بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Graduate Studies

A Survey of Two Fruit Flies : Asian Fruit fly(*Bactrocera invadens*) and Peach fruit fly (*Bactrocera zonata*) , Diptera " Tephritidae) , and Repellent Effects of two Plant Extracts against their Adults

مسح لنوعين من ذبابة الفاكهة (الآسيوية والخوخ) و التأثير الطارد لاثنين من المستخلصات النباتية على أطوارهم الكاملة

A Thesis submitted in Partial Fulfillment of the Requirements for the M. Sc. Degree in Plant Protection

By

Arafat Ahmed Habib Allah Yassin

B.Sc. Agric. Plant Protection (Honors)

College of Agricultural and Natural Resources Abuhraz

University of Gezira (2014)

Supervisor: Prof. Awad KhalafallaTaha Elhag

Department of Plant Protection

College of Agricultural Studies -Shambat

Sudan University of Science and Technology

July, 2019

الآيـة

(مَّثَلُ الَّذِينَ يُنفِقُونَ أَمْوَالَهُمْ فِي سَبِيلِ اللّهِ كَمَثَلِ حَبَّةٍ أَنبَتَتْ سَبْعَ سَنَابِلَ فِي كُلِّ سُنبُلَةٍ مِّئَةُ حَبَّةٍ وَاللّهُ يُضَاعِفُ لِمَن يَشَاء وَاللّهُ وَاسِعٌ عَلِيمٌ) (البقرة/261)

Dedication

To My beloved mother

To my dear father

To my dear brother

To my brothers

To all my teachers and friends

With love and respect

Arafat

Acknowledgements

All thanks are due to Almighty Allah who gave me health and strength and helped me tremendously to produce this work. I would like to express my thanks to my supervisor Prof. Awad Khalafalla Taha Elhag For helpful assistance, guidance, patience and keen interest and continuous participation throughout this study.

Also, I would like to express my sincere thanks to " The Directorate of Scientific Research " at " the Ministry of Higher Education & Scientific Research " for the Financial Support of This study.

Thanks are also extended to all those who gave me hand and helped me in producing this work. Last, but not least I am greatly indebted to my family that backed and encouraged me throughout my life.

List of Contents

List of contents

List of Tables

List of Figures

List of Plates

ABSTRACT

This study was carried out to monitor and survey the fruit fly species in Slait area north of Khartoum Bahri locality, during the period from November 2017 to March 2018 to identify the major species. Hence a Survey was carried out using, the food traps (guava juice) and sticky traps (Methyl Eugenol) for capturing prevailing species in Slait area. The results of the survey showed that there are two types of fruit flies, the **peach fruit fly** *(Bactrocera zonata)*, which was the dominant species, and the **Asian fruit fly** (*Bactrocera invadens)* in the study area.

The second aim of this study was to investigate, through Laboratory Experiments, the repellency effect of ethanolic extracts of Neem leaves (*Azadirachta indica*) andUsher Plant leaves (*Calotropis procera*) on the adults of two encountered species. Accordingly two concentrations of each of the Neem and Usher ethanolic leaves extracts were used (i.e.,10% , 20%) Through topical application method.

The results revealed that both extracts have a repellency effect on the adults of the two species of fruit flies. The repellency effect was detected periodically after 2, 4, 6 and 8 hrs after application. In addition it was found that the two concentrations caused high repellency effect in comparison to the control treatment where only water was applied.

الملخص

اجريت هذه الدراسة لتحقيق هدفين اساسيين يساعدان علي مكافحة افة ذباب الفاكهة :

1: لمراقبة ومسح ذبابة الفاكهة في منطقة السليت شمال محلية الخرطوم بحري خلال الفترة من نوفمبر2017 الي مارس 2018 لتعريف الانواع الموجودة من ذبابة الفاكهة. تم المسح باستخدام الطعوم الغذائية (عصير الجوافة) والمصائد اللاصقة (ميثايل اجينول) في منطقة السليت. اوضحت نتائج المسح ان هنالك نوعان من ذباب الفاكهة وهما: ذبابة فاكهة الخوخ وهي النوع السائد في المنطقة وذبابة الفاكهة الاسيوية.

2: تقييم الاثر الطارد معمليا للمستخلصات الايثانولية لاوراق النيم والعشر علي الحشرات الكاملة لكل من ذبابة فاكهة الخوخ وذبابة الفاكهة الاسيوية. وفقا لذلك ،تم استخدم اثنان من التركيزات (10% و20%) من مستخلصات اوراق النيم والعشر الايثانولية ضد ذبابة فاكهة الخوخ والاسيوية بواسطة الطريقة الموضعية

اظهرت النتائج ان كل المستخلصين لهما تاثير طارد على البالغين من النوعين من ذباب الفاكهة. تم اكتشاف تاثير الطرد بشكل دوري بعد 2، 4، 6، 8 ساعة بعد التطبيق. بالاضافة الي ذلك ،وجد أن كل التركيزات المختبرة من مستخلصي النباتين احدثت نسبة طرد عالية مقارنة بالشاهد.

CHAPTER ONE
INTRODUCTION

1. INTRODUCTION

1.1 Historical background

Tephritid fruit flies, of the order Diptera are the most notorious insect pests that attack various fruits and vegetables (Mahmoud *et al.*, 2012).Globally, fruit flies play a vital role in the economics of horticultural crop producing countries causing serious economic losses and hindered exportation. Most of the fruit flies are polyphagous species. Over 4500 species of fruit flies are reported worldwide, about 500 species are major pests of various horticultural crops. (Fetoh,2012)

Horticultural crops represent about 12% of National agricultural income. The estimated total fruit production in Sudan is about 1.9 milion tons in a cultivated area of about 186.000ha. fruit production in Sudan needs very little Agro-chemicals thus the fruit and relatively free of chemical residues which if certified could give a comparative edge and a comparative advantage in international markets (Bashir and Imam,2010).

In recent years fruit production is greatly hampered by fruit flies worldwide with a loss about 30%. Also, the loss of fruit production in many African countries was estimated between 30-80%; howeverit reached about 100% during outbreak years (Mohamed, 2003). In addition to causing direct loses in the yield and marketability, fruit flies pose as significant threats to quarantine security and thus to international trade in fruit and fresh vegetables worldwide (El-Aw *et al.*,2008).

Major fruit flies species in Sudan:

Major species of fruit flies attacking crops in the Sudan are Mediterranean fruit fly or med fly (*C. capitata*), Mango fruit fly or Marula fruit fly (*C. cosyra*), Rhodesian fruit fly (*C.* quinaria), African invader fly (*B. dorsalis*) Melon fly *Zeugodacus cucurbitae*, *Dacus vertibratus*, *D. Cilliatus* and *D. longistylus* (Mahmoud *et al.*, 2012). In 2012, peach fruit fly *B. zonata* has been added to the list of the economic fruit flies of Sudan (Salah *et al*., 2012).

1.2 Objectives of the study

1. Survey, Collection and identification of fruit flies in some fruit orchards, **at** (Slait Agricultural Scheme), Khartoum State

2. Evaluation, under Laboratory conditions, of the effectiveness of the Repellency rate of some Plant Extracts against adults of fruit flies.

CHAPTER TWO

LITERAURE REVIEW

2.1 Asian fruit fly (*Bacterocera invadens*) and Paech fruit fly (*Bacterocera zonata)*

2.1.1 Taxonomic status

Fruit flies are belonging to the Domain: Eukaryota, Kingdom: Metazoa, Phylum: Arthropoda, Subphylum: Uniramia, Class: Insecta, Order: Diptera, Family: Tephritidae, Genera the family Tephritidae include several genera such as *Ceratitis, Dacus*and *Bactrocera* that contain numerous species of economic horticultural importance.(White *et al.*,1994) and (Mahmoud, 2011).*Bactrocera* is the most economically significant genus, with about 40 species considered to be important pest(Ibrahim, 2007).The genus *Ceratitis*is endemic to the Afro tropical region and contains about 56 species considered as polyphagous, (Mahmoud, 2011). In the Sudan, the genus *Bactrocera* consists of the most hazardous and alien invasive species that threatened horticultural and vegetables production *viz; B. zonata* and *B. dorsalis.*

2.1.2 Origin and Distribution:

The family Tephritidae is represented in all continents except Antarctica, but the major genera have limited natural distributions, *Anastrepha* spp. occur in South and Central America and the Caribbean; *Bactrocera spp*. are native to tropical Asia, Australia and the South Pacific; *Ceratitis* and *Dacus* are native to tropical Africa (Mafirakurewa, 2014)

2-1-3 Host Range

Generally, fruit flies are polyphagous with host plants such as apple, guava, banana, date palm, orange, papaya, peach, eggplant, tomato and cucurbits (Averill, 1996).

B.invadens is an emerging polyphagous fruit fly pest, and in Africa, it has been reported to attack over 43 fruit species from 23 families with mango being one of the most preferred cultivated hosts (Ekesi, 2007, Rwomushana*et al.,* 2008, Mwatawala *et al.*, 2009 and Goergen, 2011). Direct damage to mango due to *B. invadens* has been reported to range from 30-80% depending on the cultivar, locality and season (Ekesi, 2006; Rwomushana *et al.,* 2008 and Vayssieres, 2009). In addition to the direct losses, indirect losses attributed to quarantine restrictions have been enormous. The direct and indirect damage continue to have wide reaching socio-economic implications for millions of rural and urban populations involved in the mango value chain across Africa. The pest has been described as "a devastating quarantine pest" by the Inter-African phytosanitary Council (French, 2005).

In Sudan, fruit flies were first reported by Venkatraman and Elkhidir in 1965 on egg-plant (*Solanum melongena*) and guava (*Pisidium* sp).

Ali (1967) reported that, nine species of fruit flies were found in Sudan, of which five are well known pests of economic crops in many parts in Africa. Schmutterer (1969) reported that, the family Tephritidae was considered the fourth group of insect pests causing serious damage to fruit crops in Sudan. Among the fruit flies were *Dacus* species which highly infest Cucurbitaceae and *Ceratitis* spp. Which constitute the major pests of guava, citrus (orange, tangerine, and grape fruit), mango, and egg-plant.

2.1.4 Nature of Damage and Economic Importance:

The direct damage to crops caused by fruit flies resulted from oviposition in fruits and soft tissues of reproductive parts of certain plants, feeding by the larvae and decomposition of plant tissue by invading secondary microorganisms (Duyck *et al.,* 2004) and, while indirect damage is losses resulted from the implementation of regulatory controls and loss of export market.

Direct damage caused by the fruit flies usually range from 20 to 92% (Mafirakurewa, 2014). (Sarwar, 2014, and Jose, *et al.*, 2013). European and Mediterranean Plant Protection Organization, (EPPO, 2005) reported that, the annual costs of damage of *B. zonata* in the Near East are estimated to 320 million EUR. In Africa, fruit flies cause losses of 40% of the total production of mangoes, Ugandan mangoes' industry lost more than 116 millions of Dollars due to *B. dorsalis* and causing losses of up to 40% in mangoes in East Africa(Serge *et al.,* 2016). The annual losses in the eastern Mediterranean (Israel, Palestinian Territories, Jordan) linked to fruit flies infestations are estimated at 192 million US $ (De Meyer *et al.,* 2009).

In Sudan fruit flies are among the major pests that cause serious damage. In 2007, fruit flies were added to the national list of pests (Khair, 2013) while indirect damage is losses resulted from the implementation of regulatory controls and loss of export market.

2.1.5 Biology of the fruit flies

The fruit fly (*Bactrocera invadens* (Drew *et. al*., 2005) is a new fly species for which few scientific data are available. The females pierce the fruits using their ovipositors to lay their eggs in the pulp. Each female can lay on average 700 eggs depending on the host. The species is multivoltine (i.e. several generations / year) with an average life span of about 3 months (Ekesi *et al*., 2006). The mean generation time for *B. invadens* was found to be 30.7 days at 28 ± 1º C. However, generation time is largely dependent on temperature. In order to determine phenological events in the field for monitoring and eradication purposes, it is important to determine the temperature-development rate of the pest. The developmental rates of *B. invadens* were determined at five constant temperatures of 15°C, 20°C, 25°C, 30°C and 35°C and a photoperiod of L12:D12. The table below shows the mean total developmental time of the immature stages (egg to pupa) in days. (Rwomushana *et al*., 2008).

Temperature ^{o}C	Mean (egg to pupa)time (days)
15	**75.74**
20	**31.45**
25	**21.19**
30	**17.76**

Females begin to lay eggs about 8 days after emergence from the puparium. Under optimum conditions, a female can lay more than 3000 eggs during her life time, but under field conditions approximately 1200 to 1500 eggs per female is considered to be the usual production. Ripe fruits are preferred for laying egg, but immature ones may be also attacked. Adult flies live for many months (Ronald, 2007).

2.1.6 Number of annual generations

Bactrocera spp. was reported to have 6-10 annual field generations (FAO, 2004).The duration of the different stages varies with species, host plant, and climatic conditions.

2.1.7 Behavior of the fruit flies

Tephritids exhibit a wide array of interesting and sometimes spectacular behaviors in many aspects of their life especially during their dispersal, feeding and ovipostion.

2.1.7.1Oviposition behavior

Females often discharge a marking pheromone on the fruit (or other part of the plant in which eggs are deposited).This pheromone deters ovipostion by other females (Headrichs and Goeden, 1994).

The ovipostion behavior appears to be more uniform than epigamic behavior. The female lays several eggs singly or in clusterbeneath the skin of mature ripe fruits during an extended period of many hours (Aluja and Norrbom, 1999).

2.1.7.2 Feeding behavior

Feeding behavior of Tephritids in nature is poorly understood (Headrichs and Goeden, 1994). The larvae feed on the internal tissues of infested fruits causing rot and the fruit drop (FAO, 2004). Adult nutritional requirements vary and largely depend on the quality of the larval food and usually include at least carbohydrates and water, (Aluja and Norrbom,1999). Adults may feed on plant exudates, including those from the ovipostion punctures or rotting fruits, bird feces, nectar, honey dew, pollen grains and rain drops (Headricks and Goeden, 1994).

2.1.8 Monitoring and control of fruit flies

2.1.8.1 Monitoring

Mohamed and Ali (2008) and Mohamed and Taha (2008) mentioned that, homemade traps with methyl eugenol lure were used to attract the adult males of *B. invadens* in Sudan. Gubara *et al.,* (2009) adapted that, the para pheromone trap 95% TC (methyl eugenol 95% TC) with 3 ml of mixture of 80% methyl eugenol and 20% of malathion 57%, by volume in a cotton wick (4 cm long X 1cm diameter) was applied for controlling the adult males of *B. invadens* in Sudan.

Also, Bashir (2007) reported that, extracts of mango *M. indica*, guava *P. guajava* and Sidir, *Zizyphus spinachristi* can attract *C. cosyra*. Rosseler (1989) mentioned that, ammonium acetate, 1, 4-diaminobutane (putrescine) and tri methylamine (FA-3) are used as long-lasting dispensers for attracting fruit flies. Males of *C. cosyra* do not respond well to Tri med-lure (TML), Cuelure or Methyl Eugenol (ME). However, they respond to Terpinyl Acetate and several terpinoids, while females respond to food baits as Nulure (Lux *et al*., 2003).
Males of *Ceratitis rosa* and *C. fasciventris* respond very well to TML where *B. invadens* is attracted to ME and respond to Nulure. One of the most effective mechanical control methods is bagging the fruits to exclude egg laying (Hill, 1983).

2.1.8.1.1 Methyl Eugenol (ME)

The first use of specific bait attractant for males of fruit flies was (ME) for *bactrocera zonata* in 1912 (IAEA, 2003). Methyl eugenol (ME) occurs naturally in more than 450 plant species from 80 families, *e.g*. (Canellaceae (*Canella winterana* stems), Fabaceae (*Acacia farnesiana*), Lamiaceae (*Ocimum* spp.) etc…) that grows mainly in the tropics and is a fundamental nutrient of some *Bactrocera* spp. (Aluja and Norrbom, 1999; Vayssieres *et al*., 2007 and Tan and Nishida, 2012). Derw and Hooper (1981) reported more than 40 species of Tephritidae responding to ME. In addition to being a powerful fruit fly attractant, ME is commonly added to processed foods as flavoring agent (*e.g.* jellies, chewing gum, relish and ice cream, and as a fragrance in several cosmetic products). In order to control *B. dorsalis* complex, methyl eugenol (ME), a highly potent male attractant, was extensively used with great success, especially in male annihilation programs (Steiner *et al.,* 1970). Recently, it was found that the consumption of ME enhances the mating competitiveness of males (Hee and Tan, 1998). According to Chuang and Hou (2008), the attract-and-kill system containing ME incorporated with toxicants is presently the most commonly used technology for field monitoring and fruit fly control in Taiwan. Also, Vayssieres *et al.* (2007) mentioned that, the MAT has been used successfully in eradicating several *Bactrocera* spp. Such as the oriental fruit fly, *B. dorsalis* from Rota and Japan and the papaya fruit fly, *B. papaya*, from Australia. It is also the current method used to eradicate infestations of *Bactrocera* spp. In California and Florida. The specific method of formulating and constructing bait stations in each of these programs in individually tailored to local conditions and resources, but all consist of a mixture of ME with toxicant and a carrier matrix in which it is applied. The MAT bait stations that were used in French Guiana were made of absorbent fiberboard block. These blocks were soaked in a mixture of ME and ultra-low volume Malathion (96%) (3:1 vol/vol) and then hung by a wire in host trees throughout the area in which

the population had been detected. The males attracted by the ME, consume a small portion of the mixture (although contact is sufficient) and are killed by the Malathion. Very high levels of male mortality (near 100%) are needed in MAT programs for an effective reduction in the fruit fly infestation rate, requiring a thorough distribution of the bait stations throughout the area (Vayssieres *et al.*, 2007).

2.1.8.1.2 Bait Application Technique (BAT)

Food baits based on protein solutions, fermenting sugar solutions, fruit juices and vinegar have been used since 1918 for the capture of adult fruit fly of several species (IAEA, 2003). Worldwide, the use of protein baits mixed with insecticide, termed as the bait application technique (BAT), is one of the main methods of fruit fly control. The technique works on an attract and kill principle, whereby adult flies (in particular females) in search of food (protein) to mature sexually are attracted to the bait and are killed by an insecticide mixed with the bait, either upon contact or following ingestion of the mixture. Such poisoned bait mixtures limit the use of insecticide and at the sometime increase efficacy of control. Baits that have been found to be effective against fruit flies are hydrolysed yeast or vegetable proteins. Poisoned baits can be applied either as foliar sprays (aerial or ground) or in discrete containers known as bait stations. Bait stations are currently being used in some fruit fly management programmes. The use of bait stations further limits the release of insecticide in the environment as well as limiting residues on fruits (Mangan and Moreno, 2007 and Manrakhan and Kotze, 2009).

2.1.8.2. Control of fruit flies

2.1.8.2.1 Cultural control

The principal cultural control method used for controlling this pest is field sanitation. Field sanitation directed towards the destruction of all unmarketable and infested fruits. Infested fruits should be buried 3 feet under soil surface

with addition of sufficient time to kill larvae. Harvesting of fruits weekly also reduces food sources from which large populations may develop by keeping the quantity of ripe fruit on the trees to a minimum. Other procedures that reduce the amount of in-field breeding of flies should be used (Heppner, 1985).

2.1.8.2.2 Legislative control

Quarantine laws aimed at preventing the entry and establishment of flies in areas where they do not occur have been established and are vigorously enforced. The United States (US) Government has strict laws regulating the movement of certain commodities to prevent the establishment of fruit flies into the continental US. Also, the Japanese Government restricts the entry of commodities attacked by these pests into their country (Mahmoud, 2011).

2.1.8.2.3 Biological control

Biological control is the use of natural enemies to control pests. Common natural enemies of fruit include predators, *e.g.* Ants and lizard, Opiine parasitoids and pathogens, e.g. *Metarhizium anisopliae*, *Beauvaria bassiana* and *Bacillus* spp. (Wharton, 1989 and Ekesi *et al.*, 2005). Although they can't always prevent economic damage, they are important for managing these pests. Often the effectiveness of natural enemies is adversely affected by farming practices, such as the use of broad spectrum insecticides (Ekesi *et al.*, 2005).

2.1.8.2.4 Chemical control

The chemical or the insecticidal methods of control of fruit flies fall under three main categories: spray the adults with suitable insecticides, trapping of the adult flies by means of a chemical attractant and bait spray that insecticide mixed with bait (Ali, 2007).

Steven *et al.*,(2000) found that, spinosad, a bacteria-derived toxin, and phloxine B, a red dye with phototoxic properties, can significantly control the Mediterranean fruit fly, *C. capitata* (Wiedemann) in the Hawaiian Islands. Because of their environmental safety, this approach should be considered for eradicating incipient populations of this invasive species of fruit fly. Spinosad

and phloxine B were found to be effective up to one week; Malathion remained effective at least for two weeks.

2.2Neem Tree "*Azadirachta indica"*

Neem is versatile tree, it is considered to be one of the most promising trees of the 21 century. It has great potential in the pest management, environment protection and medicine. Also it has showing reappraise as potential fertilizer (Abdalla, 2010).

2.2.1 Classification

Kingdom: plantae

Division: magnoliophyta

Order: Rutales

Suborder: Rutinae

Family: Meliaceae

Subfamily: Melioideae

Genus: *Azadirachta*

Species: *indica*

2.2.2. Origin of Neem

Neem is versatile tree of Indian and Burma origin where the ancient healers of that region knew it very well in health (ICIPE, 2002).

2.2.3 Description

Neem is a fast growing tree that can reach a height of 15-20m, rarely to 35-40m. Its over green but under severe drought it shed mostly or nearly all of it leaves. The branches are wide spread, the fairly dens crown is roundish or oval may reach diameter of 15-20m. In old tree standing specimen the trunk is relatively short straight and many reach a diameter of 1.2m. The bark is hard fissured or reddish-brown. The sap wood is grayish white and heart wood reddish when first exposed to the air becoming reddish after exposure. The root system consists of a strong tap root and well developed tateral roots. The alternate, pinnate leaves are medium (Ganguli, 2002).

2.2.4 Distribution:

Neem is widely distributed throughout South East Asia and West Africa and part of Central America (Stoll, 2000). Neem is introduced to Sudan in the 20 century. The first one were planted at shambat in 1916, today trees are spread in town and villages along the Blue and White Nile, irrigated areas of Central Sudan, Kordofan and Darfur (Schmutterer, 1969).

2.2.5 Ecology:

The Neem trees is famous for its drought resistance, normally it thrives in areas with sub-arid to sub humid conditions with an annual rainfall between 400 and 1200 mm. it can also grow in regions with an annual rainfall 400MM. but in such cases it depends largely on the ground water levels. Neem can grow in many different types of soil, but it seems to develop best on well drained, deep sandy soils. It is a tropical and subtropical tree, and exists at annual means temperatures and does not tolerate (Ganguli, 2002).

2.2.6 Chemical Compounds of Neem tree:

Various compounds were isolated from different parts of neem tree using different chemicals. Most of the known active compounds belong to the group of titer penoids (Schmutterer, 1990). Azadirachtin and Solanin are the most important constituents of Neem seed kernel composition, other active compounds in the seed kernel are Salanin, Salanol, Acetate, Nimbin and Deactly nimbidin (Jacobson, 1989).

2.2.7 Neem Research in Sudan

Neem research in Sudan started in the 60; concentrating on it is use as pesticide.Currently three is extensive research, reported and projects published by the National Centre for Research (Khartoum, Sudan) NCR and many other universities(El-abjar, 1992).

2.2.8 Uses of Neem in pest and disease control:

Neem is deemed very effective in the treatment of scabies although only preliminary scientific proof exists which still has to be corroborated and is recommended for those who are sensitive to Permethrin. A known insecticide which might be irritants and also the scabies mite has yet to become resistant to Neem, so in persistent cases Neem has been shown to be very effective, there is also anecdotal evidence of its effectiveness. In treating infestations of head lice in humans, it is also very good for treating worms (soak the branches and leaves in lukewarm water and drink it). In the traditional medicine Neem trees originated on the Indian subcontinent. The Neem twig is nature's tooth brush to over 500 million people daily in India alone. Herbal medicine is the oldest form of therapy practiced to be mankind and much of the oldest medicinal use of plants seems to have been based on highly developed 'dowsing instinct' (Grigs, 1981). Siddig (1993) reported from Sudan that Neem seed water extracts at1Kg/1Liter of water repelled foliage pest of potato including *B. tabaci*, *Aphis gossypii* and *J. lybica* and yield increased to 5 ton/ ha. Mohammed (2002) reported that Neem seed showed good performance against *A. gossypii*, *B.tabaci*, and *J. lybica* on Okra. Dawood (2001) reported that Neem water extracs at 1Kg/liter water reduced the number of onion thrips at 63.5% under the field condition.

2.3 Usher Plant *"Calotropis procera"*

2.3.1 Classification

Kingdom: Plantae
Division: Magnoliophyta

Class: Dicotyledoneae

Order: AsclePeadales

Family: Asclepeadaceae

Genus: Calotropis

Species: *Calotropis procera*

2.3.2 Description

A large Shrub or small tree of 2-4m height, with a white latex and smooth, grey - green stems and thick, soft bark. The plant has a deep tap root of 3 - 4 m length. The simple and opposite leaves are 8 - 25 cm long, 4 - 14 cm width, ovate, thick and waxy. They have a short pointed tip at the end and a heart - shaped base partly clasping the stem. The white and purple flowers have five lobes, are more or less tubular, and 2 - 3 cm in diameter. Fruits are grey - green, fleshy or dry capsules of 8 - 12 cm length and 6 - 8 cm width.They contain numerous small, brown and flattened seeds of 8 -10 mm length and 4-5 mm width, with long white hairs attached at one end (Weber, 2003). "Shrubs, mostly less than 6 ft., but up to 15 ft. similar to *C.gigantea*, but leaves belong to elliptical corolla usually about in. Across with lobes move erect, coronalobes glabrous or pubescent, and follicle 4 - 5 long (Bailey and Bialy, 1976).

2.3.3 Distribution

According to Erdman (1983) the Usher Plant has large broad leaves, ever green and grows abundantly in arid land semi-arid regions of the world without irrigation, fertilization, pesticides, or other agronomic practices.

According to Rahman and Wildcock(1991).*C. Procera* is native to West Africa as for south as Angola. North and East Africa, Madagascar, the Arabian Peninsula, southern Asia, and In to China to Malaysia, central and South America and the Caribbean Islands.

Foster (1992) reported that *C.procera* is widely distributed in north tropical Australia. In Sudan it is spreading widely throughout Sudan, abundant and available the whole year round (Eltayeb, 2004).

2.3.4 Chemical Properties

The milky sap contains a complex mix of chemical some of which are steroidal heart poison known as (*cardiac aglycones*). These belong to the same chemical family as chemicals found in foxglove (*Digitalis Purpurea*).

The steroidal component includes and hydroxyl group in the C3β position, as second attached to the carbon, a C/D – C is ring junction and a, β – unsaturated – γ – Lactone in the (17 position.in the plants, the steroidal component commonly attached via a glycosidic link to 2-desoxy or a 2.6 didesoxy sugar molecule (Aiton, 2010).

The features described are those required for toxicity but in addition there can be other substitutions into the steroid nucleus. These can be a C19 - aldehyde in place of the more usual methyl group in position as well as additional hydroxyl functions and sometimes epoxide structures. In the case of the *Calotropis* glycoside, their names are calotropin, calotoxin, uscharidin and vorusharin (The latter involve rare sugars with nitrogen and sulphur in the structures). The steroidal moiety (known as "calotropagenin", Formula, $C_{23}H_{32}O_2$) has one more unusual structure the C-19 formyl (CHO) group is present and there is an additional secondary alcohol as well as the common C3 and C14 hydroxyle Functions. The position of this third hydroxyl function remains in some doubt it was apparently established by the Swiss group under the dues Rechistein as being in the C2 position with an equatorial configuration. However, this assignment does not explain some of the non-features and behaviors of this molecule, in particular the absence of spin - spin coupling of the two axial protons associated with their geminal hydroxyl group and failure react iodateinacleavadge reaction which presence of such ariscinal 1, 2 diol would require (Aiton, 2010)

2.3.5 Uses of Usher in Pest and Disease Control

This plant has been widely used in the Sudanese medicinal system (Ayoub and Kingston, 1981; Ayoub and Srenden, 1981). The latex of the plant was reported having potential anti in flammatory, antidiarrhoeal, analogesic, antipyretic and Schizonticida activities (Kumar and Basu, 1994; Dewan, *et al;* 2000, Kumar *et al;* Sharma and Sharma, 2000). Bioactivities of the plant such as insecticidal (Jacoband Sheila, 1993; khan and Siddiqui, 1994 and Moursy, 1997), a caricidal (Chung Samanyart, *et al*., 1994), rematocidal (Rakesh, *et al*., 2001), molluscidal (Hussein *et al*., 1994), had been reported.

Water containing latex of the plants was able to avoid adult females of *Anopheles Stephens* and *Culex fatigans* to oviposit in the water and the latex water could kill eggs and larvae of *A.Stephens*, *C. Fatigans* and *Aedesaegypti*, (Girdhar, *et al*., 1984).

Calotropis Extracts has been reported (Deka and Singh, 2001; Singh *et al*., 2002). Plant parts and plant extract can be used effectively because these are less expensive and biodegradable, hence environmentally suitable - many farmers in Asia and Africa had been using plant extracts such as Neem, wild tobacco, dried chillies, *calotropis procera* and wood ash etc. For controlling and repelling termites(Anonymous, 2000).

CHAPTER THREE

MATERIALS ANDMETHODS

3.1The study Site

This study was carried at a Rhamnus Orchard at Slait areain Khartoum North Locality, Khartoum State(**Figure No. 1**).

Figure No.1. The Study area

3.2. The Survey of Fruit Flies :

This survey was carried out during the period from November 2017 up to March 2018, in an Orchard of Buckthorn (*Rhamnus parsee*,), with an area of "7 Feddans " in Slait Scheme, Khartoum North Locality (**Figure No. 1**).

The Orchard contains Rhamnus trees as the main plantation, in addition to grapefruit, lemon, orange, banana and guava trees. The neighboring farms were grown with eggplant, tomato and papaya. The survey and monitoring of fruit flies was made through the use of two types of fruit fly traps.

Types of Traps :

Two types of Locally made Traps were used:

1. Food- bait Traps:

The traps ware made of Round clear Plastic Bottles of Soft Water Drinks. In each bottle (i.e., Trap) 3 circular holes (each 3 cm in diameter) were made near the bottle neck. Each Trap was equipped with200ml guava juice, as an attractant for fruit flies, with 100ml of water and a 5 ml dose of the Insecticide " Malathion 57%", as a poison for fruit flies. (**Plate No. 1**).

Plate No.1. A food- bait Trap

2. Sticky Traps:

These were Locally made from Hard card board, rectangular in shape (with an area of 20cm x 17cm), and covered with an adhesive substance, yellow in Colour. Also here, each Trap was equipped with a small open plastic vial containing a piece of cotton wool, saturated with three parts of the Pheromone " Methyl Eugenol (ME)" as an attractant for fruit flies and one part of the Insecticide "Malathion 57%", as a poison for fruit flies. (Plate No. 2).

Plate No. 2. A Sticky Trap

3.3 Monitoring and Collection of Fruit Flies :

A number of 40 Food- bait Traps and 8 Sticky Traps were used for fruit fly monitoring in the Orchard. Each Trap was hang on a strong branch of Rhamnus tree at a height of 1.5 m above ground. A distance of 20 meters was determined between each Two traps.

The traps were inspected at a biweekly interval, and the caught flies in each trap were collected in glass vials using a hairbrush. At each time of inspection, the food-baits in the food traps were replaced regularly with new materials. Also, in the sticky traps , the trap was cleaned after collection of flies , and the saturated cotton wool and the sticky substance were replaced with new materials, and Data were recorded regularly.

3.4. Laboratory Studies :

3.4.1. Collection of Infested Rhamnus Fruits :

To aid in the Process of fruit flies identification, large number of infested Rhamnus Fruits were collected, either directly from the trees, or those fallen on the ground, and brought to the laboratory (**Plate No. 3**). In the Laboratory, the infested fruits were distributed in Plastic Rearing Cages, each covered with a fine nylon netting and measuring (40 cm x 25 cm x 20 cm). Each cage was lined with a smooth layer of fine sand, slightly moistened to allow for larval pupation (**Plate No. 4**).

Plate No.3. Infested Rhamnus fruit

Plate No.4. Plastic Rearing Cages

3.4.2. Collection of Infested Guava Fruits from Local Market :

For further identification of Fruit Flies, regular collections were also made for infested guava fruits brought from different areas outside Khartoum State. All these materials were bought from the Local market and taken to the Laboratory and distributed Plastic rearing cages (40 cm x 25 cm x 20 cm) for collecting adults required for identification and repellency study test

3.5. Rearing and Identification of fruit flies

All adult fruit flies emerged, either from Rhamnus fruits or guava fruits, were collected, identified and transferred to separate Glass and Fiber Glass Rearing Cages, each measuring (40 cm x30 cm x 30cm) (**Plate No. 5**). The adult flies were provided with artificial diet in a Petri-dish, containing a piece of cotton wool saturated with water. The diet consists of measuring amounts of suger (3gm),and brewer yeast (1gm) (3:1). Fruit flies were maintained under controlled laboratory conditions at : 26 ± 1 ^{0}C and 30± 5% R.H. , and at a Photoperiod of 12h. L : 12 h. D.

Plate No.5. Fiber Glass Rearing Cages of adult Flies

3.6. Plant materials

3.6.1. Collection and preparation of the plant materials

Neem (*Azadirachta indica*) (**Plate No.6)**.and Ushar leaves (*Calotropis procera*) (**Plate No.7**).were collected from Shambat area. Both plant materials were brought to the Entomology Laboratory where they were washed and shade- dried. After complete dryness, the plant samples were crushed by a mortar and pestle, to prepare the powders for the extraction processes.

3.6.2 Extraction Procedures

Extraction processes were conducted at the Chemistry Laboratory, College of Agricultural Studies – Shambat. 50 grams of each of the previously prepared powders of Neem and Ushar. Each part was placed separately in a thimble and placed in an extraction chamber of a Soxhlet extractor apparatus **(Plate No. 8).**and then extracted with 500 ml of Ethanol (99.7%) for each sample. The extraction continued for 6 hours, and the Ethanol solvent was removed off the crude extract using a Rotary Evaporator **(Plate No.9).** The obtained crude materials for the two plants were weighed and carefully stored for the preparation of the required extract concentrations used for measuring repellency. **(Plate No. 10)**

Plate No.8.Soxhlet extractor apparatus

Plate No.9.Soxhlet and rotary evaporator

Plate No.13.The Plant Extract

3.7 The equipment and materials used in this study

3.7.1 Equipments:

1-Plastic cages

2-Sensitive balance

3-Hand sprayer

4- Camera

5-Petri dishes

6-Brush

7-Gloves

8-Pipette and micropipette

9-Registration form

10- Marker pen

11- Sokhlet Extractor apparator

3.7.2 Materials:

1-The neem leaves

2-The usher leaves

3-Soap

4-UHU (Sticker)

5- Malathion 57%

6- Sand

7-Beakers

8- Muslin cloths and cotton

9-Cylinder

10-Distillied water

Plate No. 10. The equipment used in this study

3.8. Laboratory experiments "Bioassay tests"

These experiments were conducted at the Entomology laboratory, Department of Plant Protection, Faculty of Agricultural Studies – Shambat. The experiments were made to test the efficacy of the extracts of two plants: Neem leaves **(Plate No.6)** and Usher leaves **(Plate No.7)** against the adults male and female of fruit flies, and the repellency were accorded after 2, 4, 6, 8 hrs respectively.

PlateNo.6 ***Neem "Azadirachta indica"*** **leaves**

Plate No.7.Usher Plant leaves

3.8.1. Bioassay with *Bactrocera invadens*

A. Bioassay Using Neem leaves extract

Three guava fruits were introduced in a rearing glass cage (40cm x 30cm x 30 cm).The fruits were hanged at the ceiling of the cage using, a sticker. One fruit was treated with 10% concentration of Neem leaves extract, the second fruit was treated with 20% concentration of Neem leaves extract, and the third untreated fruit was treated with water only, and used as control. All fruits were allowed to dry for 2 hrs. Then Ten adults' of fruit flies of *B.invadens* (5 Males & 5 Females) were introduced, into the cage. Observations were made to test the repellency of the concentrations of the plant Extracts at 2hrs, 4hrs, 6hrs and 8hrs.

B. Bioassay Using Usher leaves extract

Also in another cage, three guava fruits were introduced in a rearing glass cage (40 x 30 x 30 cm).The fruits were hanged at the ceiling of the cage using, a sticker. One fruit was treated with 10% concentration Usher leaves extract, the second fruit was treated with 20% concentration Usher leaves extract, and the third untreated fruit was treated with water only, and used as control. All the treated fruits war allowed to dry for 2 hrs. Ten adults of fruit flies of *B.zonata* (5 Males &5Females) were introduced, into the cage. Observations were made to test the repellency of the plant Extracts concentrations after 2hrs, 4hrs, 6hrs and 8hrs respectively. All data of the observations were recorded Repellency.

3.8.2.Bioassaywith *Bactrocera zonata*

A. Bioassay Using Neem leaves extract

Three guava fruits were introduced in a rearing glass cage (40 x 30 x 30 cm).The fruits were hanged at the ceiling of the cage using, a sticker. One fruit was treated with 10% concentration of Neem leaves extract, the second fruit was treated with 20% concentration of Neem leaves extract, and the third untreated fruit was treated with water only, and used as control. All the treated

fruits war allowed to dry for 2 hrs. Ten adults of fruit flies of *B.invadens*(5 Males & 5 Females) were introduced, into the cage. Observations were made to test the repellency of the plant extracts concentration after 2 hrs, 4 hrs, 6 hrs and 8hrs respectively.

B. Bioassay Using Usher leaves extract

Also in another cage three guava fruits were introduced in a rearing glass cage (40 x 30 x 30 cm).The fruits were hanged at the ceiling of the cage using, a sticker. One fruit was treated with 10% concentration Usher leaves extract, the Second fruit was treated with 20% concentration Usher leaves extract, and the third untreated fruit was treated with water only and used as control. All the treated fruits war allowed drying for 2 hrs. Ten adults of fruit flies of *B.zonata* (5 Males &5Females) were introduced, into the cage. Observations were made to test the repellency of the plant extracts concentrations after 2hrs, 4hrs, 6hrs and 8hrs respectively. All data of the observations were recorded Repellency.

3.9.Statistical analysis

The obtained data were statistically analyzed according to analysis of variance (ANOVA), using Mstatc Program, and Duncan Multiple Range Test was used for means separation.

CHAPTER FOUR

RESULTS

4.1 Survey and Identification of fruit fly species in the Study area

The results of the survey and identification indicated that, only two species of fruit flies were found in the study area,**(**Slait Agricultural Scheme**).** The species found were, the Asian fruit fly, *Bactrocera invadens*, **(Plate No.11).**and *Bactrocera. zonata*, **(Plate No.12).** There was a significant difference between numbers of *B. zonata* (603) and *B. invadens* (407) which were caught by food traps as well as the sticky traps. There was no significant difference between the *B. zonata* numbers caught in the food traps and those caught in the sticky traps, but there was a difference between the numbers of the *B.invadens* caught in the food traps and those caught by the sticky traps. The numbers of each species caught in the 2 types of traps in the study area are shown in Tables (1, 2).

Plate No.11 The Male and female *Bactrocera invadens*

Plate No.12 The Female of *Bactrocera zonata*

Table.No.1. Numbers and species of fruit flies caught in the food traps throughout the experimental period

Week	Food trap	Food trap
	B. zonata	*B. invadens*
1	140	90
2	113	100
3	150	77
4	200	140
Total	603	407

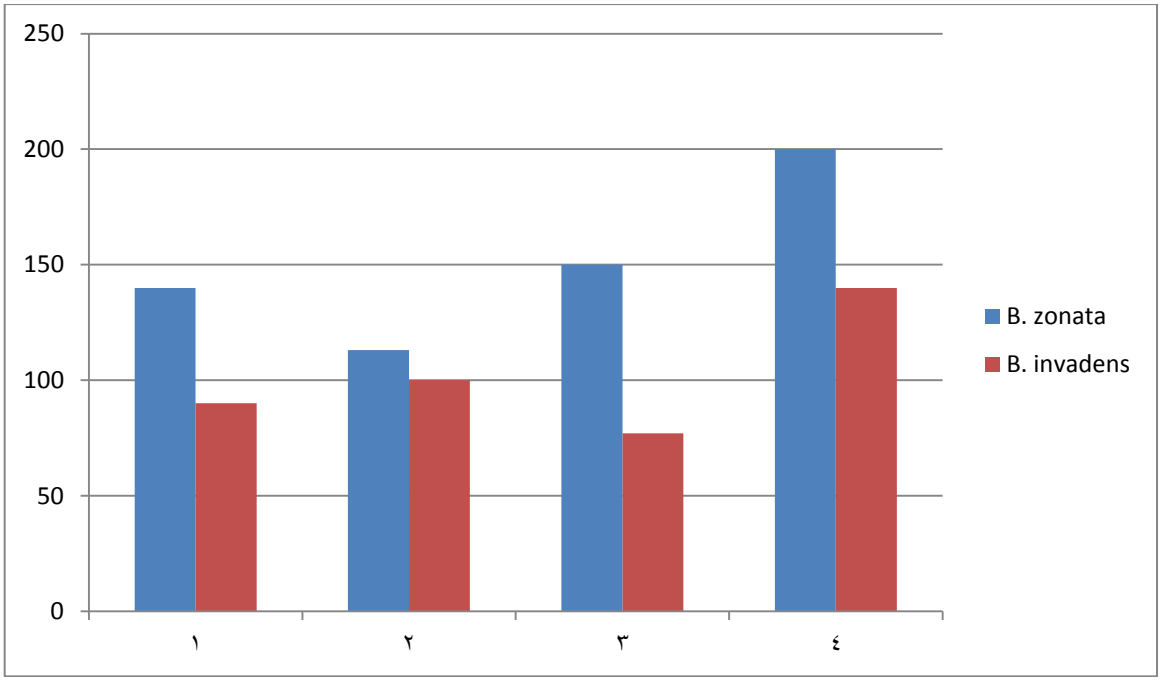

Figure No. 2. Numbers and species of fruit flies caught in the food traps throughout the experimental period

Table No. 2. Numbers and species of fruit flies caught in the sticky traps throughout the experimental period.

Week	Sticky trap	Sticky trap
	B.zonata	*B. invadens*
1	125	75
2	77	60
3	100	60
4	130	56
Total	432	251

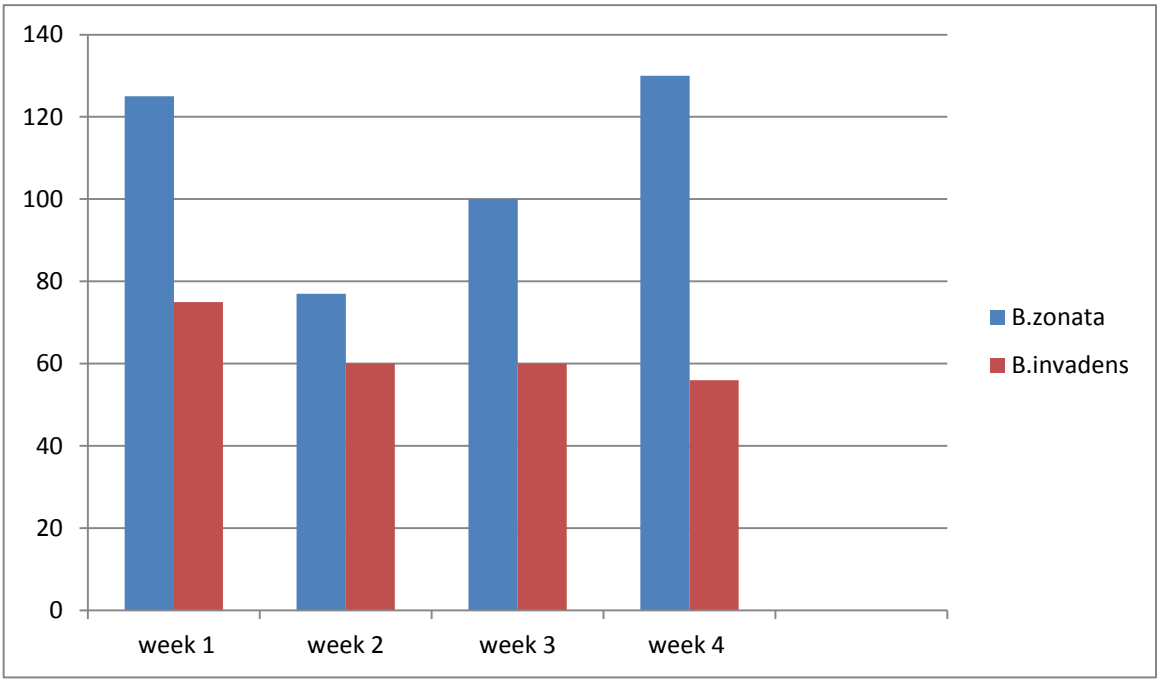

Figure No. 3. Numbers and species of fruit flies caught in the sticky traps throughout the experimental period.

4.2 Laboratory experiments :

4.2.1 Repellency Effect of Neem and Usher ethanolic leaves extracts against adults fruit fly: (*Bacterocera invadens)* by using topical application methods (after 2*hrs)*

Results of the Repellency effect against *B.invadens* after 2 hour of treatment are shown in table (3), in the column (1) and in figure (3), it was found that there were no significant differences between the concentration of neem while significant differences between the concentrations of usher (10%, 20%) recorded the higher number of the repellency against insects compared to the control, and there are no significant differences between them.

4.2.2 Repellency Effect of Neem and Usher ethanolic leaves extracts against adults fruit fly: (*Bacterocera invadens)* by using topical application methods (after 4 hrs)

Results of the Repellency effect against *B.invadens* after 4 hour of treatment are shown in table (3), in the two column (2) and in figure(3), it was found that there were significant differences between the concentration of neem and usher(10%, 20%) revealed the highest number of the repellant insect compared to control and threr are no significant differences between them

4.2.3 Repellency Effect of Neem and Usher ethanolic leaves extracts against adults fruit fly: (*Bacterocera invadens)*by using topical application methods (after 6 hrs).

Results of the Repellency effect against *B.invadens* after 6 hour of treatment are shown in table (3), in the column (3) and in figure (3), it was found that there were no significant differences between the concentrations of Neem. While significant differences between the concentrations of usher. Usher

(10%, 20%) showed the high number of the repellant insect compared to control and there are no significant differences between them.

4.2.4 Repellency Effect of Neem and Usher ethanolic leaves extracts against adults fruit fly: (*Bacterocera invadenc)*by using topical application methods after Eight hrs.

Results of the Repellency effect against *B.invadens* after 8 hour of treatment are shown in table (3), in the column (4) and in figure (3), It was found that there were no significant differences between the concentration of neem while significant differences between the concentrations of usher. Usher (10%, 20%) recorded the high number of the repellant insect compared to control and there are no significant differences between them.

Table.No.3. Means of Repellency effect (%) against the adults of fruit fly *B. invedens* treated with Neem Extracts

Plant extract	repellency after Two hour	repellency after Four hour	repellency after Six hour	repellency after Eight hour
	N=3±SD			
Neem 10%	1.732 [b]	1.520 [ab]	1.000 [b]	1.276 [b]
Neem20%	1.414 [c]	1.276 [b]	1.000 [b]	1.382 [ab]
Control	1.911 [a]	1.900[a]	1.715 [a]	1.911 [a]
L.s.d	0.1692	0.4833	0.3383	0.5359
C.V.	6.2	15.5	13.3	17.6
Sig.	***	*	**	*

- Means followed by the same letter (s) are not significantly different at (P<0.05).

Table.No.3. Repellency effect (%) against the adults fruit fly *B. invedens* treated with Usher Extracts

Plant extract	repellency after Two hour	Repellency after Four hour	repellency after Six hour	repellency after Eight hour
	N=3±SD			
Usher10%	1.000[b±] 0.19	1.732 [b]	1.276 [b]	1.382[b]
Usher20%	1.138 [b]	1.414 [c]	1.276 [b]	1.626 [ab]
Control	1.520 [a]	1.911 [a]	1.732 [a]	2.079 [a]
L.s.d	0.3477	0.1784	0.3901	0.4988
C.V.	14.3	5.3	13.7	14.7
Sig.	*	***	*	*

- Means followed by the same letter (s) are not significantly different at (P<0.05).

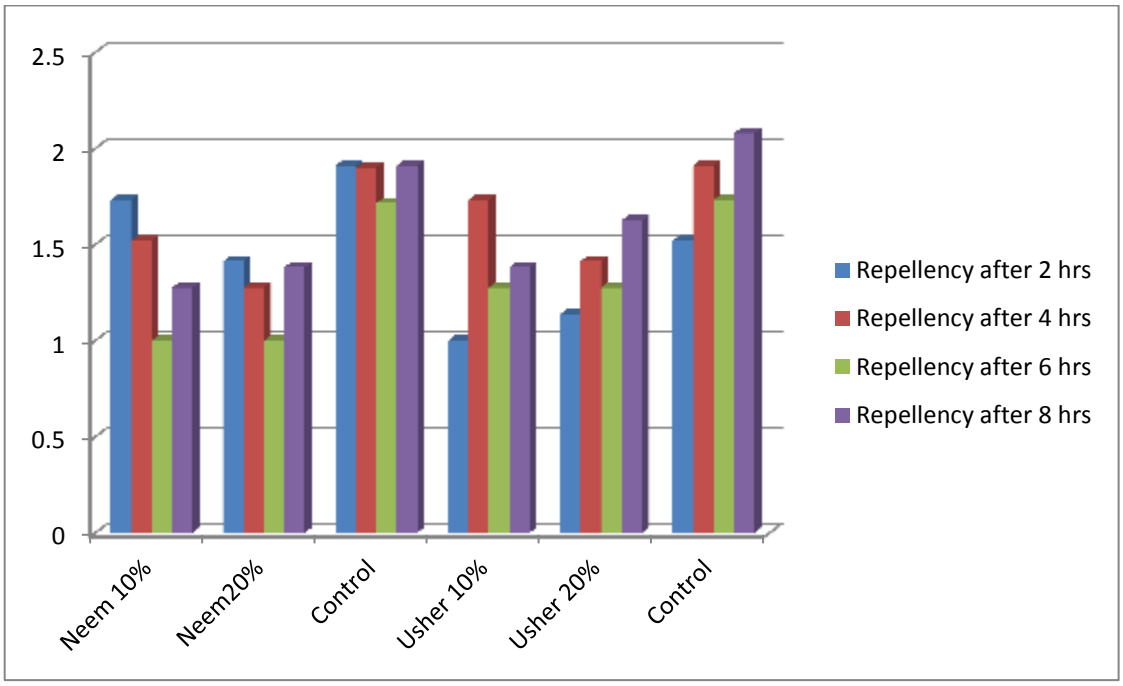

Figure No.4. Means of Repellency effect (%) against the adults of fruit fly *B. invedens* treated with Neem and Usher Extracts.

4.2.5 Repellency Effect of Neem and Usher ethanolic leaves extracts against adults fruit fly: (*Bacterocera zonata)*by using topical application methods (after 2 hrs).

Results of repellency effect against *B. zonata* after (2 hrs) of the treatment, are shown in table (4), column (1) and in figure (4), It was all the

concentrations of the ethanolic leave extracts of the Neem and Usher gave significantly higher repellency percentage against the tested adult fruit flies than the control after 2 hrs of exposure by using Topical application Also Neem and Usher (10%, 20%) revealed the higher number of the repellant insect compared to control and there were no significant differences between them.

4.2.6 Repellency Effect of Neem and Usher ethanolic leaves extracts against adults fruit fly: (*Bacterocera zonata)*by using topical application methods (after 4 hrs).

Results of repellency effect against *B. zonata* after (4 hrs) of the treatment, are shown in table (4), column (2) and in figure (4), It was found that there were significant differences between the all concentrations were recorded. Neem and Usher (10%, 20%) revealed the higher number of the repellant insect compared to control and there were no significant differences between them.

4.2.7 Repellency Effect of Neem and Usher ethanolic leaves extracts against adults fruit fly: (*Bacterocera zonata)*by using topical application methods (after 6 hrs).

Results of repellency effect against *B. zonata* after (6 hrs) of the treatment, are shown in table (4), column (3) and in figure (4), It was no found significant differences between the concentrations of neem and usher were recorded. (10%, 20%) revealed the highest number of the repellant insect compared to control and there were no significant differences between them.

4.2.8 Repellency Effect of Neem and Usher ethanolic leaves extracts against adults fruit fly: (*Bacterocera zonata)*by using topical application methods (after 8 hrs).

Results of repellency effect against *B. zonata* after (8 hrs) of the treatment,

are shown in table (4), column (4) and in figure (4). It was found that there were significant differences between the concentration of neem and Usher were recorded. Neem (10%, 20%) revealed the highest number of the repellant insect compared to control and there were no significant differences between them.

Table No.4. Means of repellency effect (%) against the adults of fruit fly *B. zonata* treated with Neem extracts

Extract of the plant	repellency after Two hour	Repellency after Four hour	repellency after Six hour	repellency after Eight hour
	N=3±SD			
Neem 10%	1.000 [b]	1.626 [ab]	1.821 [b]	1.609
Neem 20%	1.000 [b]	1.276 [b]	1.732 [b]	1.520
Control	1.715 [a]	1.821 [a]	2.157 [a]	1.989
L.s.d	0.3383	0.3908	0.2378	0.5307
C.V.	13.7	12.4	6.3	15.6
Sig.	**	*	**	NS

- Means followed by the same letter (s) are not significantly different at (P<0.05).

Table No.4. Means of repellency effect (%) against the adults of fruit fly *B. zonata* treated with Usher extracts

Extract of the plant	repellency after Two hour	Repellency after Four hour	repellency after Six hour	repellency after Eight hour
	N=3±SD			
Usher10%	1.276 [b]	1.626 [ab]	1.732	1.911
Usher20%	1.138 [b]	1.276 [b]	1.520	1.732
Control	2.000 [a]	1.989 [a]	1.900	2.150
L.s.d	0.3901	0.4533	0.3968	0.3485
C.V.	13.3	13.9	11.6	9
Sig.	**	*	NS	NS

- Means followed by the same letter (s) are not significantly different at (P<0.05).

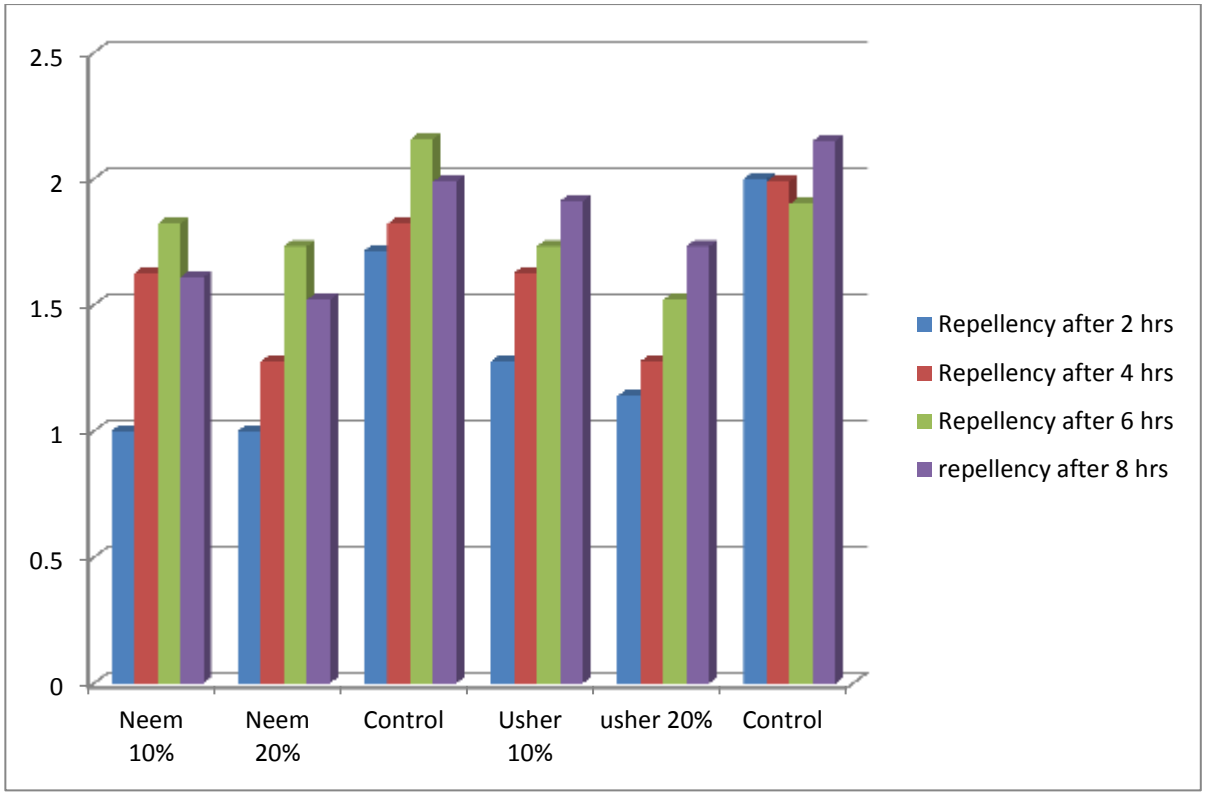

Figure No.5. Means of Repellency effect (%) against the adults of fruit fly *B. zonata* treated with Neem and Usher Extracts

CHAPTER FIVE

DISCUSSION

DISCUSSION

Monitoring of fruit flies was made during the period from November 2017 to March 2018 by using food bait traps and male sticky traps at a Rhamnus orchard in Slait area, Khartoum North. In the study area, monitoring proved the presence of two species of fruits flies, *Bactrocera zonata* and *Bactrocera invadens.* During this study, *B. zonata* was found to be the dominant species in the study area. Current results have shown that food traps were more effective in attracting fruit flies because they attract both males and females of the fruit fly species present in the study area, where the sticky traps only attract males. These results are somewhat similar to those stated by Sabah (2015) who reported that two species of fruit flies were found in the 3 locations in the study area, Elkadaroo, Elfaki Hashim and Elkhogalab, all in Khartoum North. The Species found were, the Asian fruit fly, *B.invadens*, and the Mediterranean fruit fly, *Ceratitis capitata*. *B. invadens* was found to be the dominant species with up to (99.4%). In many parts of the mango production areas in Sudan the fruit fly species found in association with mango and guava fruits were *B. invadens*, *C. cosyra* and *C. capitata*. However *C.cosyra* was reported as the main pest of mango, but in a study by Abdo Keikha (2011) in Shendi, Elzidab, Elkitiab and Elbawga areas (River Nile State), the *B. invadens* was found to be the dominant species in the study areas. In Singa area,the mango fruits grown were infested by three species, *Bactrocera invadens* constituting 80% of the detected FF populations, *Ceratitis cosyra* constituting 19.8%, and *Dacus longistylus*, which forms about 0.2%(Abdelaziz et al., 2008). Also, in another study by Suliman(2013) in the River Nile State, The 3 species of fruit flies were found, Asian fruit fly, *Bactrocera invadens* , Mango fruit fly, *Ceratitis cosyra* and Mediterranean fruit fly, *Ceratitis capitata*. These studies indicated that, in past years *Ceratitis sp*. were very widespread in fruit production areas, but have gradually disappeared and began to be replaced by *Bactrocera spp*. Duyck *et al*,(2004&2007) reported that, *Bactrocera spp* was able to displace

Ceratitis flies, as observed in recent invasions. *B. invadens* become to be the dominant in horticultural production areas but according to the present results *B.zonata* began to dominate the fruit fly species within the horticultural production areas and spread rapidly in all areas of fruit production. The use of chemicals in fruit fly management leads to environmental imbalances and has many risks. These risks have forced researchers to find alternative materials that are safer for the environment. In the experiments by Plant extracts applied in this study, Neem and Usher plant extracts have proved effective than or at least showed Repellency effects as chemical pesticides. The results of the topical application in this study showed the efficiency of the neem and usher extracts against adult fruit flies with high expulsion rate compared to control.

CONCLUSION AND RECOMMENDATIONS

Conclusion

- The results showed that there were two species of fruit flies: *B.invadens* and *B. zonata*, in the study area.
- *B.zonata* Is the dominant species in the study area, and became one of most serious national pests in Sudan.
- The study proved that food bait traps are more effective in attracting fruit flies.
- This study clearly shows that Neem and Usher extracts have a repellency effects on the expulsion of adults of *B.invadens* and *B.zonata*.

RECOMMENDATIONS

- Using food bait traps must be done before fruits maturity.
- Food bait and sticky traps should be used for detection and monitoring of fruit flies.
- Early harvest of fruits is recommended before the fruits reach he yellow mature susceptible stages.
- Collect the falling infested fruits from the ground and get rid of them.

References

Abbas, A.M. (2008). Cultural practices to control fruit flies. Workshop of National Project for Control of Fruit Flies in Sudan, 27-28 August, 2008, Khartoum.

Abdelmagid, F.M.; Abass, A.M. and Ali, E.E. (2012). Fruit flies review in Sudan from 1960-2011. TEAM 2nd International Meeting, "Biological invasions of Tephritidae and economic impacts", Kolymbari, Crete.

Abdo Keikha, H. M. (2014). Identification of Fruit Flies (Diptera: Tephritidae) and their Host Range and Attractants in the River Nile State.(Shendi, Elzidab, Elkitiab and Elbawga). M.Sc. Thesis in Crop Protection, College of agricultural, University of Khartoum.

Abdalla. B.H. (2010) .the effect of USHER leaves powder (calotropis protera) and neem seeds powder(indica azadirachra) on the third larval stage of khapra Beetle (Trogoderama granavium everts). (Coleoptera: Dermestidae) . B.Sc. (Honors) Graduation Project.

Abhishek, D.; Mohit, C.; Ashish, G. & Ameeta, A. (2010). Medicinal utility of *Calotropis procera* (Ait.) R. Br. as used by natives of village Sanwer of Indore District, Madhya Pradesh. IJPLS, 1(3): 188-190.

Aiton. W.T. (2010) *Calotropis Procera* Germplasm Resource information network. United States Department of Agricalture.

Ali, E. E. (1967).Studies on some Trypetidae of Economic importance in the Sudan, M. Sc. Thesis, Faculty of Agriculture, University of Khartoum, Sudan.

Ali, S. A. I. (2007). Detection and monitoring of some tephritidae of fruit trees and their host range in Abugubeiha, South Kordofan State. M.Sc. thesis, Sudan Academy of Sciences.56 pp.

Ali, E. E.; Abbas, A. M.; Ahmed, H. M.; Abdurrahman, A. A. and Abdelmajid, F. M. (2008). Fruit Fly Review in Sudan from 1960-2008. Workshop of National Project for Control of Fruit Flies in Sudan, 27-28 August, 2008, Khartoum.

Allwood, A.J, Leblanc, L., Vueti, E.T. and Richard. B. (2001). Fruit Fly control methods for Pacific Island countries and territories. Pest Advisory Leaflet /Secretariat of the Pacific Community.Plant Protection Service; 40.

Aluja, M. and Norrbom, A. L. (1999). Fruit flies (Tephritidae): phylogeny and evolution of behaveior. CRC. Press, Florida. U.S. 987pp.

Anonymouse, (1994). Le CIRAD en 1993. Crayonet Cie, Montpellier. CIRAD-SAR, 130 p.

Aluja, M. and Norrbom, A.L. (1999). Fruit flies (Tephritidae):Phylogeny and Evolution of Behaviour. CRC Press, Boca Raton. p751-792.

Anonymouse (2000). Finding Alternatives persistent organic pollutants (PoPs) for temitc management.Global IPM Facility Export Group on termite Biology and management.Stockholm convention food Agric. Org., 118 - 168 pp.

Archived (2013) Material fact sheet – Neem Archived 12 February atb the Waydack Machine

Averill, A. I. (1996). Effect of recent experience on forging in tephritid fruit flies. Journal of Insect Behavior, 9: 571-583.

Ayoub, S. M. H. and Svendsen, A. B. (1981). Medicinal and aromatic plants in Sudan: Usage and exploration. Fitoterapia LII, 66: 243-246.

Ayoub, S. M. H., and Kingston, D. G. I. (1981). Screening of plants used in Sudan folk medicine for anticancer activity.Fitoterapia, 52: 281-284.

Bailey, L. H. & Bailey, E. Z. (1976). Hortus third: Aconcise dictionary of plants cultivated in the United States and Canada. Macmillan,New York. 1290 pp. p.206.

Bashir, H.A. and Imam, M.A. (2010). Status Report on Fruits and Vegetables Production and Processing Industry in Sudan. AARDO workshop on technology on reducing post-harvest losses and maintaining Quality of fruits and vegetables, Taiwan.168-179 pp.

Beije, C. M. (1996). Reports on field trip to Kassala and Gash Delta.FAO IPM Project GCP/SUD/025/NET, ARC, Wad Medani, Sudan.

Back, E. A. and C. E. Pemberton (1918). The Mediterranean fruit fly in Hawaii. U.S.D.A. Bull. 536: 1-118.

Bashir, Y. G. (2007). Studies on mango fruit flies in Kordofan Area, Sudan. Ph. D. Thesis, Faculty of Agricultural Sciences, University of Gezira.

Bess, H. A. and Harmomoto, F. H. (1969). Contribution to the biology and ecology of oriental fruit fly *Dacus dorsalis* in Hawaii. Hawaii Agri. Exp. Sta. Tech. Bull 31: 251-285.

Chavan, B. L. and Rasal, G. B. (2010). "Sequestered standing carbon stock in selective tree species grown in University campus at Aurangabad, Mahar ashtra, India". International Journal of Engineering Science and Technology 2.7 (2010): 3003-3007.

Chuang, Y. and Hou, R. F. (2008). Effectiveness of attract -and-kill systems using Methyl Eugenol incorporated with Neonicotinoid insecticides against the oriental fruit fly (Diptera: Tephritidae). Journal of Economic Entomology, 101(2): 352-359.

Clark, L. R. (1957). The Ecology of Insect Population in Theory and Practice 245pp.

Clarke, A.R.; Armstrong, K. F.; Carmichael, A. E.; Milne, J.R.; Raghu, S.; Roderick, G. K.; Yeates, D. K. (**2005).** Invasive Phytophagous pests arising through a recent tropical evolutionary radiation: the *Bactrocera dorsalis* complex of fruit flies. Annual Review of Entomology, 50: 293-319.

Correia, A. R. I.; Rego, J. M. and Olmi, M. (2008). A pest of significant economic importance detected for the first time in Mozambique: *Bactrocera invadens* Drew, Tsuruta & White (Diptera: Tephritidae: Dacinae). Boll. Zool. Agr. Bachic. Serie II, 40 (1): 9-13.

Chungsamarnyart, N., Ratanakreetakul, C. and Jansawan, W. (1994). Acaricidal activity of the combination of plant crude-extracts to tropical cattle ticks. Kasetsart J. Natl. Sci., 28: 649-660.

Christenson, L. D. and Foote, R. H. (1960). Biology of fruit flies. Annual Review of Entomology 5 171-192.

Copeland, R.S.; Wharto, N. ; Robert, A. ; Luke, Q.; Meyer, D.E.M.; Lux S.; Zenz, N.; Machera, P. and Okumu, M. (2006). Geographic distribution, host fruit, and prasitoids of African fruit fly pests *Ceratitis anonae*, *Ceratitis cosyra*, *Ceratitis fasciventris*, and *Ceratitis rosa*(DipteraTephritidae) in Kenya. Annual Entomology.Society of America, 99(2): 261- 278).

De Myer. M., Robertson, M. P., Mansell, M.W., Ekesi, S., Tsuruta, K., Mwaiko, W., Vayssie, J-F., and Peterson, A.T. (2009). Ecological niche and potential geographic distribution of the invasive fruit fly *Bactrocera invadens* (Diptera, Tephritidae) Bulletin of Entomological Research (2010) 100, 35–48.

Dawood, K. H. (2001). Some aspects of ecology factors effecting infestation and control of Thrips tabaci lind , a pest of onion crop. Ph. D. Thesis, faculty of Agriculture, University of Khartoum, Department of Plant Protection, Sudan

David, K. J. and Ramani, S. (2011). An illustrated key to fruit flies (Diptera: Tephritidae) from peninsular India and Andaman and Nicobar Islands. Zootaxa 3 021: 1–31.

Deka, M.K. and Singh, S.N. (2001). Neem formulation in the management of sugar cane insects and pest. Precede 63rd Ann. Conv. Sugar Technool. Associ. 28 - 27 August, Jailpur, India 35 - 38.

De Meyer, M.; Copeland, R.S.; Lux, S.; Mansell, M.; Whartone, R.; White, I. M.; Zenz, N.; (2002). : Annotated checklist of host plants for Afro tropical fruit flies (Diptera: Tephritidae) of the genus (*Ceratitis*. 2001. Doc. K. MU S. Mid. Atr. 27, 1 –92.).

Delhi.; 9 January (2015). "Union Agriculture Minister emphasises about the potential of 'neem' coated urea" – via Business Standard.

Dhillon, M. K.; Singh R.; Naresh, J. S.; Sharma H. C. (2005). The melon Fruit Fly, *Bactrocera cucurbitae*: A review of its biology and management. Journal of Insect Science, 2005; 5(40):1-16.

Drew, R.A. I.; Tsuruta, K. and White, I.M. (2005). A new species of pest fruit fly (Diptera: Tephritidae: Dacinae) from Sri Lanka and Africa. African Entomology, 13: 149-154.

Drew, R.A. I. and Hooper, G. H. S. (1981). The responses of fruit fly species (Diptera: Tephritidae) in Australia to various attractants. Journal of Wallingford Entomological Society, 20: 201–205.

Drew, R.A.I. (1989). The tropical fruit flies (Diptera: Tephritidae: Dacinae) of the Australian and Oceanian regions. Memoirs of the Queensland Museum 26, 521pp.

Drew, R.A. I., Tsuruta, K., and White, I.M. (2005). A new species of pest fruit fly (Diptera: Tephritidae: Dacinae) from Sri Lanka and Africa. African Entomology. 13(1): 149-154.

Ducyk, P.F.; David, P. and Quilici, S. (2004). A review of relationships between interspecific competition and invasions in fruit flies (Diptera: Tephritidae). Ecological Entomology, 29: 511-520.

Duyck, P.F., Sterlin, J.F., and Quilici, S. (2004), Survival and development of different life stages of *B. zonata* (Diptera: Tephritidae) reared at five constant temperatures compared to other fruit fly species. *Bulletin of Entomological Research*Volume 94, Issue 1February 2004 , pp. 89-93.

Esmail, A. & Al-Snafi., (2015). The constituents and pharmacological properties of *calotropis procera*- an overview. International journal of pharmacy review and research., 5(3): 259-275

El-Aw, M.A.M; Draz, K.A.A; Hashem, A.G. and El-Gendy, I.R (2008). Mortality comparison among spinosad-, actara-, malathion-, and methyl- containing baits against peach fruit fly, *Bactrocera zonata* Saunders (Diptera: Tephritidae) under laboratory conditions. Journal of Applied Sciences Research, 4(2): 216-223.

El-Samea SAA; Fetoh BEA, 2006. New record of Bactrocera zonata (Saundera) (Diptera:Tephritidae) on potatoes in Egypt. Egyptian Journal of Agricultural Research, 84(1):61-63.

Eltayeb, E. M. (2004).A review of studies on some plants with insecticidal potentialities in the Sudan M.Sc.These fac. Agric. University of Khartoum.

Ekesi, S.; Rwomushana, I.; Gordon, I. and Ogol, C.K. (2008). Host plants and host plant preferences studies for Bactrocera invadens (Diptera: Tephritidae) in Kenya, a new invasive fruit fly species in Africa. Annuls of the Entomological Society of America, 101(2): 331-340.

Ekesi, S.; Rwomushana, I.; Gordon, I. and Ogol, C.K. (2008). Host plants and host plant preferences studies for Bactrocera invadens (Diptera: Tephritidae) in Kenya, a new invasive fruit fly species in Africa. Annuls of the Entomological Society of America, 101(2): 331-340.

Ekesi, S.; Maniania, N.K.; Mohamed S.S. and Lux, S.A. (2005). Effect of different formulations of *Metarhizium anisopliae* on three tephritid fruit flies and their associated endoparasitoids. Biological Control, 35: 83-91.

Ekesi, S; Nderitu, P. W. and Rwomushana, I. (2006). Field infestation, life history and demographic parameters of the fruit fly *Bactrocerainvadens*(Diptera: Tephritidae) in Africa. Bulletin of Entomological Research, 96: 379–386.

Ekesi, S., De Myer, M., Mohamed, S. A., Virgilio, M., Borgemeister C. (2016). Taxonomy, Ecology, and Management of Native and Exotic Fruit Fly in Species in Africa, *Annu Rev Entomol*. 2016; 61:219-38 (ISSN: 1545-4487).

Ekesi, S. and Mohamed, S. A. (**2011).** Mass rearing and quality control parameters for tephritidae fruit flies of economic importance in Africa. Wide Spectra of Quality Control, pp 387–410.

Ekesi, S. and Billah, M. K (Eds.). (**2007).** A Field Guide to the Management of Economically Important Tephritid Fruit Flies in Africa ICIPE Science Press.

EPPO and CABI for the EU under Contract, Data Sheets on Quarantine Pests, 90/399003.

European and Mediterranean Plant Protection Organization (2005). 371-373.

Fetoh, B. E. (2012). Temperature-Dependent Development and Degree-Days Models of the Peach Fruit Fly, *Bactrocera zonata* (Saunders) and the Cucurbit Fly, Dacusciliatus (Loew), Plant Protection Research Institute (PPRI), Department of Vegetable and Aromatic Plant Insects.

French, C. (2005).The new invasive*Bactrocera*species. in Insect Pest Control Newsletter, No. 65, International Atomic Energy Agency, Vienna, Austria. 19 – 20 pp.

F. A. O. (2004). Peach fruit fly, *Bactrocera zonata* (Saunders) TCP/RAB/2902. 28p.

Fletcher, B. S. (1987). The biology of Dacine fruit flies. Annual Review of Entomology, 32: 115-144.

Frochlich, G. and Rodewald, W. (1970). Pests and Diseases of Tropical Crops and Their Control. Permgamon Press, New York.

Goergen, G.; Vayssieres, J.-F.; Gnanvossou, D. and Tindo M. (2011). *Bactrocera invadens* (Diptera: Tephritidae), a new invasive fruit fly pest for the Afrotropical region: host plant range and distribution in West and Central Africa. Environmental Entomology 40,844–854.

Ganguli, S. (2002). "Neem "A Therapeutic for all seasons "current science". 82 (11), June. Pp. 1304 (AL JAZEERA report on neem treatment in Senegal).

Grigs, K. (1981). The neem tree *Azadirachta indica* A. Juss .and othe meliaceru plant

Girdhar, G., Devel, K. and Mittel, P. K. (1984). Mosquito control by Calotropis latex. Pesticides, 18: 26-29.

Gubara, S. and Abu Elgasim, M. (2004). Fruit flies. Plant Protection Administration, Ministry of Agriculture and Forestry Bull., Nov. 2004.

Gubara, S.; Ahamed, J.; Hussein, F.; Abu Elgasim, M.; Mokhtar, A. and Bashir, Y.G.A. (2009). Evaluation of para pheromone trap 95% TC (Methyl Eugenol 95% TC) for mass trapping of *Bactrocera invadens* (Diptera: Tephritidae) in fruit trees. The 80th meeting of National pests and Diseases Committee, Agricultural Research Corporation, Wad Medani, Sudan.

Headricks, D. H. and Goeden, R. D. (1994). Reproductive behavior of California fruit flies and the classification and evolution of the tephritidae (Diptera) mating system. Stud. Dipterol. 1: 195-252.

Heppner, J. B. (1985). Larvae of Fruit Flies.II. Ceratitis capitata(Mediterranean Fruit Fly) (Diptera Tephritidae). Entomology Circular No. 273. Fla.Dept. of Agr., Division of Plant Industry.

Hanna, A. D. (1947). Studies on med fly *Ceratitis capitata* (Weidmann) biology and control. Bull. Soc. Fouad. IER. Entomol, 31: 25-285

Hasseb, M. (2007). Current status of insect pest problems in guava. Acta Horticulture. 735:453-467.

Hee, A. K. W. and Tan, K. H. (1998). Attraction of female and male *Bactrocera papaya* to conspecific males fed with Methyl Eugenol and attraction of females to males' sex pheromone components. Journal of Chemical Ecology, 24(4): 753-764.

Hill, D. S. (1983). Agricultural insect pests of the tropics and their Control, 2nd Edition.Cambridge University Press, 386 pp.

Hussein, H.I., Karmel, A., Abuu-Zeid, M., El-Sabae A. K. H. and Uscharin, S. M. A. (1994). The most potent molluscicidal compound tested against land snails. J. Chem. Ecol., 201: 135-140.

Hennessey, M. K. & Knight, R. J. (1996). Resistence to Caribbean Fruit Fly in Carambola Tektran, ARS, USDA, 03/24/1996: 1 pp.

IAEA. (2003). Trapping guidelines for area-wide fruit fly programmes. International Atomic Energy Agency (IAEA), Vienna, 48pp.

ICIPE (2002). International Center of insect physiology and ecology, annual

scientific report Nairobi Kenya.

Ibrahim, S. A. A. (2007). MSc. theses Detection and Monitoring of Some Tephritidae, of Fruit Trees and their Host range in Abugubeiha, South Kordofan State 2007**.**

Indian Horticulture database. Area and production estimates for Horticulture crops. 2011. http://www.nhm.org

Jacobson, M, E. (1989). The neem tree. Bacaratom , Florida , USA ,CRC Press Ine. 178. pp

Jacob, S., and Sheila, M. K. (1993). A note on the protection of stored rice from the lesser grain borer, *Rhizopertha dominica* Fabr. by indigenous plant products. Ind. J. Entomol., 55: 337-779.

Jose, L., Cugala, D., and Santo, L., (2013). Assessment of Invasive Fruit Fly Fruit Infestation and Damage in Cabo Delgado Province, Northern Mozambique ,2013 *African Crop Science Journal*, Vol. 21, No. 1, pp. 21 – 28.

Khair, A. M., (2013). Tephritidae Fruit Fly in Sudan, University of Shendi, February,2013.

Khan, S. M. and Siddiqui, M. N. (1994). Potential of some indigenous plants as pesticides against the larvae of cabbage butterfly Pieris brassicae L. Sarhad J. Agric., 10: 291-301.

Kumar, V. L. and Basu, N. (1994). Anti-inflammatory activity of the latex of Calotropis procera. J. Ethnopharmacol., 44: 123-125.

Kapoor, V. C. (2005). Taxonomy and biology of economically important ruit flies of India. Israel Journal of Entomology. 35-36:459.

Kapoor, V.C. (1993). Indian fruit flies: (Insecta: Diptera: Tephritidae).228 pp. New Delhi, India, Oxford & IBH Publishing Co. Pvt. Ltd

Khairnar, A. K; Bhamare, S. R; Bhamare, H. P. (2012) *Calotropis procera*: An ethno pharmacological update. Adv Res Pharm Biol;2:142-56.

Lux, S. A.; Ekesi, S.; Dimbi, S.; Mohamed, S.and Billah, M. (2003). Mango-infesting fruit flies in Africa: perspectives and limitations of biological approaches to their management, In Neuenschwander , P., Borgemeister , C., and Langewald, Journal of Biological control in IPM systems in Africa. CABI Publishing, Wallingford, United Kingdom.277–294 pp.

Mafirakurewa, V. C., (2014). MSc. Thesis, University of Zimbabwe, Faculty of Scienc, Department of Biological Sciences ,Diversity and Population Dynamics of Bactrocera invadens and other Tephritidae Fruit Flies Species Infesting Mango (Mangifera indica), in Zimbabwe and Relative Efficacies of Selected Insecticides in Corporated in Food Baits**.**

Mahmoud, M. E. E. (2011). Population Dynamics, Mass Trapping and Molecular Characterization of Major Fruit Flies (Diptera: Tephritidae) in Khartoum,

Kassala and South Kordofan States (Sudan). PhD, Thesis, University of Khartoum Faculty of Science Department of Zoology 2011.

Mangan, R.L. and Morno D.S. (2007). Development of bait stations for fruit fly population suppression. Journal of Economic Entomology, 100: 440-450.

Manrakhan, A. and Kotze, C. (2009). Attraction of *Ceratitis Capitata, C. rosa*and *C. cosyra* (Diptera: Tephritidae) to proteinaceous baits. Journal of Applied Entomology, 135: 98-105.

Mahmoud, M. E. E., Kambal, A. O., and Abukashwa S. M. A. (2012). Prospects of Using Protein Hydrolastes for Trapping and Monitoring Major Fruit Flies (Tephritidae:Diptera) in Sudan.*Persian Gulf Crop Protection Journal*. 1:2 pp 6-14.

Mahoney (1967). Depectinizing guava juice with fungal pectinase. Food Technol., 21: 305.

Mangan, R. L. and Morno D.S. (2007). Development of bait stations for fruit fly population suppression. Journal of Economic Entomology, 100: 440-450.

Manrakhan, A. and Kotze, C. (2009). Attraction of *Ceratitis Capitata*,*C.rosa* and *C. cosyra* (Diptera: Tephritidae) to proteinaceous baits. Journal of Applied Entomology, 135:98-105.

Material Fact Sheets Neem Archived 12 February (2013). At the Wayback Machine.

Mohamed, A. S. (2003). Biology, host and Host Plant Relationship of two *Psyttalia* species (Hymenoptera: Braconidae): Parasitoids for Fruit Flies (Diptera: Tephritidae) in Kenya. Ph. D. Thesis, University of Gezira.

Mohamed, A .H. and Ali, E.A. (2008). Evaluation of para- pheromones and three components food baits for mass trapping of fruit flies in fruit trees. The 78th

Meeting of the Pests and Diseases Committee, Agricultural Research Corporation, Wad Medani, Sudan.

Mohamed, A.H. and Taha, A.K. (2008). Pheromones, para pheromones and food lure in fruit fly management. Workshop of National Project for Control of Fruit Flies in Sudan, 27-28 August, 2008, Khartoum.

Mohamed, S. M. A. (2004). Competition between Mediterranean fruit fly and Peach fruit fly in fruit fly infestation. Journal of the Egyptian German Society of Zoology, 43: 17-23.

Mohamed, S.A. (2003). Biology, host and host plant relationships of two *Psyttalia*species (Hymenoptera: Braconidae), parasitoids of fruit flies (Diptera: Tephritidae) in Kenya. M. sc. Thesis, University of Gezira, Sudan.

Mohamed E.S. (2002). Towards an integrated pest management (IPM) PROGRAMME ON okra, *Ablemoschus esculentus* L. (Malvaceae) Ph.D. Degree Thesis, Faculty of Agriculture, University of Khartoum, Department of Plant Protection, Sudan.

Moursy, L. E. (1997). Insecticidal activity of *Calotropis procera* extracts on the flesh fly, Sarcophaga haemorrhoidalis Fallen. J. Egypt. Soc. Parasitol., 27: 505-514.

Mozaffarian, V. (1991). Plant Systematics: AmirKabir: University Press.

Mwatawala, M. W.; De Meyer, M.; Makundi, R. H. and Maerere, A. P. (2006). Seasonality and host utilization of the invasive fruit fly, *Bactrocera invadens* (Dipt., Tephritidae) in Central Tanzania. Journal of Applied Entomology 130 (9-10): 530-537.

Mwatawala, M.W; De Meyer, M.; Makundi, RH.andMaerere, A.P (2009). Host range and distribution of fruit-infesting pestiferous fruit flies (Diptera,

Tephritidae) in selected areas of central Tanzania.Bulletin of Entomological Research, 1- 13 pp.

Narayanan, E. S and Bartra, H. N. (1960). Fruit flies and their control. Published by Indian Council of Agricultural Research, New Delhi. 56-60pp.

Oukil, S.; Bues, R.; Toubon, J. F. and Quilici S. (2002) "Allozyme polymorphism in population of *Ceratitis capitata* from Algeria, the north western Mediterranean coast and Reunion Island" Fruits, Vol.57, No.3, pp.143-191.

Prakash, Gunjan; Srivastava, Ashok K.(2008-04-05). "Production of Biopesticides in an In Situ Cell Retention Bioreactor". Applied Biochemistry and Biotechnology. 151(2–3): 307–318.doi:10.1007/s 12010-008-8191-6.ISSN0273-2289. PMID18392561.

Puhan, Sukumar, et al. (2005). "Mahua (Madhuca indica) seed oil: a source of renewable energy in India".

Qureshi ZA; Hussain T; Siddiqui QH, 1991. Relative preference of mango varieties by Dacus zonatus (Saunders) and D. dorsalisHendel. Pakistan Journal of Zoology, 23(1):85-87

Rahman, M. A. and Wilcock, L. C. (1991).A taxomic Revision of *calotropis* (Asclepidaceae) Nordic Journal of Botany - 11:3. 301 - 308.

Ramadan, M. M. and Messing R. H. (2003). A survey for potential biocontrol agents of *Bactrocera cucurbitae* (Diptera: Tephritidae) in Thailand. Proc. Haw. Entomological Society, 36: 115-122.

Robacker, D.C. (2002). Attraction of Meican fruit flies to grapefruit enhancement by mechanical wounding of and experience with grapefruit. Journal of Insect Behavious, 15(3): 399-413.

Ronald , F. L.(2007). Bactrocera cucurbitae (coquillett) the melon fruit fly. Proc. Hawaiin Entomol. Soc.

Rwomushana, I., Ekesi, S., Ogol, C. K. P. O., and Gordon, I. (2008). Effect of temperature on the development and survival of the immature stages of Bactrocera invadens (Diptera: Tephritidae), Journal of Applied Entomology. Volume 132 : 9-10. P 832 – 839.

Salah, F. E. E., Abdelgader, H., and De, Villiers, M. (2012). The occurrence of the peach fruit fly, *Bactrocera zonata* (Saunders) (Tephritidae) in Sudan. In TEAM 2nd International Meeting: Biological Invasions of Tephritidae Tephritidae: *Ecological and Economic Impacts* (pp. 3-6). Greece: Kolymbari, Crete**.**

Schumutterer, H. (1969). Pests of Crops in Northeast and Central Africa.Gustav Fischer, Verlag, Stuttgart, Portland, USA.

Schmutterer, H. (1990) Properteis and potential Natural pesticide from neem tree, *Azodirachta indica*. Annual reviewing Entromlo. 35: 2797.

Schmutterer, H. [ed].(1995). The neem tree *Azadirachta indica* A. Juss. and other meliaceous plants: sources of unique natural products for integrated pest manage-ment, medicine, industry and other purposes. VCH, Weinheim, Federal Republic of Germany.

Schmutterer, H. (Editor) (2002) .The neem tree: source of unique natural product for integrated pest management medicine , industry and other purpose . (Hard cover) .2nd Edition, Weinheim, Germany: VCH verlags gesllschaft. ISBN3-527-200546

Schroeder, Paul. (1992). "Carbonst orage potential of short rotation tropical tree plantations."For est. Ecology and Management 50.1-2: 31- 4i:10.1016/0378-1127 (92)90312-W.

Stoll, G. (2000). Natural crop protection in the Tropics. Pp 117-199.

Steiner, L.F.; Hart, W.G. and Harris, E.J. (1970). Eradication of the oriental fruit fly from Marina Islands by methods of male annihilation and insect sterile release.*Journal of Economic Entomology*. 63: 131-135.

Stanley, D. (1998). Lychees and Longans--No Host for Carib Fly. Agricultural News, 46(1): 8-9.

Steiner, L. F.; Hart, W.G. and Harris, E. J. (1970). Eradication of the oriental fruit fl/y from Marina Islands by methods of male annihilation and insect sterile release. Journal of Economic Entomology. 63: 131-135.

Stibick, J.N.L. (1993). Action Plan, Malaysian Fruit Fly, *Bactrocera latifronss*. Planning and Design, Plant Protection and Quarantine, USDA, 54 pp.

Stibick, J.N.L. (1993). Action Plan Draft, Mediterranean Fruit Fly, *Ceratitis capitata* Planning and Design, Plant Protection and Quarantine, USDA, 60 pp.

Stone house, J.M.; Verghese, A.; Mumford, J. D.;Thomas, J.; Jiji, T.; Faleiro, R. et al. (2005). Research conclusions and recommendations for the o n–farm IPM of Tephritid fruit flies in India. Pest Manage. Hortic. Ecosys.; 11:172-180.

Steven, L.; Peck, G. and McQuate, T. (2000). Field Tests of Environmentally Friendly Malathion Replacements to Suppress Wild Mediterranean fruit fly (Diptera:Tephritidae) Populations. *Journal of Economic Entomology*, 39 (2) :280–289.

Serge, L. T. ; Léonard, S. T. N. and Pierre, M. (2016). Diversity of fruit flies (Diptera: Tephritidae) of economic importance and their host plants in the Sudan Guinean plateau of the Adamawa region (Cameroon). *International Journal of Fauna and Biological Studies*, 3 (5):

Sabah, F. A. M. (2015). Survey of the Asian Fruit Fly (*Bactrocera invadens*, Drew, and White*)* (Diptera: Tephritidae), and Efficacy of two Plant Extracts against the Adults Fly, M.Sc. Agric. Plant Protection (Honors) College of Agricultural Studies-Shambat Sudan University of Science and Technology.

Sarwar Sarwar, M., Hamed, Muhammad., Rasool, Bilal., Yousaf, M.,and Hussain, M. (2013). Host Preference and Performance of Fruit Flies Bactrocera zonata (Saunders) and Bactrocera cucurbitae (Coquillett) (Diptera: Tephritidae) For Various Fruits and Vegetables 2013.

Sarwar, M., Hamed, M., Yousaf, M., Hussain, M. (2014). Surveillance on Population Dynamics and Fruit infestation of Tephritidae fruits flies (Diptera:Tephritidae) on mango (Mangifera indica L.) orchards of Faisal abad, Pakestan. April 2014, DOI10.12983/ijsres-2014-p0113-0119**.**

Selman, H.L., and Heppner, J.B. (1998). (Revised, 2001). Papaya Fruit Fly. In: Featured Creatures, University of Florida, Dept. of Entomology and Nematology.

Severin, H. H. P. (1913). The life history of med fly *Ceratitis capitata* with a list of fruits attacked in Hawaiian Island. J. Econ. Entomo l,6: 399-403.

Sharma, D. R., Singh, S. and Aulakh, P. S. (2011). Management of Fruit Flies in Fruit Crops. Department of Horticulture, Punjab Agricultural University, Ludhiana.

Sharma, K. Kharb, R. Kaur R.(2011). Pharmacognostical aspects of *Calotropis procera* (Ait.) R.Br. Int J Pharm Bio Sci;2:1-9.

Shehata, N. F.; Younes, M. W. F.; Mahmoud, Y.A. (2008). Biological studies on the peach fruit fly, *Bactrocera zonata* (Saunders) in Egypt. Journal of Applied Sciences Research, 1103-1106.

Siddiqui, S. (1942). A note on the isolation of three new bitter principles from the nim oil .*curr. Sci* ., 11: 278-279.

Siddig, S.A. (1993). Evaluation of neem seed and leaf water extracts and powder from the control of insect pest insect in the Sudan / Agric. Res. Cro Tech Bull. Bull, NO.6.

Suliman A. Ibrahim Ali.; Mohammed, E. E.; Mahmoud Wang Man-Qun And Diakite Mory Mandiana. (2013). PGCP (Persian Gulf Crop Protection) Survey and Monitoring of Some Tephritidae of Fruit Trees and Their Host Range in River Nile State, Sudan.

Syed, R. A.; Ghani, M. A.; Murtaza, M. (1970). Studies on the tephritids and their natural enemies in West Pakistan. III. *Dacus zonatus* (Saunders). Technical

Umeh, V. C.; Garcia, L. E. and De Meyer, M. (2008). Fruit flies of citrus in Nigeria: species diversity, relative abundance and spread in major producing areas.

USDA (2005). National nutrient database for standard reference, release p.18.

US Department of Agriculture (USDA), Agricultural research servicee,(2005). USDA nutrient Database for standard Reference 19 online:Retrieved on 11 June 2006 from the nutrient Data Laboratory Home page.

Vayssières, J. F.; Georg, G.; Orphée, L.; Dossa, P.; Akponon. C. (2005). A new *Bactrocera* species in Benin among mango fruit fly (Diptera: Tephritidae) species. Fruits, 60(6): 371-377.

Vietmeyer, N. D. (Director) (1992). Neem : A tree for solving global problems. Report of an ad hot panel of the Board on science and technology. For international development, National Research council, Washington, DC.USA: National Academy Press. Pp. 71-24. INBS. – 301-04686-6

Venkatraman, T. V.; and ElKhidir, E. I. (1965). Outbreaks and new records (Sudan).*FAO Plant Protection Bull*., p. 22.

Vayssieres, J.F.; Cayol, J.P.; Perrier, X. and Midgarden, D. (2007). Impact of Methyl Eugenol and malathion bait stations on non-target insect population in french Guiana during an eradication program for *Bactrocera carambolae*. Entomologia Experimentalis Applicate, 125: 55-62.

Vergas, R. I. (1983). Distribution and seasonal occurrence of med fly on Island of Kauai in Hawaii Island. Env. Entomol.15:507-512.

Vayssiéres, J. F.; Sanogo, F. and Noussourou, M. (2008). The mango tree in central and northern Benin: Cultivar inventory, yield assessment, infested stages and loss due to fruit flies (Diptera: Tephritidae) Fruits 63:335-348.

Vayssiéres, J. F.; Sinzogan, A. and Adandonon, A. (2009). Range of cultivated and wild hosts plants of the main mango fruit fly species in Benin IITA-CIRAD Leaflet No 8.

Verghese, A.; Sreedevi, K.; Nagaraju, D.K. Pre and post- harvest IPM for the mango fruit fly, *Bactrocera dorsalis* (Hendel). In Proceedings of the 7th International Symposium on Fruit Flies of Economic Importance, Salvador, Brazil,10–15 September 2006;pp.179–182.

White, I. M. and Elson-Harris, M. M. (1992). Fruit flies of economic significance their identification and bionomics. C. A.B international Wallingford, 602pp.

White, I., and Elson-Harris, M. M. (1994). Fruit Flies of Economic Significance: Their Identification and Bionomics. CAB International with ACIAR. 601, Addendum**.**

Wharton, R.H. (1989). Control; classical control of fruit-infesting tephritids, in: Robinson, A.S.; Hooper, G, (eds.) Fruit flies; their biology, natural enemies

and control. World crop pests 3(B). Amsterdam, Netherlands: Elsevier, 303-313.

Yash Roy, R. C.; Gupta, P. K. (2000). "Neem-seed oil inhibits growth of termitesur face-tunnels". Indian Journal of Toxicology. 7(1): 49–50.

APPENDICES

Appedix 1: Repellent Effect Usher leaves ethanolic extracts against adults fruit fly (*Bacterocera invadens)* using 10% and 20%, concentrations

Replication 1	Repellent Effect	Number of adults treated	C20%	C10%	Control
	After 2hrs	10	-	-	1
	After 4hrs	10	1	2	3
	After 6hrs	10	1	1	2
	After 8hrs	10	2	2	3
Replication 2	Repellent Effect	Number of adults treated	C20%	C10%	Control
	After 2hrs	10	-	-	1
	After 4hrs	10	1	2	2
	After 6hrs	10	1	-	2
	After 8hrs	10	2	2	4
Replication 3	Repellent Effect	Number of adults treated	C20%	C10%	Control
	After 2hrs	10	1	-	2
	After 4hrs	10	1	2	3
	After 6hrs	10	-	1	2
	After 8hrs	10	1	-	3

Appedix 2: Repellent Effect Neem leaves ethanolic extracts against adults fruit fly (*Bacterocera invadens)* using 10% and 20%, concentrations

Replication 1	Repellent Effect	Number of adults treated	C20%	C10%	Control
	After 2hrs	10	1	2	2
	After 4hrs	10	-	1	2
	After 6hrs	10	2	2	3
	After 8hrs	10	1	-	2
Replication 2	Repellent Effect	Number of adults treated	C20%	C10%	Control
	After 2hrs	10	1	2	3
	After 4hrs	10	1	1	2
	After 6hrs	10	1	2	2
	After 8hrs	10	2	1	3
Replication 3	Repellent Effect	Number of adults treated	C20%	C10%	control
	After 2hrs	10	1	2	3
	After 4hrs	10	1	1	4
	After 6hrs	10	1	1	2
	After 8hrs	10	-	1	3

Appedix 3: Repellent Effect Usher leaves ethanolic extracts against adults fruit fly (*Bacterocera zonata)* using 10% and 20%, concentrations

Replication 1	Repellent Effect	Number of adults treated	C20%	C10%	Control
	After 2hrs	10	1	-	3
	After 4hrs	10	-	1	3
	After 6hrs	10	1	2	2
	After 8hrs	10	2	2	5
Replication 2	Repellent Effect	Number of adults treated	C20%	C10%	Control
	After 2hrs	10	-	1	3
	After 4hrs	10	1	2	2
	After 6hrs	10	2	2	4
	After 8hrs	10	2	3	3
Replication 3	Repellent Effect	Number of adults treated	C20%	C10%	Control
	After 2hrs	10	-	1	3
	After 4hrs	10	1	2	4
	After 6hrs	10	2	2	2
	After 8hrs	10	2	3	3

Appedix 4: Repellent Effect Neem leaves ethanolic extracts against adults fruit fly (*Bacterocera zonata)* using 10% and 20%, concentrations

Replication 1	Repellent Effect	Number of adults treated	C20%	C10%	Control
	After 2hrs	10	-	-	2
	After 4hrs	10	-	1	2
	After 6hrs	10	2	2	4
	After 8hrs	10	1	1	2
Replication 2	Repellent Effect	Number of adults treated	C20%	C10%	Control
	After 2hrs	10	-	-	3
	After 4hrs	10	1	2	2
	After 6hrs	10	2	3	4
	After 8hrs	10	3	1	4
Replication 3	Repellent Effect	Number of adults treated	C20%	C10%	Control
	After 2hrs	10	-	-	1
	After 4hrs	10	1	2	4
	After 6hrs	10	2	2	3
	After 8hrs	10	2	3	3