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Insecticidal effectiveness of seed and leaf oil extract of neem (*Azadirachta indica*) against larvae and adults of *Anopheles stephensi*

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ABSTRACT

This study was conducted to investigate the effect of neem (*Azadirachta indica*) seed and leaf oil extract on larvae and adults of *Anopheles stephensi* mosquitoes in the Biology Laboratory, Faculty of Education (Bayda), Omar Al-Mukhtar University, Libya. The Anopheles mosquito larvae 3rd larval instar was obtained from laboratory colony established in the insectary**.** Larvae were maintained at a temperature of 25± 1°C, with a relative humidity of 80± 5%, and a photoperiod of 12/ 12 hours light/ dark. For the larvicidal bioassay, six concentrations (50, 100, 150, 200, 250 and 300 ml/l) of seed oil and leaf extract of *A. indica.* A set of the control group using distilled water was included. The 100 % larval mortality was observed due to both *A. indica* seed oil and extract at concentration of 300 ml/l followed by 250 ml/l after exposure to 72 hours while the control treatment don't recorder any adults mortality percentage under treatment with neem oil and neem leaf extracts against *Anopheles stephensi* larvae. The results show that the mortality rate of *Anopheles stephensi* larvae increases with increasing concentration of both neem oil extract and neem leaf extract with increasing exposure period. The extracts of neem leaves of *Azadirachta indica* demonstrated strong larvicidal activity, with LC_{50} and LC_{90} values, with neem oil and neem leaf extracts.

Keywords: Neem (*Azadirachta indica*), *Anopheles stephensi* mosquitoes, larvicidal, larvicidal effects.

فعالية مستخلص زيت بذور وأوراق النيم (*Azadirachta indica*) كمبيد حشري ضد يرقات وبالغات *Anopheles stephensi*

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أُجريت هذه الدراسة لدراسة تأثير مستخلص بذور وأوراق النيم (*Azadirachta indica*) على يرقات وبالغات بعوض *Anopheles stephensi* في مختبر الأحياء بكلية التربية (البيضـــاء)، جامعة عمر المختار، ليبيا. تم الحصـــول على الطور اليرقي الثالث ليرقات بعوض الأنوفيليس من مســـتعمرة معملية أُنشـئت في مختبر الأحياء. حُفظت اليرقات عند درجة حرارة ٢٥ ± ١ درجة مئوية، ورطوبة نسـبية ٨٠ ± ٥٪، وفترة ضوئية ١٢/١٢ ساعة ضوء/ظلام. لإجراء اختبار حيوي مبيد لليرقات، تم استخدام ستة تركيزات (50، 100، 150، 200، 250، 300 مل/لتر) من مســـتخلص زيت بذور وأوراق نبات *A. indica*. أُدرجت معاملة الكنترول باسـتخدام الماء المقطر. لوحظت نسـبة نفوق 100% لليرقات نتيجةً لاستخدام كلٍّ من زيت بذور ومستخلص *Azadirachta indica* بتركيز 300 مل/لتر، يليه 250 مل/لتر بعد التعرض لمدة 72 سـاعة، بينما لم تُسـجل معاملة الكنترول أي نسـبة نفوق لليرقات البالغة بالمعاملة بزيت النيم ومسـتخلص أوراق النيم ضـد يرقات *Anopheles stephens*. تُظهر النتائج أن معدل نفوق يرقات *Anopheles stephensi* يزداد بزيادة تركيز كلٍّ من مسـتخلص زيت النيم ومسـتخلص أوراق النيم وزيادة فترة التعرض. أظهرت مسـتخلصـات أوراق و زيت النيم نشـاطًا قويًا في قتل اليرقات، بقيم LC_{50} وLC_{90}، مع زيت النيم ومستخلصات أوراق النيم.

الكلمات المفتاحية: بعوض الأنوفيليس - زيت بذور ومستخلص النيم- اليرقات- الحشرات البالغة

INTRODUCTION

Mosquitoes (Diptera: Culicidae) are major arthropod groups that existed over 180–220 million years ago **(Benelli and Duggan, 2018; Hillary and Ceasar, 2021).** Mosquitoes belong to two subfamilies: Anophelinae (Anopheles) and Culicinae (Aedes, Culex, and Mansonia), these two subfamilies pose a severe threat to humans and animals because of their widespread occurrence **(Gabrieli *et al.*, 2014)**.

According to **Govindarajan *et al.* (2016),** mosquitoes continue to play a significant role in the transmission of the most deadly epidemic diseases, which threaten the lives of millions of people worldwide. Mosquito Numerous diseases are spread to humans by female mosquitoes, including malaria, which is one of the most severe diseases spread by female mosquitoes and kills over a million people annually and kills a kid every 30 seconds worldwide. Malaria is caused by the Plasmodium parasite. They also spread the nematode worms that cause elephantiasis, a disease that is not lethal but results in disability and social misery. As a source of permanent disability, it ranks second only to leprosy. Furthermore, they spread the virus that causes dengue fever, which is currently one of the most significant and pervasive viral diseases spread by mosquitoes. Indicators show that the disease is steadily increasing in both the number of endemic countries and the number of infection cases **(Govindarajan and Benelli, 2016).**

Because they are carriers for numerous harmful organisms that infect humans, mosquitoes pose a serious threat to public health, particularly in underdeveloped nations **(Medlock *et al.*, 2015).** To name a few, they act as vectors for the spread of dengue fever, filariasis, malaria, and yellow fever **(Nazareth *et al.*, 2016).** Africa accounted for 95% of the global malaria burden in 2020, with an estimated 241 million cases reported globally, according to the 2021 World Malaria Report. Additionally, of the 627 000 malaria deaths predicted worldwide in 2020, 96% were in the Africa Region, according to the World Health Organization **(WHO, 2021).** By using repellant, the human-vector contact transmission cycle can be interrupted **(Abiy *et al.*, 2015).** Furthermore, utilizing bed nets and appropriate mosquito repellant on clothing has produced a lot of benefits, particularly in Africa, and protects the user **(Njumkeng *et al.*, 2019).** Furthermore, one of the best methods for reducing mosquito bites outside is topical repellent **(Wilson *et al.*, 2014).**

Mosquito-borne diseases pose a major threat to global health, affecting millions of people annually. The capacity of plant extracts to control mosquitoes has garnered attention as a viable environmentally friendly solution **(Ghosh *et al.*, 2024).** Numerous fatal illnesses, including as chikungunya, dengue fever, malaria, and the Zika virus, are infamously spread by mosquitoes. These illnesses' high prevalence presents a serious threat to world health, which is why scientists are looking for more sustainable and alternative approaches to mosquito control. Utilizing plant extracts, which have been effective in deterring and eliminating disease-carrying mosquitoes, is one promising approach **(Ghosh *et al.*, 2024).**

The use of synthetic insecticides against mosquitoes may lead to resistance development and poten tial health hazards in humans and the environment. Consequently, a paradigm needs to shift towards the alternative use of botanical insecticides that could strengthen an insecticide resistance management programme **(Muhammed *et al.*, 2022).**

Synthetic insecticides have been used repeatedly to control mosquitoes, which has upset natural biological control systems and caused mosquito populations to rebound. Additionally, it has led to the emergence of resistance **(Liu *et al.*, 2006),** unfavorable impacts on organisms that are not the intended target, and sparked environmental and human health concerns that prompt the search for substitute control methods **(Hayes and Laws 1991).** According to **Georgewill *et al.* (2010),** plants are thought to be a rich source of bioactive compounds and could serve as a substitute supply of mosquito control agents.

To reduce the risk of contracting diseases spread by mosquitoes, it is possible to employ botanicals and their derivatives as insect repellent, especially against mosquitoes **(Shukla *et***

***al.*, 2018; De Sá *et al.*, 2019; Pandiyan *et al.*, 2019).** Neem seed oil and other natural organic compounds derived from the *Azadirachta indica* neem tree have long been known to offer potential as mosquito repellents **(Aremu *et al.*, 2009).**

Alternative and environmentally friendly methods of controlling mosquitoes are now required due to the negative ecological effects of chemical pesticides and the growing problem of insecticide resistance. Examining the environmental and resistance problems related to chemical pesticides in detail is essential to improving knowledge of the topic. The various insect pest populations are managed using a variety of techniques. These techniques, which impact insect growth, development, and population, include chemical insecticides, biological control, synthetic insecticides, resistant types, and semi-chemicals **(Ahmed *et al.*, 2018; Ahmed *et al.*, 2019).**

Alternative, environmentally friendly mosquito control techniques are becoming more and more popular due to worries about the environment and chemical resistance in pesticides **(Ahmed *et al.*, 2021; Iqbal *et al.*, 2021).** According to **Ahmed *et al.* (2021) and Iqbal *et al.* (2021),** synthetic pesticides are now the most effective method of managing insect pests. In comparison to chemical pesticides, botanical insecticides are thought to be safer, more environmentally friendly, and biodegradable **(Iqbal *et al.*, 2021; Ahmed *et al.*, 2021).** Rich in bioactive substances such as flavonoids, terpenoids, phenols, and alkaloids, plant extracts have shown potential as natural insecticidal substitutes for preventing mosquito vectors **(Iqbal *et al.*, 2021; Ahmed *et al.*, 2021).**

The main ingredient that gives neem seeds their insect-repelling properties is azadirachtin, a complex tetra-terpenoid limonoid molecule. Furthermore, unlike synthetic DEET (N, N-diethyl-3-methylbenzamide), essential oil repellents are biodegradable, safe for the environment, and do not damage non-target organisms **(Usharani *et al.*, 2019).**

The neem tree, *Azadirachta indica*, is a versatile plant that has long been used in farming, traditional medicine, and even the textile industry. The neem tree produces a variety of compounds, including neem oil and neem extract, which have been demonstrated to possess insecticidal, antibacterial, and antifungal properties **(Abd El-Salam *et al.*, 2024).**

Of the about 99 physiologically active substances found in neem seeds, azadirachtin, nimbin, nimbidin, and nimbolides are the main molecules. Not only do these derived chemicals regulate insect growth and repel insects, but they also exhibit anti-feedancy, ovicidal activity, and fecundity suppression properties **(Isman 2006).** Antiseptic, antiviral, antipyretic, anti-inflammatory, anti-ulcer, and antifungal substances have been found in the seeds, bark, and leaves **(Sudhir *et al.*, 2010).** According to **Patel *et al.* (2012),** essential oils are complex, volatile, naturally occurring substances that have a strong smell and are produced by plants as secondary metabolites.

Neem oil has a bitter flavor, smells like sulfur or garlic, and is yellow to brown in color. It has been used to manage illnesses and pests for hundreds of years. It has a bitter taste since it is mostly made up of triglycerides and contains a lot of tri-terpenoid chemicals. According to **Sudhir *et al.* (2010),** the active constituents are Quercetin, Gedunin, Sodium Nimbinate, Azadirachtin, Nimbin, Nimbidin, and Nimbidol.

The effectiveness of neem extracts in controlling mosquitoes has been impressive. By interfering with mosquitoes' physiological functions, the active ingredient azadirachtin impairs their capacity for eating and reproduction. Neem has been shown in studies to have larvicidal and pupicidal properties against a variety of mosquito species, including those that transmit dengue and malaria **(Govindarajan *et al.*, 2016).** The essential oil from neem showed good repellency against Anopheles mosquitoes, which spread malaria, according to a study by **Maia and Moore (2011).** Azadirachtin, a substance found in neem extracts, interferes with the mosquito's capacity to feed and procreate. Furthermore, compared to manufactured chemicals, neem extracts have a negligible environmental impact **(Pramanik *et al.*, 2023).**

Neem extract is especially useful in the textile sector since it can serve as a natural color fixative. This makes it a valuable component in the dyeing process since it can aid in enhancing the colorfastness of textiles. Furthermore, it has been discovered that neem extract possesses anti-bacterial qualities, which may aid in inhibiting the development of bacteria and fungi in textiles and prolonging their longevity. Neem extract is also being investigated for its potential to replace synthetic chemicals in the textile sector in a sustainable manner. Neem extract may provide a sustainable and natural way to dye and finish textiles as the market for non-toxic, environmentally friendly textile production methods expands **(Abd El-Salam *et al.*, 2024)**.

In addition to the fact that mosquitoes did not develop resistance to chemical pesticides, some studies also demonstrated the benefits of employing medicinal plant extracts for mosquito control, stating that they are efficient and greatly lower the risks of negative environmental effects from their use. Many researchers worldwide are starting to examine some medicinal and herbal plants for mosquito control as a result of the recent surge in interest in the possible application of plant extracts as substitutes for synthetic pesticides **(Choochote *et al.*, 2004).**

Thus, the purpose of this study was to assess the insecticidal properties of neem (*Azadirachta indica*) seed and leaf oil extract against *Anopheles stephensi*.

MATERIALS AND METHODS

- **Insect rearing**

The third larval instar of *Anopheles* mosquitoes was gathered using the techniques outlined by **Kauffman *et al*. (2017)** from a laboratory colony set up in the insectary of the laboratory of economic entomology in the plant protection department, Faculty Education Omar Al-Mukhtar University, Al-Bayda. Under ideal conditions, the larvae were kept at 25± 1°C, 80± 5% relative humidity, and a photoperiod of 12/12 light/dark hours.

- **Collection of Anopheles Mosquito Larvae:**

Larvae of the Anopheles mosquito, which were discovered in the stagnant water surrounding homes, were gathered using the **Rathy (2015)** method, which involves collecting larvae of the Anopheles genus for the study and using the **Kent *et al.* (2005)** method, which uses the larva morphology as the basis for selection and identification.

Larvicidal effects of seed oils: In a lab setting, against *Anopheles stephensi*. Different seed oil concentrations were investigated for their parricidal effects on Anopheles stephensi larvae.

- **Statistical analysis:**

Sigma Plot software Version 12.5 was used to do a one-way analysis of variance (ANOVA) on the acquired results. A P value of less than 0.05 indicated that the differences between the results were statistically significant. If necessary, all mortalities were adjusted using **Abbott's (1925)** formula. By dividing the number of dead and inactive larvae by the total number of larvae tested, the percentage of larval mortality was determined. Data analysis was conducted using IBM SPSS Statistics for Windows and Microsoft Excel.

RESULTS AND DISCUSSION

A) Insecticidal activity:

The insecticidal activity of neem oil (*Azadirachta indica*) and neem leaf extracts against *Anopheles stephensi* larvae in their third instar was demonstrated by the results presented in **Table (1) and Fig. (1).** However, larvae's mean mortality increased progressively with the concentration of extract of neem oil. It was observed that after 72 hour of exposure to various concentrations of 50, 100, 150, 200, 250 and 300 mg/l) neem oil, the mean mortalities of *Anopheles stephensi* larvae were (23.33, 56.66, 71.66, 80.83, 99.58 and100.00), respectively, while neem leaf extracts recorded the higher mean of mortality of *Anopheles stephensi* larvae after exposure to 72 hours under concentrations of 50, 100, 150, 200, 250 and 300 mg/l) were (21.66, 53.33, 68.33, 75.85, 98.61 and 100.00), respectively, When *Anopheles stephensi* larvae are treated with neem oil and leaf extracts, the control treatment does not record any adult mortality percentage. The findings indicate that when exposure duration and concentration of neem leaf extract and neem oil extract rise, so does the mortality rate of Anopheles stephensi larvae.

The lethal toxicity doses of neem oil (*Azadirachta indica*) and neem leaf extracts against *Anopheles stephensi* larvae are shown in **Table (2) and Fig. (2).** The extracts of neem leaves of *Azadirachta indica* demonstrated strong larvicidal activity, with an LC_{50} value of 37.69 ppm and LC_{90} value of 106.28 ml/l. In a similar vein, *Azadirachta indica* neem oil demonstrated good larvicidal activities with LC_{50} and LC_{90} values of 41.94 ppm and 97.02 ppm. With mortality rates that were dose-dependent and impacted by exposure duration, the results showed that the tested seed oil was effective against the target larvae. Of the seed oils, *A. indica* seed oil showed the best efficacy. Neem oil's ability to repel different mosquito species was evaluated by **Sharma, (1995).** Plant-derived essential oils (EOs) are becoming more popular as a substitute for synthetic insecticides in the management of Anopheles larvae because of the spread of resistant strains of malaria vectors and the growing resistance to these pesticides **(Atenafu and Atnaf, 2025).**

In this regard, our results are in line with earlier studies that reported relatively high fatality rates in Anopheles species using extracts from a range of medicinal herbs **(Laojun and Chaiphongpachara, 2020).** For instance, research on *A. indica* and *O. sanctum* revealed that their bioactive phytochemicals, especially at higher concentrations, have strong larvicidal activity **(Pavela, 2015).** According to earlier studies, plant extracts had stronger larvicidal effects with extended exposure **(Ghosh *et al.*, 2012).**

Despite their considerable larvicidal capability, synthetic larvicides like Temephos, which reliably achieve 100% mortality at the concentrations utilized, generally perform better than plant extracts. This disparity demonstrates how synthetic chemicals are more effective, yet plant-based insecticides are favored because of their safety for the environment **(Pavela, 2015; Abai *et al.*, 2016)** and concerns over the development of resistance **(Abai *et al.*, 2016).** The results clearly demonstrate a concentration response relationship, with higher concentrations of plant extracts associated with higher mortality rates.

It has been demonstrated that plant extracts with higher concentrations have superior larvicidal effects **(Oliveros-Díaz *et al.*, 2022; Dey *et al.*, 2023).** When **Dey *et al.* (2023)** studied extracts from *Annona muricata*, for instance, they discovered a similar pattern: higher concentrations were associated with higher mosquito larval mortality rates. This conclusion is in line with prior research that demonstrated longer exposure to plant extracts increased mosquito larval mortality rates. This is explained by the extracts' bioactive chemicals' cumulative effects, which may take some time to kill the larvae **(Daz and Rossini, 2012).**

For example, **Awosolu *et al.* (2018) and Chatterjee *et al.* (2023) f**ound that the LC_{50} values for *A. indica* against *Aedes aegypti* ranged from 80 to 100 ppm, suggesting that *C. macrostachyus* may have a better larvicidal activity. **Hillary *et al.* (2024)** state that *C. macrostachyus's* LC_{50} against *Anopheles stephensi* is likewise lower than that of methanol extracts of O. sanctum (85 ppm). The potential of *C. macrostachyus* as an efficient all-natural pesticide is indicated by each of these findings. Depending on the plant species and extraction techniques used, these variances would suggest that the efficacy of plant extracts can vary considerably **(Njuabe *et al.*, 2022).** According to a study **(Bagavan and Rahuman, 2011),** the presence of different phytochemicals in plant extracts may actually cause unequal biological reactions. Further evidence that variety affects *R. abyssinicus's* efficiency may come from the species' larger confidence ranges. All *A. indica* extracts shown larvicidal action against Anopheles mosquito larvae, according to the experimental results of this investigation. This conclusion is consistent with a prior study conducted by **Ghosh *et al.* (2013).** The extracts' larvicidal efficacy was incredibly diverse. Different phytochemical classes found in the plant may be the cause of the diverse biological actions of these plant extracts; these substances may work together or separately to provide larvicidal activity. Water, which has no effect on mosquito larvae and exhibited an abnormal response, was utilized as the negative control. In line with a study by **Kajla *et al.* (2016),** the data demonstrated that the larvicidal efficacy increased progressively as the dose was increased, reaching a peak of 100% mortality after 6 mg/ml of the extract.

Table (1): Larvicidal effect of *Azadirachta indica* seed oil and leaves extract

Conc. (mg/l)	Larval Mortality (%)					
	Neem seed oil			Neem leaves extracts		
	24h	48h	72h	24h	48h	72h
Control	0.00	0.00	0.00	0.00	0.00	0.00
50	10.00f	18.33f	23.33f	8.33f	16.66f	21.66f
100	26.66e	48.33e	56.66e	23.33e	46.00e	53.33e
150	46.66d	66.66d	71.66d	43.33d	63.33d	68.33d
200	60.00c	73.99c	80.83c	51.79c	70.30c	75.85c
250	90.42b	95.00b	99.58b	86.25b	91.39b	98.61b
300	100.00a	100.00a	100.00a	100.00a	100.00a	100.00a

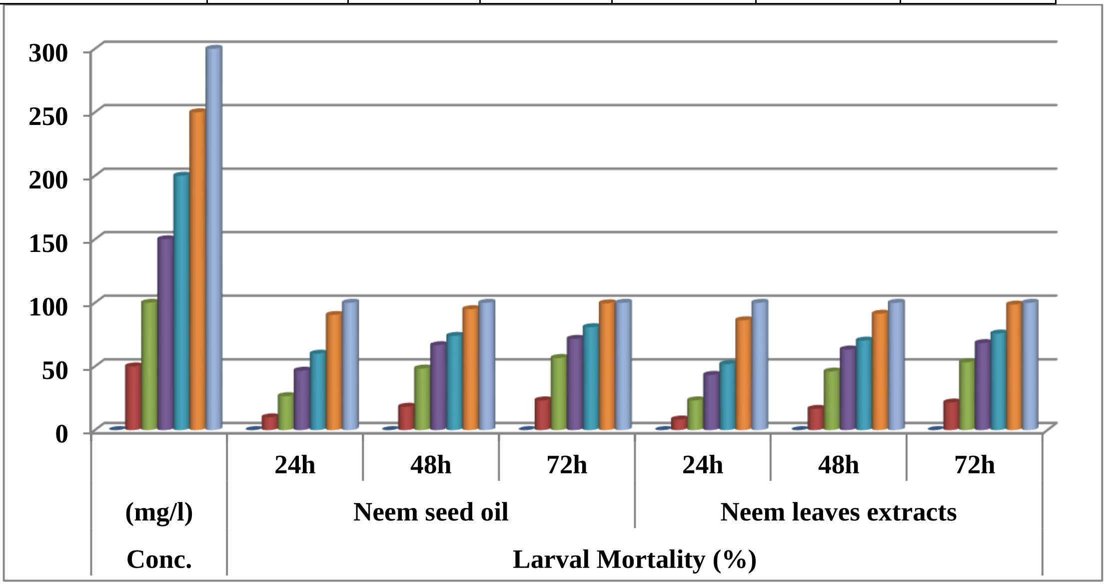

Fig. (1): Larvicidal effect of *Azadirachta indica* seed oil and leaves extract

Table (2): LC_{50} and LC_{90} (%) of leaf extracts of neem against the third instar larvae of *Anopheles stephensi*

Treatments	LC_{50}	95% Confidence limit		LC_{90}	95% Confidence limit		χ^2 (df = 5)
		LCL	UCL		LCL	UCL	
Neem seed oil	44. 52	41. 94	47. 20	97. 02	84. 78	107. 81	4.51
Neem leaves extracts	37. 69	36. 57	42.28	106. 28	95.72	120. 30	2.39

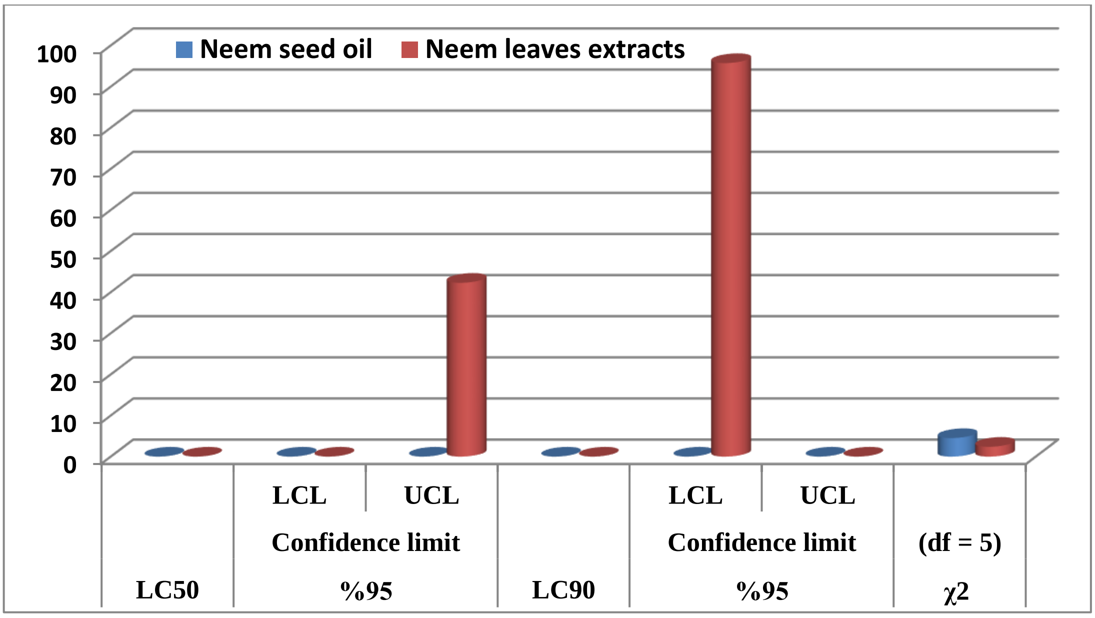

Fig. (2): LC_{50} and LC_{90} (%) of leaf extracts of neem against the third instar larvae of *Anopheles stephensi*

B) Adulticidal activities:

The Adulticidal activity of neem oil (*Azadirachta indica*) and neem leaf extracts against *Anopheles stephensi* adults in their third instar was demonstrated by the results presented in **Table (3) and Fig. (3).** However, mean adults mortality percentage increased progressively with the concentration of extract of neem oil. It was observed that after 72 hour of exposure to various concentrations of 50, 100, 150, 200, 250 and 300 mg/l) neem oil, the mean mortalities of *Anopheles stephensi* adults were (11.67, 15.00, 18.33, 26.67, 55.00 and 84.00), respectively, while neem leaf extracts recorded the higher mean of mortality of *Anopheles stephensi* adults after exposure to 72 hours under concentrations of 50, 100, 150, 200, 250 and 300 mg/l) were (10.50, 13.50, 16.50, 24.00, 49.50 and 75.60), respectively, Neem oil and leaf extracts are used to treat *Anopheles stephensi* adults, while the control therapy does not record any adult mortality percentage. According to the findings, the mortality rate of adult *Anopheles stephensi* rises as exposure duration and concentration of neem leaf and oil extracts increase.

The lethal toxicity doses of neem oil (*Azadirachta indica*) and neem leaf extracts against *Anopheles stephensi* adult are shown in **Table (4) and Fig. (4).** The extracts of neem leaves of *Azadirachta indica* demonstrated strong adulticidal activity, with an LC_{50} value of 333.27 ppm and LC_{90} value of 1031.74 ppm. In a similar vein, *Azadirachta indica* neem oil demonstrated good adulticidal activities with LC_{50} and LC_{90} values of 297.75 ppm and 762.63 ppm.

Depending on their action, plant extracts can be applied as repellents to prevent mosquito bites or as insecticides to kill adult or larval mosquitoes **(Sukumar *et al.*, 1991).** Different phytochemical classes found in the plant may be the cause of the diverse biological actions of these plant extracts; these substances may work together or separately to provide larvicidal activity. Water, which has no effect on mosquito larvae and elicits a typical response, was employed as the negative control **(Chombo, 2021).** The outcome is consistent with research by **Okumu *et al.* (2007) and Ayinde *et al.* (2020),** which claimed that neem oil formulation is a very successful larvicide for controlling anopheline mosquito vectors. Additionally, under field settings, *A. indica* oil has demonstrated strong larvicidal efficacy against many mosquito genera, such as Aedes, Anopheles, and Culex **(Mgbemena, 2010).**

Table (3): Adulticidal activities of *Azadirachta indica* seed oil and leaves extract

Conc. (mg/l)	Adult Mortality (%)					
	Neem seed oil			Neem leaves extracts		
	24h	48h	72h	24h	48h	72h
Control	0.00	0.00	0.00	0.00	0.00	0.00
50	5.33	7.76	11.67	4.80	6.98	10.50
100	8.20	8.67	15.00	7.38	7.80	13.50
150	13.33	16.67	18.33	12.00	15.00	16.50
200	18.33	21.67	26.67	16.50	19.50	24.00
250	23.33	48.33	55.00	21.00	43.50	49.50
300	61.55	65.00	84.00	55.40	58.50	75.60

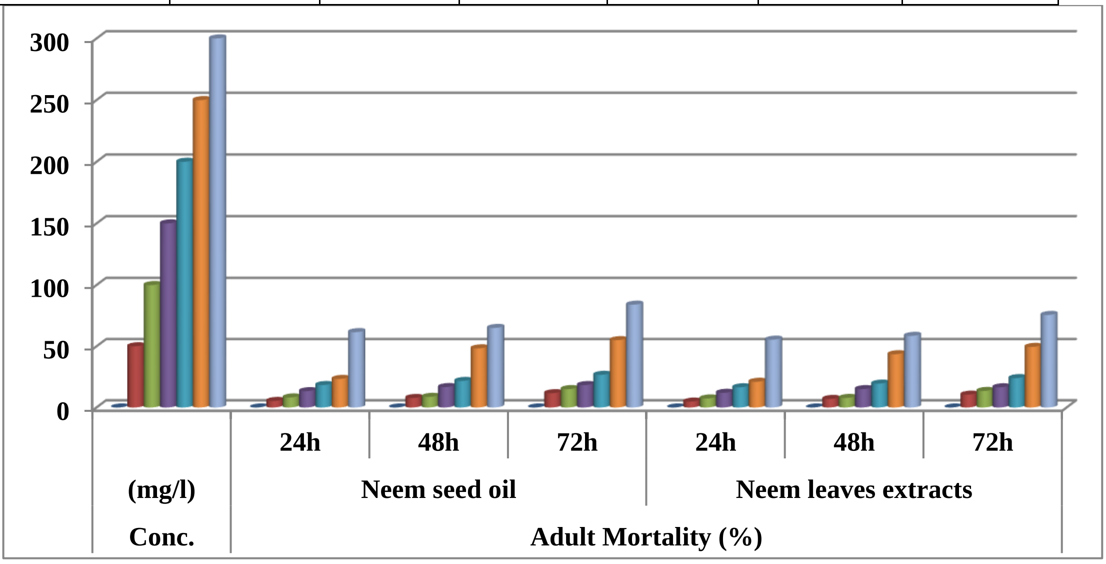

Fig. (3): Adulticidal activities of *Azadirachta indica* seed oil and leaves extract

Table (4): LC_{50} and LC_{90} (%) of leaf extracts of neem against the third instar larvae of *Anopheles stephensi*

Treatments	LC_{50}	95% Confidence limit		LC_{90}	95% Confidence limit		χ^2 (df = 5)
		LCL	UCL		LCL	UCL	
Neem seed oil	297. 75	254. 95	340. 56	762. 63	491. 13	1034. 13	0.88
Neem leaves extracts	333.27	268.92	397.63	1031.74	569.06	1494.43	0.75

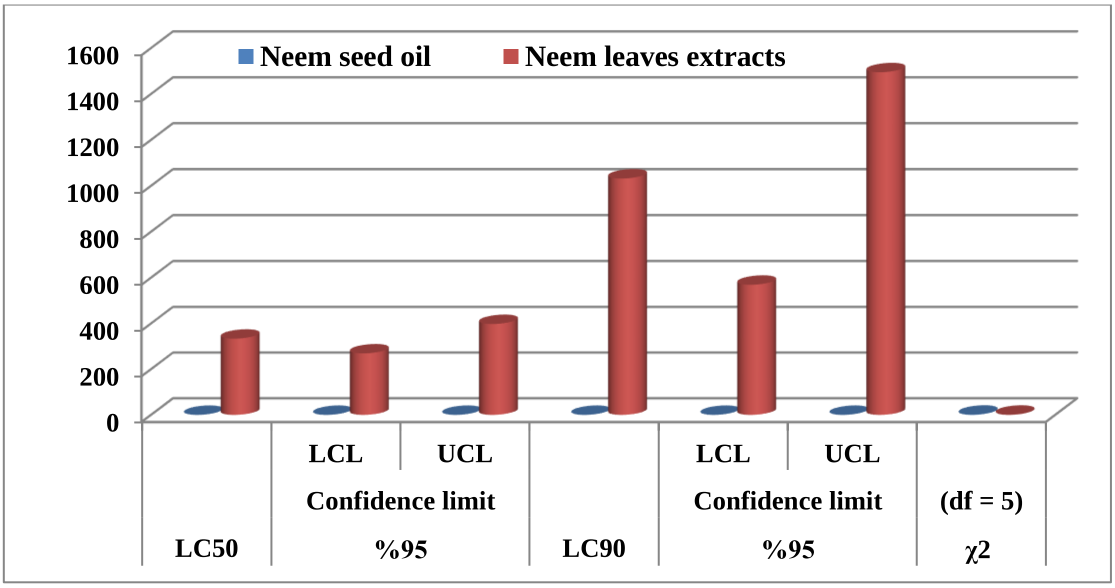

Fig. (4): LC_{50} and LC_{90} (%) of leaf extracts of neem against the third instar larvae of *Anopheles stephensi*

CONCLUSION

According to the results of this study, the neem plant, *Azadirachta indica*, has a larvicidal effect on mosquitoes. Because the plant's leaf extract is extremely poisonous, even at low concentrations, it may one day be used as a larvicide. To identify the active ingredients and ideal dosages that provide the larvicidal action, more research is necessary. This plant's product can also be used to make phytochemicals or biocides that can protect non-target organisms from dangerous vectors. This plant would be environmentally beneficial and could be a good substitute for synthetic larvicides, which are widely accessible, reasonably safe, and index pensive in many parts of the world. This plant is environmentally beneficial and could be a good substitute for synthetic larvicides, which are widely accessible, safe, and reasonably priced worldwide.

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