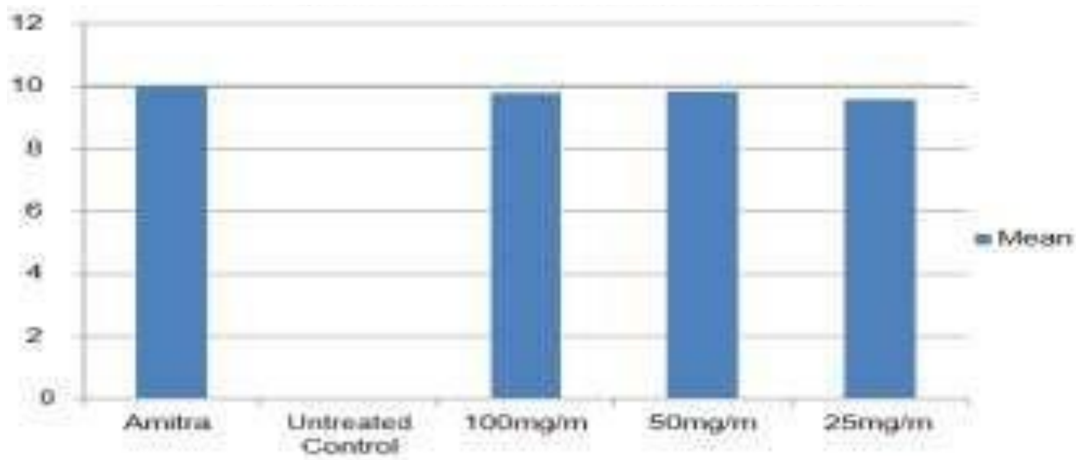

Figure 3. Graph showing the mortality of *Rhipicephalus appendiculatus* larvae with different treatments that was assessed using the mean efficacy obtained.

in contrast with the findings. In his study where *S. marianum* was evaluated against engorged females *B. annulatus* ticks and the results showed that there was increase in percentage inhibition of eggs laying with increase in the concentration of the crude extract. The difference observed could be attributed to differences in the rate at which they penetrate the target cells. On the other hand, the phytochemical in fruit extracts could be having low solubility in water thus reduced rate of penetration and consequently less inhibitory effects. Also, different soils in the different locations where plant extracts were harvested may influence the concentrations of the active ingredients hence affecting the results.

Mortality of *R. appendiculatus* larvae treated with *S. incanum* fruit extract

The crude fruits sap extract of *S. incanum* produced appreciable acaracidal activity against larvae of *R. appendiculatus*. These findings are in agreement with the effects of other plant extracts tested against various tick species. Similar work carried out by Gazirayil et al. (2007) demonstrated effective acaracidal activities of plant extract of *Tephrosia vogelii* in controlling cattle ticks. The results may be due to ease of penetration of the active principles of both preparations into the cell membrane of the larvae. This study conforms to the findings by ascertaining that the acaracidal properties of this plant probably explain its traditional use for tick control.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the study, *S. incanum* fruit extract is acaracidal. The plant fruit extract was effective on both engorged females and tick larvae. Treatments for the larval packet test were as effective as the synthetic commercial acaricide, amitraz, hence the extract can be a viable option for tick control since it is cheap, readily available to local farmers and environmentally friendly.

More in depth studies should be carried out to reveal the exact potential of the plant in tick control. Use of other solvents such as alcohol for extraction of phyto constituents is needed. More time should be given for tick observation.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

REFERENCES

Abdisa T (2017). Review on Traditional Medicinal Plant and its Extract Effect on Tick Control in Ethiopia. Journal of Veterinary Medicine and Research 4(4):1082

Abebe,H, Gebre, T, Assistant AH (2014). Phytochemical Investigation on the Roots of SolanumIncanum Hadiya Zone, Ethiopia. Journal of Medicinal Plants Studies, pp. 83-93.

Abdel-Shafy S, Soliman MM, Habeeb SM (2018). In vitro acaricidal effect of some crude extracts and essential oils of wild plants against certain tick species. Acarologia 47(1-2):33-42.

Amadi JE, Salami SO, Eze CS (2010). Antifungal properties and phytochemical screening of the extracts of African Basil (*Ocimumgratissimum* L). Agriculture and Biology Journal of North America 1(2):163-166.

Andreotti R, Guerrero FD, Soares MA, Barros JC, Miller RJ, Léon APde. (2011). Acaricideresistance of Rhipicephalus (Boophilus) microplus in State of MatoGrosso doSul, Brazil. *RevistaBrasileira De Parasitologia Veterinaria* = Brazilian Journal of Veterinary Parasitology: *Orgao Oficial Do ColegioBrasileiro De ParasitologiaVeterinaria*. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/21722487

Campos RA, Boldo JT, Pimentel IC, Dalfovo V, Araújo WL (2010). Endophytic and entomopathogenic strains of Beauveriasp to control the bovine tick *Rhipicephalus (Boophilus*) microplus. Genetics and Molecular Research 9(3):1421-1430. https://doi.org/10.4238/vol9-3gmr884

Ghosh S, Tiwari SS, Kumar B, Srivastava S, Sharma AK, Kumar S, Bandyopadhyay A, Julliet S, Kumar R, Rawat AK (2015). Identification of potential plant extracts for anti-tick activity against acaricide resistant cattle ticks, *Rhipicephalus (Boophilus)* microplus (Acari: Ixodidae). Experimental and Applied Acarology 66(1):159-171.

Jongejan F, Uilenberg G (1994). Ticks and control methods. Revue scientifique et technique. International Office of Epizootics 13(4):1201-1226.

Kawo, AH, Mustapha Abdullahi B, Rogo Gaiya, Kumurya, AS (2009). Phytochemical Properties and Antibacterial Activities of the Leaf and Latex Extracts of CalotropisProcera (Ait.F.) Ait. Bajopas Bayero Journal of Pure and Applied Sciences 2(21):34-40. https://doi.org/10.4314/bajopas.v2i1.58453

Lin YI, Wang WL, Kuo YH, Chen CF (2000). Nonsteroidal constituents from *Solanumincanum* L. Journal of the Chinese Chemical Society 47(1):247-251.

Madzimure J, Nyahangare T, Hove T, Belmain SR, Stevenson PC (2013.). Efficacy of. https://doi.org/10.1007/s11250-013-0367-6

Mohammed AA, Sharma A, Saied MAM, Osman OH, Al-Balowi MH, Salih DA and Singla LD (2017). Lack of evidence for infection of camels with tick-borne diseases in Riyadh region, Saudi Arabia. Sudan Journal of Veterinary Research 32:39-40.

Mukami NA, Wanzala W (2017.). A Study of Bioactivity of *Solanumincanum* L. Fruit Extracts on Microorganisms of the Oral Cavity. Oral Health and Dental Management 16(3):1-9.

Nyigo VA, Mdegela RH, Malebo HM, Mabiki FP, Fouche G (2016). Evaluation of acaricidal efficacy of Synadeniumglaucescens (Euphorbiaceae) against *boophilus* species. Journal of Medicinal Plants Research 10(21):278-285. https://doi.org/10.5897/JMPR2016.6099

Onyango OA (2016). An Ethnobotanical, Phytochemical, toxicity and efficacystudy of selected antiblue-tick (boophilusdecoloratus) herbal remedies for cattle of Suba sub-county, Kenya. Doctoral dissertation, University of Nairobi.

Premalatha K, Sj, N, Vishnupriya R, Balakrishnan S (2018). Acaricidal activity of plant extracts on two spotted spider mite, Tetranychusurticae Koch (Acari: Tetranychidae). Journal of Entomology and Zoology Studies 6(1):1622-1625.

Rahuman AA (2011). Efficacies of Medicinal Plant Extracts Against Blood-Sucking Parasites. In Nature Helps... How Plants and Other Organisms Contribute to Solve Health Problems, pp. 19-53. Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-19382-8

Rosenkranz V, Wink M (2007). Induction of apoptosis by alkaloids, non-protein amino acids and cardiac glycosides in human promyelotic HL-60 cells. Zeitschriftfür Naturforschung 62:458-466.

Saganuwan SA (2017). Ethnoveterinary Values of Nigerian Medicinal Plants: An Overview. European Journal of Medicinal Plants 18(4):1-35. https://doi.org/10.9734/EJMP/2017/29321

Sahle T, Okbatinsae G (2017). Phytochemical investigation and antimicrobial activity of the fruit extract of Solanumincanum grown in Eritrea. Ornamental and Medicinal Plants 1(1):15-25.

Salih DA, Hussein AM El, Singla LD (2015). Diagnostic approaches for tick-borne haemoparasitic diseases in livestock. Journal of Veterinary Medicine and Animal Health 7(2):45-56.

Souza Higa LdeO (2015). Acaricide Resistance Status of the Rhipicephalusmicroplus in Brazil: A Literature Overview. Medicinal Chemistry 5:326-333. https://doi.org/10.4172/2161-0444.1000281

Stafford,K C (2001). Tick Control. The Connecticut Agricultural Experiment Station. Retrieved from http://www.caes.state.ct.us

Stafford III KC (2007). Tick management handbook. The Connecticut Agricultural Experiment Station, Bulletin 1010(1010):9-18. Retrieved fromhttp://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.138.2651&rep=rep1&t ype=pdf

Turton J (2003). Methods of Tick Control, 1–3. Retrieved from http://www.nda.agric.za/docs/Infopaks/Methods_tick.pdf

Vudriko P, Okwee-Acai J, Tayebwa DS, Byaruhanga J, Kakooza S, Wampande E, Suzuki H (2016). Emergence of multi-acaricide resistant Rhipicephalus ticks and its implication on chemical tick control in Uganda. Parasites and Vectors. Parasites and Vectors 9(1):1-13. https://doi.org/10.1186/s13071-015-1

Yanar D, Kadıo I, Gökçe A (2011). Acaricidal effects of different plant parts extracts on two-spotted spider mite (Tetranychusurticae Koch) African Journal of Biotechnology *10*(55):11745-11750. https://doi.org/10.5897/AJB11.132