CHAPTER ONE

INTRODUCTION

Groundnut is grown as a cash grop in most areas of the Sudan e.i. The rain fed areas in Western Sudan, the irrigated areas e.g. The Gezira, Rhad and other agricultural schemes. In most of these irrigated schemes it is grown as rotational crop. In the Sudan groundnuts is infested by several insects such as the Khapra beetle, *Trogoderma granarium* (Evert), the flour beetle, *Tribolium confusum* (Dur), the rice moth, *Corcyra cephalonica* (Saint) and the saw toothed beetle, *Oryzaephilus surrinamensis* (L) all occur as secodary pests in heavy damaged groundnuts (Saad, 1978).

The legume crops in Sudan have a significant role in the diets of the Sudanese people and contribute substantially to the economy of the country. They are equally important as income generating crops for their producers because of their high protein content. Food legume crops also play an important role in sustaining the productivity of the farming system in Sudan because of their beneficial effect on the soil through the fixation of atmospheric nitrogen. The yield of legume crops are known to be sensitive to weather conditions, and are reduced by high temperatures, insect pests and diseases (Salih *et al.*, 1995).

Among several pests attacking groundnut during storage, the seed beetle *Caryedon serratus* Oliver. Is one of the major importances causing about 20% damage (Dick, 1987) and gradually emerging as the major storage pest in the state. The pinkish larvae are internal borer and bore into the kernels at the germend causing deterioration of germination along with nutritive value. In case of severe damage, the kernel seed with many

holes with some powdery masses and the entire inner content is eaten away.

The protection of stored products by the use of plant materials is common practice among smallholder farmers in Africa. Repellent, anti-feeding, and insecticidal substances have been identified in a large variety of plant species, long before the ‘‘industrial insecticide revolution’’ in the 1930’s and 1940’s, when compounds such as nicotine, derris and pyrethrum were the only effective insecticides (Green *et al*., 1979). Azadirachtin, a component of *Azadirachta indica* A. Juss and *Melia azedarach* L. (Meliaceae), is presently considered as a promising alternative to synthetic insecticides, and is currently under investigation in several developing countries, (Jotwani and Strivastava, 1981; Ivbijaro, 1983 and Jilani, 1983). Plants traditionally used in the tropics to protect stored products against various insect pests have been reviewed by Golob and Webley (1980).

Farmers have traditionally resorted to the use of various botanical ingredients to protect their crops. Ingredient such as Neem leaves; seeds, castor and red hot pepper have been tried. In many areas of the world locally available materials are widely used to protect stored produce against damage by insects (Golob and Webley, 1980).

The success of synthetic pesticides during the last decades had led to their wide spread acceptance for use against various groups of agricultural and public health pests. However after 3-4 decades of intensive use, many adverse effects, such as resurgence of treated pests, toxicity to mammals and non-target organism’s especially beneficial insects, environmental pollution, development of resistance, ..Etc was found to be associated with these chemicals (Suliman, 2002).

With all these hazardous side effects of the synthetic chemicals, scientists resorted to plants and began to think seriously about exploiting these rich sources (Bowers, 1983, Casida, 1983).

Sudan with its good land, covering forests is one of the richest countries in natural flora. Plants of this country, both cultivated and wild, constituted an unlimited reservoir for medicinal, pharmaceutical, agricultural and aromatic chemicals, Example of the promising chemical, source plants in the Sudan includes, neem tree *Azadirachta indica* (A), Sadom apple (Usher) *Calotropis procera* (J), Fenugreek (Hilba) *Trigonella foenum* (G), Garlic *Allium sativum* (L), Sesame *Sesamum indicum* (L) (Fageer, 1999) and sweet basil (Rehan) *Ocimum basilicum* (L).

The problem statements of the (Study) are as follows;

- Economical and financial loss problems in the locality every year.
- Miss use of pesticides yearly.
- High infestations by *Caryedon serratus* especially in the stores, during summer period and lack of knowledge control.

Study objectives are;

1- To assess through randomized survey the degree of infestation of *C.serratus* in North Darfur- Alliet locality.

2- To reduce the use of chemical insecticides in groundnuts stores.

3- To determine the activity of Neem seeds ethanolic extract against the larvae and adults of groundnut seed beetle.

CHAPTER TWO

2-LITERATURE REVIEW

2.1 The groundnut seed-beetle, *(Cayedon serratus)* (Olivier).

Cayedon serratus is a serious pest of stored groundnuts (*Arachis hypogaea* L.), particularly when these are still in their shells. The damage caused is particularly significant when the nuts are destined for confectionery purposes.*C. serratus* (Olivier) is a well-known as a pest of international importance in stored groundnut and is wide spread in various groundnut growing areas of the world (Davey, 1958). The bruchid, *C. serratus* (Olivier) is a serious pest of legumes in West Africa (Hall, 1954), beside other hosts such as *Acacia arabica*, *Tamarindus indica* and *Bauhinia rufescens* (Diaollo and Huignard, 1993). In the Sudan, it attacks groundnuts in Alliet Jar Elnabi and may be other parts of the country as well.

2.1.1 Taxonomy:

Caryedon serratus is an important storage pest of groundnuts in Africa as reported by (Kingsolver, 2004) and give the following **calaasification:-**

Kingdom: Animalia

Phylum: Arthropoda

Subphylum: Hexapoda

Class: Insecta

Order: Coleoptera (Beetles and weevils)

Suborder: Polyphaga (Water, Rove, Scarab, Long-horned, Leaf and Snout Beetles)

Superfamily: Chrysomeloidea

Family: Chrysomelidae or Bruchidae

Subfamily: Bruchinae (Pea and Bean Weevils)

Tribe: Pachymerini

Genus*: Caryedon*

Species: *serratus* (Groundnut Bruchid)

Other Common Names Groundnut Borer, Groundnut Seed Beetle, Groundnut bruchid, Tamarind Seed Weevils, Tamarind Beetle.

Scientific name

Caryedon serratus Olivier.

2.1.2 Morphology and description

The body length is 4.7 mm. The pygidium is very large that the elytra do not cover it, the elytra are deeply striated, and the antennae consists of eleven segments with no clubs, tarsi are four – segmented; hind femur are broader than hind coxa, and have crest of stout spines on the distal third of the ventral margin; the hind tibia are strongly curved (Khalil, 1970).

According to Singh (1977), the insect has prognathous head type, the body length exceeds 6 mm. The hind femur with strong tooth in the middle followed by 10 – 14 smaller teeth, the pygidium is covered over with golden and black in the posterior region, with a thin median line of golden setae throughout its length; the hook-like exophalic valve is triangular; testes with 16 follicles and ovarioles are 6 on each side.

Davey (1958) stated that the pygidium of the male in dorsal view, is hidden by the elytra; the 5^{th} visible sternite is deeply incurved anteriorly so the 7^{th} tergite is often seen projecting between it and the pygedium can be seen in dorsal view projecting beyond the elytra; the 5^{th} sternite is fully extended so that the ventral surface is more or less flat; the 7^{th} tergite is not represented in the female. The antennae are equally serrated in both males and females (El Atta, 1993).

2.1.3 Host range

C. serratus is a primary pest type which attacked, peanuts/groundnuts, dried tamarind. Reports on damage to seeds of legumes by this insect in storage as well as in the field from different parts of the world have been well documented (Cunningham and Walsh, 2002, and Nandagopal and Prasad, 2004). They include *Tamarindus indica*Linn. *Arachis hypogaea*Linn. *Acacaia farnesiana*Willd.,*Acacia nilotica* (L.), *Acacia tortilis* Hayne., *Albizia lebbek* (Linn.) Benth.*Bauhinia malabarica* Roxb. *Bauhinia monandra* Kurtz., *Cassia fistula* Linn., *Cassia brewsteri* (F. Muell.) Benth. *Cassia tomentella* (Benth.) Domin, *Cassia renigera* Benth., *Piliostigma reticuatum* Dc., *Piliostigma thonningii* (Schum), *Pongamia pinnata* (L.) and *Prosopis juliflora* (Sw.).

Arachis hypogaea (groundnut), stored products (dried stored products), *Elaeis guineensis* (African oil palm), *Gossypium* (cotton), *Phaseolus* (beans), *Theobroma cacao* (cocoa) and *Tamaindus indica* (Indian tamarind) and *Acacia nilotica* in the Sudan (El Atta, 1993); *Acacia gerrardii* in Uganda (Mucunguzi, 1995), *Faidherbia albida* in Nigeria, (Lale and Igwebbuike, 2002). These records are very dubious because of the Mimosoideae are the hosts of different species of the *serratus* group which can easily be misidentified (Nongonierma, 1978 and Silvain and Delobel, 1998). The record of *Acacia nilotica* as a host of *C. serratus* in India (Singal and Toki, 1990) may also concern a different species.

2.1.4 Geographical distribution

C. serratus is worldwidely, subtropical to tropical distributed in groundnut growing areas of the wold from Myanmar through hawaii, India, Indonesia, Iran, Israel, Jordan, Mexico, New Zealand, Nigeria, Pakistan, Sri Lanka, Sudan,

Thailand and Uganda, (Kingsolver, 2004). Further, it has also been reported from Zambia, Senegal and West Africa (Feakin, 1973) Central Africa (Delobel, 1989) and Australia (Cunningham and Walsh, 2002). In India, *C. serratus* was first reported to be infesting groundnut round the year in Andhra Paradesh and Tamil Nadu in 1914 (Fletcher, 1914). Subsequently, several workers reported it distribution from Rajasthan, Gujara, Madhya Pradesh, Maharashtra, Uttar Pradesh, Punjab, Haryana, Jammu and Kashmir, Himachal Pradesh, Tamil Nadu, Kerala, Andhra Pradesh and Orissa (Mittal and Khanna, 1974, Arora and Singal, 1978, and Ranga Rao and Wightman, 1999).

C. serratus is of Asian origin, but is distributed to many tropic and subtropical regions of the world (Southgate, 1979). Althrough it is especially prevalent in the warm and hot parts of Asia, North-eastern and West Africa, the West Indies, Hawaii, and parts of South and Central America as far as Mexico, it is a serious pest of stored groundnuts only in West Africa.

In Africa the species is found in the Northwest, West and South West and it is a serious pest in Nigeria and Gambia (Howe, 1952 and Prevett, 1954), Senegal and Chana, (Prevett, 1954). In the Sudan the insect was reported by Peake (1952), Abdalla (1986) an El Atta (1993). The insect has been recorded in India, Pakistan, Burma and Ceylon as the tamarind beetle (Davey, 1958).

2.1.5 Biology and life cycle.

Mating takes place at the surface of stored seeds (Davey, 1958). Adults escape frome excessive heat and low humidity by burrowing amog nuts and emerge from mating and ovipositioning by night (Green, 1959).

When adults emerge from cocoons, nearly all of them are sexually mature and copulation takes place within 24 hours of emergence (Concella da Fonseca, 1964). (Makie, 1946) stated that copulation takes place a few hours after emergence, but usually occurs after 1-2 days. The pre-mating period is about 5

miniutes to hours. Normally the females start to oviposit soon after mating. The first eggs are usualy laid within 24-46 hours (De Jangh, 1935; Prevett, 1954 and Concella Da Fonseca, 1964).

The oviposition period is greatly affected by relative humidity and temperature. It is ranged from 9-15 days at 27◦ to 30C and 50-70% R.H and then decreased sharply to 4-7 days at 40◦ and 90% R.H, (Concella da Fonseca 1964). The shortes period of oviposition was 3 days (31 eggs) at 40° and 90% R.H, (Concella da Fonseca 1964). The longest period recorded by (Prevett, 1954) was 42 days at about 17° and 70% R.H. Provision of water increased oviposition period from 14 to 28 days and number of eggs laid from about 32 (range 6-99) to 45 (range 15-93) (Prevett, 1954). According to Davey, (1958) the peak of oviposition occurred during the first 5-6 days, while Concella da Fonseca (1964) recorded that the peak occurred during the first 4 days. Mean oviposition period in the Sudan was 11.6 days at 35 + or – 5° and 70% R.H, (El Atta, 1993). Average number of eggs was 92.7 at 35° and 70% R.H (El Atta, 1993) unmated females were able to lay eggs but after long pre-oviposition period ranging from 3-18 days when provided with nuts and from 2-36 days without nuts. The length of oviposition period of mated females was not affected by the absence or presence of nuts, but that unmated females was much affected. The oviposition period of unmated females lasted up to 27 days in the presence of nuts (mean 18.9) and 52 days in the absence of nuts (mean 23.8). About 30% of the unmated females laid on crevices of the shell but females deposite eggs on other objects when suitable hosts are absent (Concella da Fonseca, 1964). Most of the eggs were laid by night and out of 46.3 eggs 2% were laid by daytime. More than one mating is required for female to lay its full complement of eggs (Concella da Fonseca, 1964). Corby (1941) reported that the source of infestation is the eggs which are laid on freshly harvested nuts while they are sun dried and before they

are taken into store. Asingle gravid female lays 20-30 creamy white eggs (1 mm long), which are glued to the surface of groundnut shell or kernels. The incubation period varies from 4 to 6 days.

The average larval duration was 87.60, 46.69, 33.11 and 24.48 days on unshelled groundnut, under controled temperature of 20°, 25°, 30°, and 35° respectively (Abdalla, 1986). The mean of larval duration was 42.72 days in winter, 16.54 days in summer and 18.16 days in autumn, (El Atta, 1993). The fourth instar larva had apale brown colour or pink colour. The fuly grown larva emerges from the seed making an irregular exit hole of 2-4 mm width on the seeds testa (El Atta, 1993). The developmental period from egg to completion of the larval lasted 40-45 days at 25◦ and 70% R.H (Calderon *el al*., 1966).

Usually the fully grown fourth instar larva *C. serratus* spin a cocoon within 24 hours to start pupation. The pupal period is the period from date of cocoon formation until the adult emergence. The cocoon is formed blocking the exit hole or outside stacking to the shell and formed inside or outside the pod (Davey, 1958). The cocoon is paper like trarusluemt and id ovate in shape, covered by short spines or hairs and the larva could be seen through it during the first three days (El Atta, 1993). Cocoons are usually developed between the seeds, under or outside them, and they strongly adhere to the seed coat (El Atta, 1993). The pupal period was 25-30 days (Calderon *el al.*, 1966). The average of pupal period was 34.91, 25.14, 19.39 and 13.31 on shelled groundnut under controlled terperature of 20°, 25°, 30° and 35°respectively. (Abdalla, 1986). It 10-15 days at 26◦ and 70% R.H. The pupal period in *Acacia nilotica* seeds was 10-15 days (El Atta, 1993).

The longevity of the adult is affected by many factors such as mating, presence or absence of the material ECT. (Prevett, 1954 and Davey, 1958); Cancella da Fonseca, 1964 and Abdalla, 1986). Longevity increased with decreasing

temperature and increasing relative humidity (RH), (Cancella da Fonseca, 1964 and Abdalla, 1986; El Atta,1993). Longevity was 3-4 days at 45° and 70% R.H, 4days at 40° and 70% R.H. (18-21 days at 27.5° and 75% R.H. (Cancella da Fonseca, 1964 and Davey 1958) found longevity to be three weeks without provision of water. In the Sudan the range was 4-15 days (El Atta, 1993). Longevity was also affected by diet. Field observation in Nigeria showed that the adults live and average of 12 – 32 days (Corby, 1941). In West Africa up to 50 days longevity was observed, Sagot and Boufill (1935). The range of temperature within which adults can servive at 70% R.H. Is 15-45° (average 30°)? Temperatures being equal, an increase in relative humidity increases the length of adult life, (Cancella da Foseca, 1964). Prevett (1954) reported that the adults survived for only a few days at the very low relative humidity of 10%.

Under optimum conditions (30-33° and 70-90% relative humidity), the life cycle of *C. serratus* is completed in about 60 days.

2.1.6 Damage and economic importance

As reported by Singal and Toki (1990). The beetle damage not only reduces the weight and nutrient value but also adversely affects the quality of seed and oil. Infestation causes loss in dry mass of the kernels, increased levels of free fatty acids in the oil (there by lowering the quality) and reduction in germination potential. The heat and moisture generated by large insect population within heaps or stacks of groundnut may also increase the risk of mould growth.*C. serratus* (Oliver) is one of the major and important storage insect species causing around 20 per cent damage to groundnut and gradually emerging as the major storage pest in the state (Dick, 1987) and prevalent in Asia, Greece, Italy and the north and west coasts of Africa. The pinkish larvae are internal borers and bore into the kernels at the germend causing deterioration of germination along with nutritive value. Incase of severe damage, the kernel is seed with many holes with

some powdery masses and the entire inner content is eaten away. Considering the quick loss in germinability of these seeds.

Fully grown larva sometimes comes out through the exit holes made by the previous generations. They often live in the storage sacks and pupate in large numbers at the bottom of the pile of sacks. By this stage, the groundnut seeds are severely damaged for human consumption or oil expulsion (Wightman and Ranga Rao, 1993).

2.1.7 Management and Control

To prevent primary infestation from alternate hosts (Tamarind, Acacia and Pongamia) avoid drying groundnuts near these host trees. Incase of positive test remove the infested seeds followed by the seed treatment.Good storage management and hygiene are of great importance in preventing insect infestation of stored produce.Groundnuts must be processed properly after harvest and dried to bring the seed moisture below 7% the upper limit for safe storage. Before shifting groundnut to the store, it should be thoroughly cleaned and free from all crop residues.Storing groundnut kernels with dried neem leaves (about 500 g of leaves for every 10 kilos of kernels) in any sealed container can effective against some pests (Rao, Rao, and Nigam, 2010).

Application of chemical protectants on the surface can provide effective control, dust formulations such as Malathion (5%); fenvalerate (5%) can be applied to the surface of the bags or mixed directly with pods where pods are meant for seed purpose. (Ghanekar *et al.*, 1996).

2.1.8 Situation of the pest in Sudan

In the Sudan, it attacks groundnuts in Alliet Jar Elnabi, West, East, North and South Darfur states, West and North Kordofan, Gezira and Rahad Schemes and may be other parts of the country as well.

2.2 Groundnut (*Arachis hypogaea* L.)

Groundnut (*Arachis hypogaea* L.), is an important cash and food crop in many parts of the tropics, particularly in semi-arid areas. Also an important source of protein for human and dietary oil for most Nigerians, (Musa *et al*., 2009). Because of the unusually high nutritional value of the seeds and their pleasant flavour, groundnuts are one of the most important food crops in the tropics and sub-tropics (Orr, 1972). Groundnut is a premier oil seed crop and it holds 34% share of the total oil seed area (24 million hectare) and contributes nearly 40% of the total oil seed production (20 million tons) (Mamta *et al*., 2010). Groundnut seed contains 44-56% oil and 22-30% protein on a dry matter basis and is a rich source of minerals (P,Ca, Mg, K) and vitamins (E, K, B group), (Savage and Keenan, 1994). The crop also serves as a raw material for some food industries and also as feed concentrate for livestock (Oaya *et al*., 2013).

2.2.1 Taxonomy

Groundnut is a member of the family leguminacae or Fabaceae. The genus *Arachis*, the taxonomy of which is described by (Norman *et al*., 1996), includes 37 named species and a number of undescribed species. The grouping which is generally accepted is given below classification;

Domain: Eukarya

Kingdom: Plantae

Phylum: Magnoliophyta

Class: Magnoliosida

0rder: Fabaceae

Family: leguminosae or fabaceae

Sub-family: Papilionaceae

Genus: *Arachis*

Species: *hypogaea*

Sub species: *hypogeaea* No flora axis on main stem alternating pair of vegetative and flora axes on laterals.

Var. *hypogaea* less hair, branches short (Virginia type).

Var. hirsuta more hair branches long (Pruvian runner type).

Sub species: fastigita floral axes on main stem, continuous runs of floral axes on laterals.

Var. vulgaris more branched (Spanish type).

Scientific name *Arachis hypogaea*

Groundnut common names

The groundnut or peanut (*Archis hypogaea*) is a species in the legume or bean family (Fabaceae), it is drived from two Greek words, *Archis* meaning a legume and *hypogaea* meaning below ground, reffering to the formation of pods in the soil (Nautiyal, 2002).

Groundnut also known as peanut, earthnut, gobbers, pinders, manilanuts, etc. (Beghnin and Sewadah, 2003).

2.2.2Groundnut origin, history and distribution

The origin of the groundnut is uncertain, although they were known as early as 950 B.C. The groundnut was supposed to have been first domesticated in Brazil or Peru. Cultivation spread as far as Mesoamerica where the Spanish conquistadors found the *tlalcacahuatl* (Nahuatl=’peanut’, hence, Mexican Spanish, *cacahuate* and French *cacahue’te*) being offered for sale in the market place of Tenochtitlan (modern day Mexico City). When the Spaniards returned to Europe they took groundnuts with them. Later, traders were responsible for spreading the groundnut to Asia and Africa countries such as Mozambique (Higgins, 1951and Pattee and Young, 1982).

The genus *Arachis* is South American origin and all species are located east of the Andes, South of the Amazon and north of the river plate (Norman *et al*.,

1996). Spanish sailors took groundnut from coastal Peru across the Pacific to the far East, While the Brazil coast was the point of departure for the Portuguese who transferred the crop to West Africa and then on to East Africa (Schilling, 1996).

2.2.3 Morphology and description

The aerial part of the plant consists of a main stem, which is always erect, and two primary branches, which may be erect or trailing and which determine the plants habit. Valencia and Spanish types are erect branch in habit, while Virginias are either spreading branch or prostrate. The prostrate types are often called runners because of the stems trail over the ground. As is typical in legumes, the root system, which consist of a thick taproot and numerous fibrous side-roots, bears nodules that fix atmospheric nitrogen (Schilling, 1996). The leaves are pinnate, normally with two pairs of leaflets, and are green or dark in color. Darker leaves are found in Virginia types, where Spanish or Valencia's tend to have higher ones. The pods of two seceded Spanish and Virginia varieties are deeply constricted, with a waistline between the two seeds (Schilling, 1996). The seeds are normally pale tan in Spanish are Valencia type and dark than in Virginia, but may be red, white or purple. Variegated seeds are not uncommon. The plants vegetative growth is limited until the onset of flowering (25 to 30 days after sowing). But they follow a period rapid growth, during which the flowers bloom and pods are formed (Schilling, 1996).

2.2.4 Economic importance

Groundnuts are one of the most important food crops in the tropics. All parts of the plant can be used. The groundnut, grown primarily for human consumption, has several uses as whole seeds or as processed to make peanut butter, oil, and other products. The seeds contain 25 to 32% protein (average of 25% digestible protein) and 42 to 52% oil. A pound of groundnuts are high in food energy and

provides approximately the same energy value as 2 pounds of beef, 1.5 pounds of Cheddar chees, 9 pints of milk, 36 medium-size eggs (Schilling, 1996).

Groundnut oil is often used in cooking because it has a mild flavor and a relatively high smoke point. Due to its high monounsaturated content, it is considered healthier than saturated oils, and is resistant to rancidity.

Flour is also made from groundnuts. Groundnut flour is lower in fat than peanut butter and it is popular with cooks because of its high protein content that makes it suitable as a flavor enhancer. Groundnut flour is used because of it is gluten-free (Schilling, 1996).

Groundnuts content of edible oil (50 percent) and protein (25 percent) make it a popular human food. It is consumed either as a shelled nut, or as oil, after pressing of the kernel (Schilling, 1996). Groundnut is a particularly valuable addition to the diet in developing countries, where diets often consist manily of low-protein cereal foods. It is a good source of minerals such as phosphorus, calacium, magnesium and potassium, as well as the vitamins E, K and B (Schilling, 1996). Groundnut can be used as ingredient in a wide range of cooking, as a snack for hungry children or working adults. Its oil is also much liked in the developing world, since it can be produced easily at village level and is excellent for cooking (Schilling, 1996).

Non-food products such as soaps, medicines, cosmetics, and lubricants can be made from groundnut. The vines with leaves are excellent high protein hay for horses and ruminant livestock. The pods or shells serve as high fiber roughage in livestock feed, fuel (fireplace logs), mulch, and are even used in manufacturing particle board or fertilizer (Woodroof, 1973; Putnam *et al*., 1991and Augstburger, 2002)

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2.2.5 Planting and sowing time of Groundnuts

Weather and soil conditions determine the best time for planting groundnut. Early planting, consistent with settled weather and a well-warmed soil is usually ideal. However, some growers make succession plantings of the same variety a few days apart for the purpose of increasing the length of the harvesting season. Because of variable weather and soil conditions, this plan does not always work. A better plan is to plant early-midseason-and late-maturing varieties at one time. Differences of as much as three weeks may be often obtained in the harvesting dates between the early and the late sorts.

Groundnut seeds are very sensitive to unfavorable conditions for germination and it is wise to defer planting until a warm, moist seedbed is available. Planting date is vary with the geographical location. Groundnut seed should be covered to a depth of about 6.3 cm. (2-1/2 inches) on light-textured soil, and slightly shallower on heavier soils (Woodroof, 1973).

Planting 2-3 seeds per hole instead of only one seed will increase the prospects for plant growth, provide more pods, and contribute to a higher yield (Okito, 2009).

The normal planting time for groundnuts in South Africa is mid October to mid November. However several factors, the most important being rainfall, will determine the precise date. Groundnut must be planted as early in the season as possible when the danger of cold spells has already been reduced. Groundnut planted later, usually produce lower yields and also have higher demands in terms of of foliar disease control. The correct planting depth of 50-75 mm ensure that the plant develops and produces optimally.Seed which germinates slowly as a result of deep planting, takes longer to emerge and substandard plant will be produced. Seed germination is rapid if the soil moisture and temperature are optimal (above 18◦).

2.2.6 Groundnut husbandry practices

2.2.6.1 Soil type

Groundnut is grown in a well-drained sandy loam, or sandy clay loam soil. Deep well-drained soils with a pH of 6.5-7.0 and high fertility are ideal for groundnut. Runner and Spanish types are better suited to heavy textured soils than the Virginia types. The loss of pods is usually high in heavier soils. An optimum soil temperature for good germination of groundnut is 30°. Low temperature at sowing delays germination and increases seed and seedling diseases. (Henning *et al.*,1982 and Allison 1981).

2.2.6.2 Field preparation

Land preparation should ensure that all crop residues and weeds are completely buried. One plowing, to a depth of 15 – 20 cm, followed by two to four disk harrowing may be required to make a seedbed with fine tilth. Three systems of groundnut sowing are followed, sowing on a flat surface, on a broadbed-and-furrow system, or sowing on a ridge-and-furrow system. The broadbed-and furrow system has an advantage over flat sowing in daining off excess water, providing aeration for plant growth, and greater in-situ moisture conservation. It may be easier for weeding and mechanical harvesting (Dharmalingam and Ramakrishna, 1981).

2.2.6.3 Layout and seed preparation

Selection of seed. Bold and well-filled pods are selected for shelling about one week before sowing. The viability of the kernels may be deteriorate after being shelled and stored for long time and more subject to storage pest damage. The plants produced from bold kernels were found to be superior to those from correspondingly smaller kernels in their rate of emergence, number of successful seedlings, number of primary branches and leaves, and dry mass of roots, shoots, total dry matter, and pod yield (Dharmalingam and Ramakrishna, 1981).

Seed treatment. To control pathogens causing seed and seedling diseases, it is necessary to coat the seed before sowing with either ThiramR (a.i. 50% @ 3 g kg seed) or BavistinR (a.i. 50% @ 2 g kg seed). Seed may be inoculated at the time of sowing by field inoculation to ensure that good nodulation where a soil has been found to contain few rhizobia (Dharmalingam and Ramakrishna, 1981).

Seed rate and spacing. The seed rate depends on the variety (Spanish, Valencia, or Virginia), runner or bunch varieties is 330 000 plants ha (about one plant per 30 x 10 cm). In case of semi-spreading and spreading varieties the recommended population is 250 000 plants ha (one plant per 40 x 10 cm) (Nageswar Rao *et al*., 1985, 1988).

Seed packets. When sowing by hand is done the calculated amount of seed for each row is separately packeted and the packets for each plot are temporarily fastened together. In case of machine sowing, seed packets are arranged by groups of rows for continuous sowing (Nageswar Rao *et al*., 1985, 1988).

2.2.6.4 Manures and fertilizers

A balanced fertilizer application, based on soil tests, should provide adequate levels of especially phosphorus, potasssium, calcium, sulphur, and magnesium. Nutrient availability depends on soil pH, organic matter content, and rate of release of nutrients from the soil minerals. The availability of other essential ions such as copper, boron, iron, manganese, and nitrogen may be low in alkaline soils (pH >8.5); while and acid soil (pH <6) may be deficient in molybdenum, maganese, sulphur, nitrogen, phosphorus, potassium, and cacium. (Sahrawat *et al*. 1988).

Groundnut fixes atmospheric nitrogen with the help of *Rhizobium* in the root nodules. This helps partially fulfill its nitrogen requirement. However, it takes about 25 – 30 days to develop root nodules. Therefore, some available nitrogen

is required in the early stages for plant growth. An application of 10 kg N ha as ammonium sulphate at the time of sowing is recommended for soil with moderate to low nitrogen content. (Yadava, 1985).

2.2.6.5 Crop rotation

A crop rotation of groundnut-cereal-cereal helps in efficient nutrient utilization and reduces soilborne diseases and nematodes. It also helps to reduce the incidence of weeds. Maize, sorghum, pearl millet or small grain crops can be grown following groundnut. To reduce the incidence of soilborne diseases it is recommended not to grow groundnut after groundnut, or tabacco, or cotton, (Henning *et al*., 1982 and Allison, 1981).

2.2.6.6 Sowing

Groundnut sowing during the rainy season start with the onset of the rains, usually by the 3rd week of June. (Yadava, 1985).

Examine the soil before sowing for optimum moisture content after rainfall or give a presowing irrigation to ensure good germination.

At time of sowing, place the seed at 5-6 cm depth in the soil. Compact the soil around the seed to ensure there is firm contact with soil moisture for rapid and uniform germination. Use of a seed drill with packing wheels is useful to ensure uniform germination.

When sowing manually, make sure that plots in each block is completed by the same person to reduce within-block variation due to uneven sowing caused by human differences. (Nageswar Rao *et al*., 1985, 1988).

2.2.6.7 Weeds Control

Weeds caused much damage to the groundnut crop during the first 45 days of its growth. The most critical period of weed competition is from 3-6 weeks after sowing. The average yield loss due to weeds is about 30%, whereas under poor management yield loss by weeds may be 60%. (Dayal *et al*., 1987). Therefore, it

is advantageous to mechanically and chemically control weeds during the initial 6 weeks of groundnut growth.

2.2.6.8 Harvest

According to Dayal, Devi *et al.* (1987) premature harvesting of groundnut pods lowers the yield, oil percentage, and quality of seeds. Delay in harvesting after physiological maturity can result in increased *Aspergillus flavus* infection, and aflatoxin contamination in pods/seeds, and many pods may be left in the soil due to weakening of pegs. The Spanish bunch varieties (nondormant types) start germinating if harvesting is delayed. Therefore, it is important to harvest at optimum maturity. There are three ways of harvesting groundnut:

- Apply sprinkler irrigation for an hour and manually pull the plants.
- Provide a light surface irrigation 2-3 days before harvest and use a blade harrow that cuts the plant roots 12-15 cm below the soil surface. Then manually pull the plants.
- When irrigation water is scarce, use plow or tractor-driven digger to loosen the soil. Then manually remove the plants.

Harvested groundnuts should be stacked in the field for a few days for air and sun drying (on bright sunny days) before stripping the pods. Thereafter, pods are continuously dried to reach a mature content of 6-6% to avoid the development of aflatoxin caused by yellow mold (*Aspergillus flavus*). On cloudy days, pods should be removed and immediately placed in an air drier at 27-38 C for 2 days or until the pods dry to a content mass (6-8% moisture).

2.2.6.9 Storage

After cleaning and grading, store dry pods in gunny bags and stack them up to 10 bags high in separated stacks so that air freely circulates among them. The bags should be piled on wooden planks to avoid damage from dampness. Dusting the

bags with 5% LindaneR will protect the pods from many storage pests. (Dayal, Devi *et al*., 1987).

2.2.7 Groundnut cultivation in Sudan

Although historically groundnuts were an important cash crop and a major export for Sudan, the groundnut economy has not been developed or sustained. Groundnuts are the major cash crop in Darfur, and their history over this period (of the 1980s) is indicated of the sad decline of the cash cropping economy after the promise of the mid-1970s. Declining yields certainly played and important part, but problems with inputs, price instability, ineffective marketing structures, and accelerating transport costs were as least as important (De Waal, 2005).

The main production areas for groundnuts in Darfur are South and East States where groundnuts have long been the second-most important crop after millet (Morton, 2005). There is also significant groundnut production in West Darfur State; for example in Beida locality and in Kereinik locality, and across the borderin Chad19 as well as Wadi Salih in Central Darfur. In North Darfur State, the main area for groundnut El Lait. However, groundnut areas cultivation in the Sudan as general, West, East, North and South of part of the country. Groundnuts are grown on sandy *goz* soils and clay. Because of its nitrogen-fixing properties as leguminous plants, it is a good rotation crop with millet. Groundnuts are also generally more pest resistant than cereals.

2.3 Neem (*Azadirachta indica* Juss.)

The neem tree (*Azadirachta indica A. Juss*), from the Meliaceae (mahogany) family, known as margosa or Indian lilac, has long been recognized for its properties both against insects and in improving human health. The neem tree is an attractive broad leaved evergreen which can grow up to 30m tall with spreading branches covering some 10 m across. The flowers and fruits are borne in axillary clusters and when ripe the smooth ellipsoidal drupes are greenish yellow and comprise a sweet pulp enclosing a seed. The seed consist of a shell and 1-3 kernels which contain azadirachtin and its homologues. Both the bark and leaves also contain biologically active molecules but not high levels of azadirachtin which is found mainly in the seed kernels. Here azadirachtin occurs amounts of some 4-6g/kg seeds depending upon three ecotype and local environmental conditions. Mature trees may produce some 20 kg of seed per year. The tree is now grown in most tropical and sub-tropical areas of the world for shade, for reforestation programmes and in plantations for the production of compound which have toxic, antifeedant and repellent properties against insects.

Azadirachtin, a complex tetranortri-terpenoid limonoid from the neem seeds, is the main component responsible for both antifeedant and toxic effects in insects. Other limonoid and sulphur-containing compound with repellent, antiseptic, contraceptive, antipyretic and antiparasitic properties are found elsewhere in the tree, e.g. leaves, flowers, bark and roots (Schmutterer, 1995).

The antifeedant effects of neem were the first to be described scientifically. In 1952, Heinrich Schmutterer recorded desert locusts (*Schistocerca gregaria* (Forskal) refusing to feed on neem. Closer studies revealed that this species has unusually high sensitivity to azadirachtin as an antifeedant, perhaps related to the supposed co-evolutionary origins of both tree and locost in Burma. There have

been at least six international conferences on neem to date, the first taking place in Germany in 1980 (Schmutterer, 1995).

2.3.1 Taxonomy:

Neem (*A.indica* A. Juss.) is belong to family Maliaceae. The neem tree is described as *A. indica* as early as 1830 by De Jussieu and in taxonomic position belongs to order Rutales but recent literature describes that belong to order Sapindales (Biswas *et al.*, 2002).

Kingdom:	Plantae
Division:	Magnoliophyta
Class:	Magnoliopsida
Order:	Sapindales
Family:	Meliaceae
Genus:	*Azadirachta*
Species:	*A. Indica*
Scientific Name:	*Azadirachta indica*

Synonyms

Schmutterer *et al.*, (1995) reported that the synonyms of *A. indica*, were *Melia azadirachta* L., *Melia indica* (Juss) and *Antelaeu azadirachta* L.

Common names

They are many common names of the neem tree for example in India called Limbo, Vepo and Neem, while in Burma it is known by the name Tamarkha, in Nigeria Babo, yaro, Dagon Yaro, in USA Neem, in Latin America Nim, in Portugal it is named Margosa, (Schmutterer *et al.*, 1995) and in Sudan the common name is Neem.

2.3.2 Origin

Schmutterer *et al*., (1995) reported that the exact region of origin of *A. indica* is not known. Some authors suggest that it may lie in Myanmar (Burma) and/or in the part of southern India, such as Karnataka, this agrees with (Drame, 1997) who stated that neem tree originally comes from India and Burma.

2.3.3 Geographical distribution

A. indica is widely distributed mainly in the arid tropical and sub-tropical zones of Asia, Africa, America, Australia and south Pacific islands. Mountain areas are generally avoided, In East Africa neem was probably first introduced by immigrants from the Indian subcontinent. Neem exista along the East Africa coast in Somalia, Kenya and Tanzania. Also neem was found in areas extended from Northern Africa (Ethiopia, Sudan) to Senegal and Muritania in the West. The limit of distribution is generally latitude 17°north (Schmutterer, *et al*., 1995).

2.3.4 Morphology

Neem (*A. indica*) is a fast-growing, draught-tolerant and attractive shade-giving evergreen tree (Drame, 1997). Itusually reaches a height of 15-20 m, and under very favorable conditions it may reach up to approximately 35-40 m. The branches spread widely. The tranks is relatively short, straight and may reach a girth of 1.5 – 3.5 m. The root system consists of a strong taproot and well developed lateral roots. The unpaired, pinnate leaves are 20-40 cm long. An individual flower is 5-6 mm long and 8-11 mm wide. The glabrous fruits are olive-like drupes which very in shape from elongate oval to nearly roundish. They are green when young and yellowish-green when mature. The seeds measures 9-2.2/0.5-0.8 cm2, and the seed kernels are 0.8-1.6 x 0.4-0, 5 cm2 (Schmutterer *et al*., 1995).

2.3.5 Economic importance

One very promosing source of pest control products is the neem tree or *A. indica*. Neem is best known for multi-malady curing powers of its leave, twigs, bark and roots. But in recent years, the tree of fourty cures, has also taken its rightful place as a major source for effective, eco-friendly and low-cost natural pest control products. Extracts, from seeds of the neem tree contain ahost of active natural compounds that work gently in low doses to control agricultural pests. The seed kernels, the oil expelled from them and the residual seed cake, all contain asmall amount of azadirachtin, the primary active ingredient in neem, which has an extremly bitter taste. Besides azadirachtin, neem contains score, of other compounds collectively called liminoids (Drame, 1997). Siddig (1991) reported that neem is a forest plant in Sudan, which had been introduced from India. It is now extensively grown throughout the Sudan as a shade tree in public parks, streets and residential areas. It is also used in shelter belts in dry areas. In south-east Asia, it is used in traditional medicine, production of insecticides, lamping and for soap manufacturing using the margosa oil pressed from its seed kernels which contain up to 40% oil Dreyer (1984) indicated that people in India and other Asian countries placed neem twigs and leaves in their bed, in cupboards, among cloths and stored grains to reduce infestation by insects (Drame, 1997) reported that some 400 species of insects pests are known to be affected by neem extracts. Neem unlike synthetic pesticides, usually don’t harm most beneficial insects like wasps, ladybird, beetles and spiders. Moreover farms that use neem do not disrupt the natural balance, which serves to keep most minor pests in check. Thus prevents the problem of pest resurgence, the outbreak of secondary pests and may also delay or even stave off development of resistant among the targeted pests.

2.3.6 Chemical Composition of Neem tree

Neem tree contains different chemical compounds. 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).The Neem tree produces a copound of many active ingredients called Azadirachtin and its tetramer titer penoid compound which influences the hormonal system, feeding activity reproduction and fling ability of insect. Azadirachtin has low mammalian toxicity. It degrades rapidly in the environment and has low side effects on non-target species and beneficial insects. Seeds of the Neem tree contain the highest concentrations of Azadirachtin. Salanin inhabits the feeding of wider any of insect pests, Nimbin and Nimbidin showed antiviral effects (Ganguli, 2002).

2.3.7 Mode of action

Neem acts as insect feeding deterrent and growth regulator, the treated insects usually cannont molt to its next life stage and dies. Azadirachtin is chemically similar to ecdysone responsible for triggering molts. It also acts as repellent when applied to plant and dose not produce aquick knock down and kill (Schmutterer, 1990). Also Neem has some systemic acivity in plants, its most effectively growing immature stages and adults are not killed by the growth regulator properties of Azadirachtin, but mating and sexual communication may be disrupted which results in reduced fecundity (Schmutterer, 1990 and Pedigo, 1999).

2.3.8 Uses of Neem in pest and disease control

Neem is deemed very effective in the treatment of scabies althouth only preliminary scientific exists which still has to be corroborated and is

recommended for those who are sensitive to permethrin. Aknown insectide 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 arecdotal evidence of its effectiveness. In treating infestations of head lice in humans. It's also very good for trearting worms (soack the branches and leaves in warm water and drink it). The Neem twig is nature's tooth bruch 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 medicine use of plants seems to have been based on highly developed dowsing instinct (Schmutterer, 2002), Siddig (1993) reported that from Sudan that Neem seed water extract at 1kg/1litre of water repelled foliage pest of potato including *B. tabaci*, and *Aphis gossypii* and *J. lybica* and yield increased to 5 ton/ha. Mohamed (2002) reported that Neem seed showed good performance against *A. gossypii*, *B. tabaci* and *J. lybica* on Okra. Dawood (2001) reported that Neem water extracts at 1kg/1litre water reduced the number of onion thrips at 63.5% under the field condition.

CHAPTER THREE

3- MATERIALS ANDMETHODS

3.1 Study area

This work was carried out from April to May 2015 in Alliet Jar Elnabi locality in North Darfur state, Sudan, figure (1).Its geographical coordinates are 11° 57' 0". North and 27° 4' 0.012". East, covered area of about 4000 km^2, its located southeast of the capital city of North Darfur (El Fasher).It has a population of 104,000 residents with 38 village councils. The surrounding areas are Eltaweisha locality in the North, East Darfur State in the South/West and West Kordofan in the East direction. Thecity serves as an agricultural marketing point for cereals specially groundnuts and its products. Alliet is linked by the road with both El Fasher and Umm Kaddadah. The dominant cropping pattern in the area is traditional rainfed shifting cultivation. The main crops in the area are millet, sorghum, groundnut, watermelon and roselle grown within natural forest like Hashap tree (*Acacia Senegal*). The groundnut both shelled and unshelled used were the local variety found in the study area popularly known as ‘’Ghebish and Sudari’’and it was obtained locally from the farmers in the locality. The climate is typically of Semi-arid Savannah, with dry hot and long summer with rain period extending from June up to October, the minimum temperature is about 11^{o}c in winter while the temperature maximum is 42^{o}c in May to June. The relative humidity is about 12% and decreases down in October 6%. The rainfall annually is estimated to be about 500 to 600 mm/year. The soils are generally sandy loam or clay soils found in some areas.

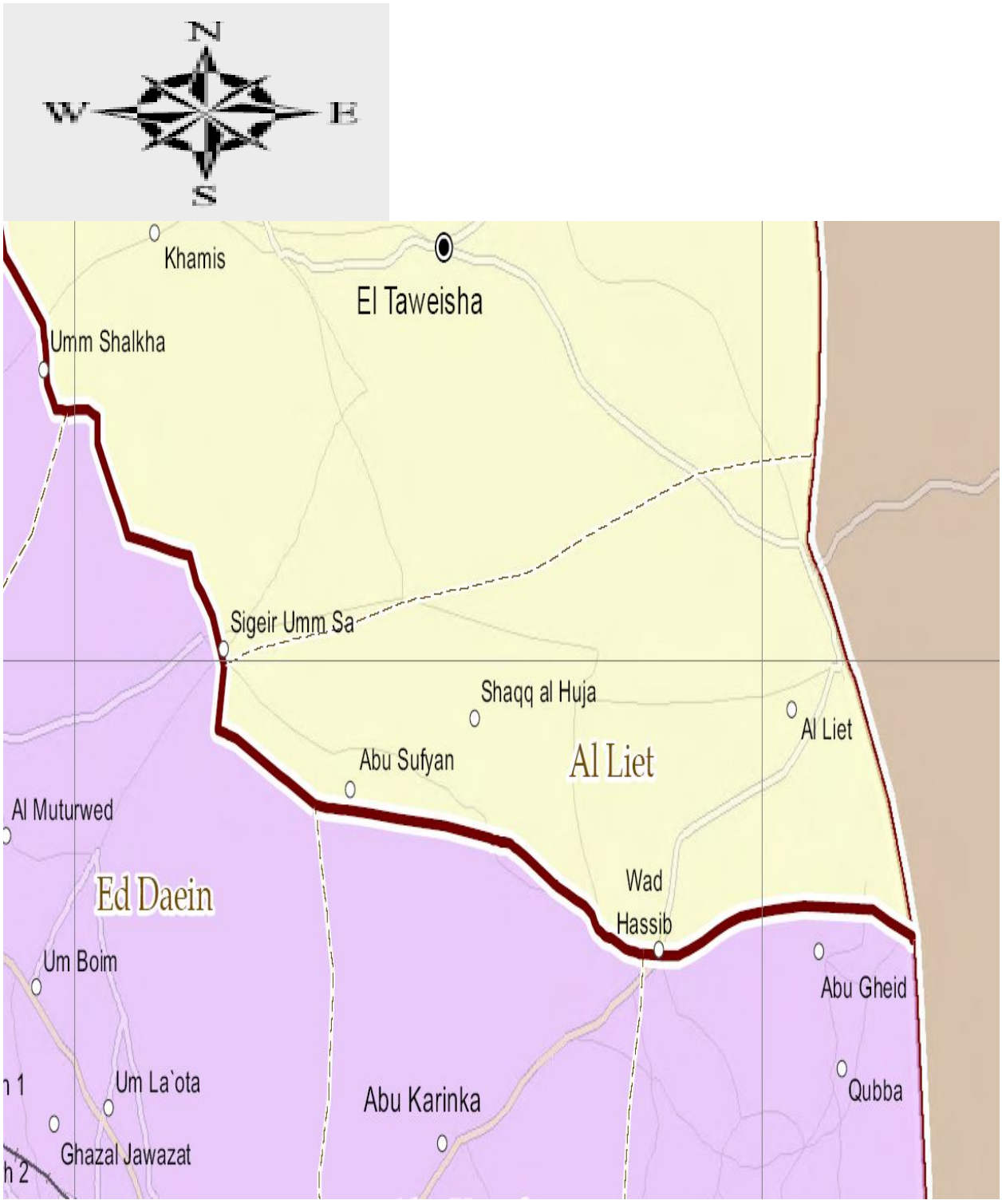

Figure 1. Administrative Map showing the location of the study area in North Darfur State

3.2 The store survey

The first survey was conducted in April, 2015, while the second in May, 2015, for determining the presence of insect pest or infection symptoms Five different areas were selected randomly.From each area one store was selected, then a sample of 250 gm of shelled groundnut was drawn randomly from four sacks in each store, and examined for damage symptoms and immature stages or adult presence.

3.3 Biology study of *C. serratus*

In order to deterimine the biology of the *C. serratus* a number of 10 insect were selected, drawn into 4 jars covered with mosquito net and tiet up with ruber and kept in the laboratory.The insects were supplied with shelled and unshelled groundnut for about two months and the following observations were recorded.

- Incubation period.
- Oviposition period.
- Larval period.
- Pupal period.
- Adult longevity.

3.4 Insect rearing:-

The experiments were carried out at El Fasher University Faculty, of Environmental Science and Natural Resources, during the period of April – June, 2015.The groundnut bruchid, *C. serratus* (Olivier), were collected from infested groundnuts (Shelled & Unshelled) obtained from Alliet Jar Elnabi locality during April and May, 2015.*C. serratus* were reared under room condition in the laboratory on shelled and unshelled groundnuts in jars (20 x 12 x 10 cm) lined with mosquito screen to provide the insect when needed.

The kernels containing the eggs deposited by the females were collected and transferred to clean jars (20 x 12 x 10 cm), and moisture was provided in a piece

of cotton. The jars were covered by muslin cloth and left in the laboratory until the eggs hatched.The hatched larvae were transferred to clean jars (20 x 12 x 10 cm) supplied with heat-treated groundnuts and rearing was continued until pupation and adult emergence. The adults emerged were transferred to clean jars, (20 x 12 x 10 cm) supplied with heat-treated kernels. Heating was done in an oven at 70°c to insure that the groundnuts are free from any infestation. The jars were covered with muslin cloth and kept until the female laid their eggs. In order to get a continuous supply of insects for experimentation, the culture was maintained releasing insects at regular intervals in different jars. To avoid any kind of contamination, care was taken not to handle the pods and insects with naked hands. During experimentation, forceps, camel hair brush and aspirator were used for transferring the insects.

3.5 Collection and Preparation of Neem Seed kernel Powder

Full mature fruits of neem tree *A. indica* were randomly collected from ground (under neem trees) from El Fasher area (plate 2). The fruits were soaked in water for 6 hours (plate 3) and washed by hand to remove the outer skin and the slimy tissue (plate 4). The seeds were shade dried for one week. The kernels inside the seeds were collected by breaking the seed coat and winnowing, and then powdered by mortaringin an electric grinder (plate 5), before that proper care was taken to clean the bowl of grinder before grinding the plant material. The powder was kept in the refrigerator for use in the experiment. The method was according to Siddig (1991).

3.6 Extraction of Neem Seed kernel

Sixity gm of neem seed powder were taken and weighted in a sensitive balance (plate 6), then 250 ml of absolute ethanolic 99.9% was used for extraction for 6 hours' time, the solution was evaporated (plate 8), to get the crude extraction.

Then was kept in glass bottle and stored in refrigerator until using it. Extraction method was done according to Ahmed (1995).

Plate 1. Neem tree

Plate 2. Collection of Neem fruits

Plate 3. Soak the fruits in water

Plate 4. Removing the outer skin of Neem fruits

Plate 5 Fruit powder

Plate 6. Sensitive balance

Plate 7. Neem seed ethanolic oil extraction

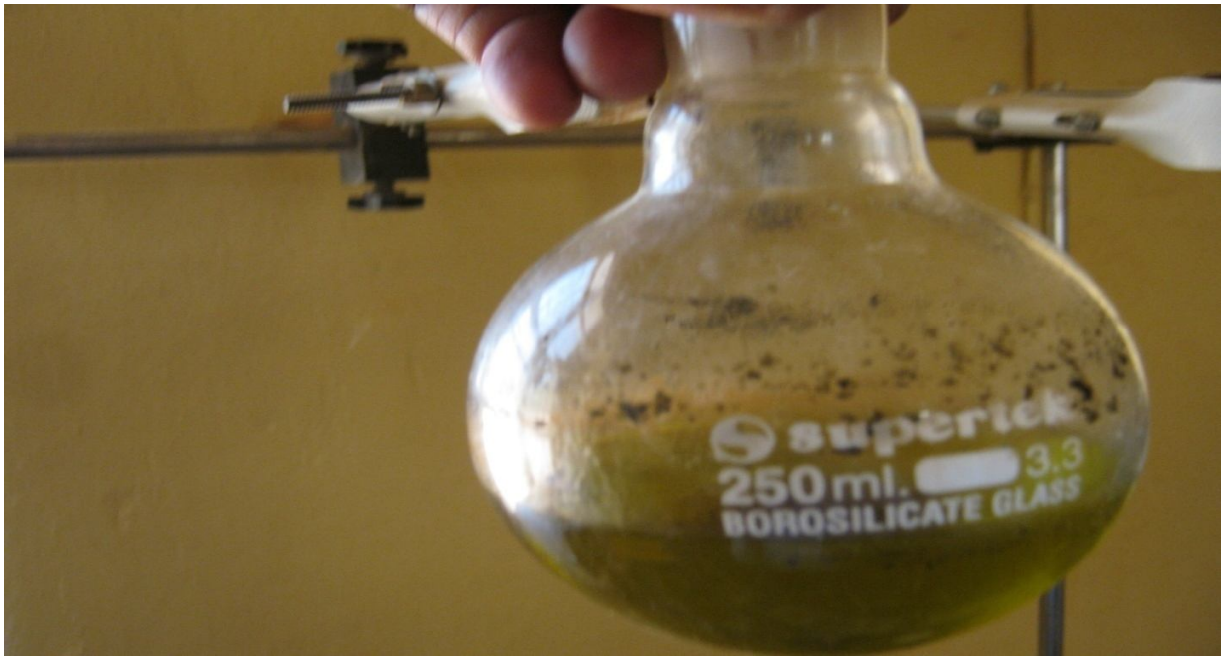

Plate 8. Finally extract after evaporation

3.7 Bioassay test

From the crude extract standard solution was prepared and then three different concentrations 5%, 2.5% and 1.5% were made for bioassay test.

3.7.1 Mortality test

Three concentrations 5%, 2.5% and 1.5% of Neem Seed ethanolic extract and control were used in this experiment. Each treatment consists of 10 adults and 10 larvae. Each treatment was replicated four times. 2ml of each concentration was placed in a petri dish which was lined with filter papers and groundnuts. The petri dishs were slowly rotated to gurantee even distribution of the solution; the insects were placed in the petridishes for 3 days. This method was used for both neem and Malathion. Proper care was taken not to handle pods and insects with naked hands to avoid any kind of contamination, untreated control treatment was considered. Percentage of adult and larvae mortality was recorded after 24, 48 and 72 hours consecutively. The actual percent of adults & larvae mortality was corrected for natural mortality using Abott (1925) formula.

$$\% \text{ corrected mortality} = \frac{\% \text{ treatment mortality} - \% \text{ control mortality} \times 100}{100 - \% \text{ control}}$$

3.7.2 Repellency test

Ten (10) newly emerged adults and 10 larvae of *C. serratus* were introduced separately in each a petri dish containing filter paper and groundnuts treated with doses of 5%, 2.5% and 1.5% of neem seed kernel ethanolic extract.Proper care was taken not to handle the pods and insects with naked hands to avoid any kind of contamination.Untreated control treatment was considered. Four replicates were used. A completely Randomized Design (CRD) was adopted. Percent of adult and larvae repellency was calculated after 24, 48 and 72 hours consecutively. A ccording to the method of Ogendo *et al*., (2004).

Repellency (%) was calculated according to the method that described by Talukder and Howse (1993) as follows;

PR = 2 x (C-50).

C is the precent of adults or larvae that settled on the treated groundnuts.

Trails showed a positive (+) PR values demonstrate repellency.

3.7.3 Statistical analysis

Data were recorded after 24, 48 and 72 hours after exposure. Mortality and Repellency data were subjected to ANOVA using MSTAT-C program and mean separation were made by Duncan's Multiple Range Test (DMRT). Results with $P \geq 0.05$ were considered to be statiscally significant.

Plate 9. The treatment Design

CHAPTER FOUR

4- RESULTS

4.1 The store survey

The first survey of the stores for *C.serratus* to determine the presence and infestation in the stores was carried out during April, 2015 revealed that, there is an infestation precence of exit holes, eggs, larvae and few adult emergences (plates 10- 13) While the second survey was conducted during May, 2015, revealed that there were precence of eggs, Larvae, pupae, adults and exit holes of *C. serratus* (plates 10 – 13).

Store (1) showed atotal of 6 larvae, 8 pupae, 4 adults and 11 exit holes.

Store (2) showed a total of 9 larvae, 12 pupae, 7 adults and 18 exit hols.

Store (3) showed a total of 11 larvae, 8 pupae, 6 adults and 14 exit holes.

Store (4) showed a total of 12 larvae, 7 pupae, 10 adults and 22 exit holes.Store (5) showed a total of 7 larvae, 11 pupae, 5 adults and 17 exit holes(table 1 and figure 2).

4.2 Biology of the groundnut seed beetle (*Caryedon serratus)*

The copulation takes place feivew hours after emergence, but usually occurs after 1-2 days. The pre-mating period is about five miniutes to hours. Normally the females start to oviposit soon after mating. The first eggs are usually laid within one to two days.The incubation period varies from 4 to 6 days, larval development is completed in 14 to 16 days, the pupal stage lasts for about 12.5 days and the life cycle is completed in about 45.5 to 49.5 days Table (2) Figure (3).

Plate 10 Eggs of groundnut seed beetle

Plate 11 Neonate larvae of groundnut seed beetle

Plate 12 Groundnut pupae

Plate 13 Exit holes caused by groundnut beetle larvae

Table 1. Number of larvae, pupae, adults and exit hoes of *Caryedon serratus* found in five different stores in Alliet Jar Elnabi in May, 2015.

Store No	Area	Larvae	Pupae	Adults	Exit holes
1	First store	6	8	4	11
2	Second store	9	12	7	18
3	Third store	11	8	6	14
4	Forth store	12	7	10	22
5	Fifth store	7	11	5	17
Total	Stores	45	46	32	82

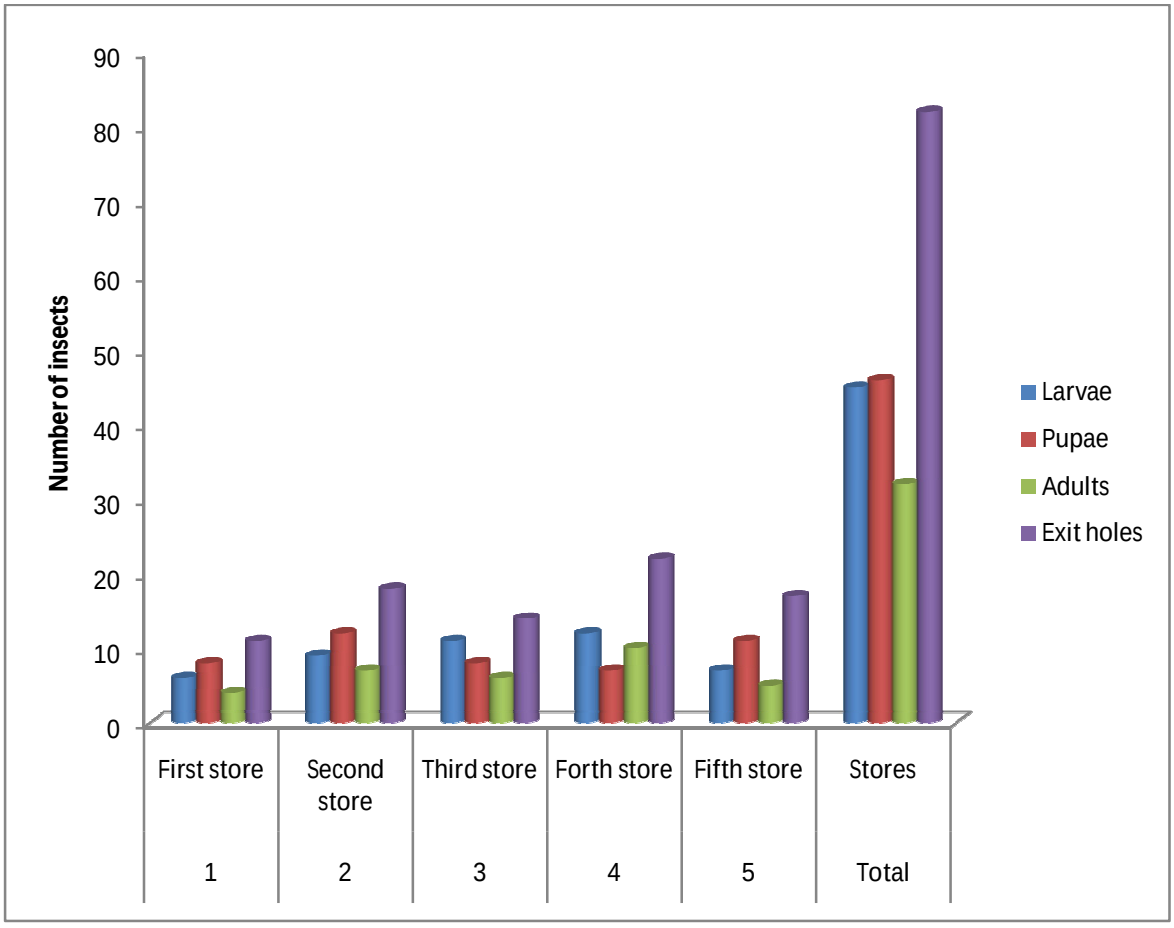

Figure 2. Number of larvae, pupae, adults and exit holes of *C. serratus* found in five different stores in Alliet Jar Elnabi in May, 2015

Tale 2. Developmental period of *C. serratus* from egg to the adult.

Developmental period (days)	Number of insects	Range (days)		Mean (days)	
		Females	Males	Females	Males
Incubation period	10	4-6	5-6	5	5.5
Oviposition period	10	3-6	-	4.5	-
Larval period	10	14-16	15-16	15	15.5
Pupal period	10	12-13	12-13	12.5	12.5
Adult longevity	10	10-11	11-13	10.5	12
Total life cycle	10	43-56	43-48	49.5	45.5

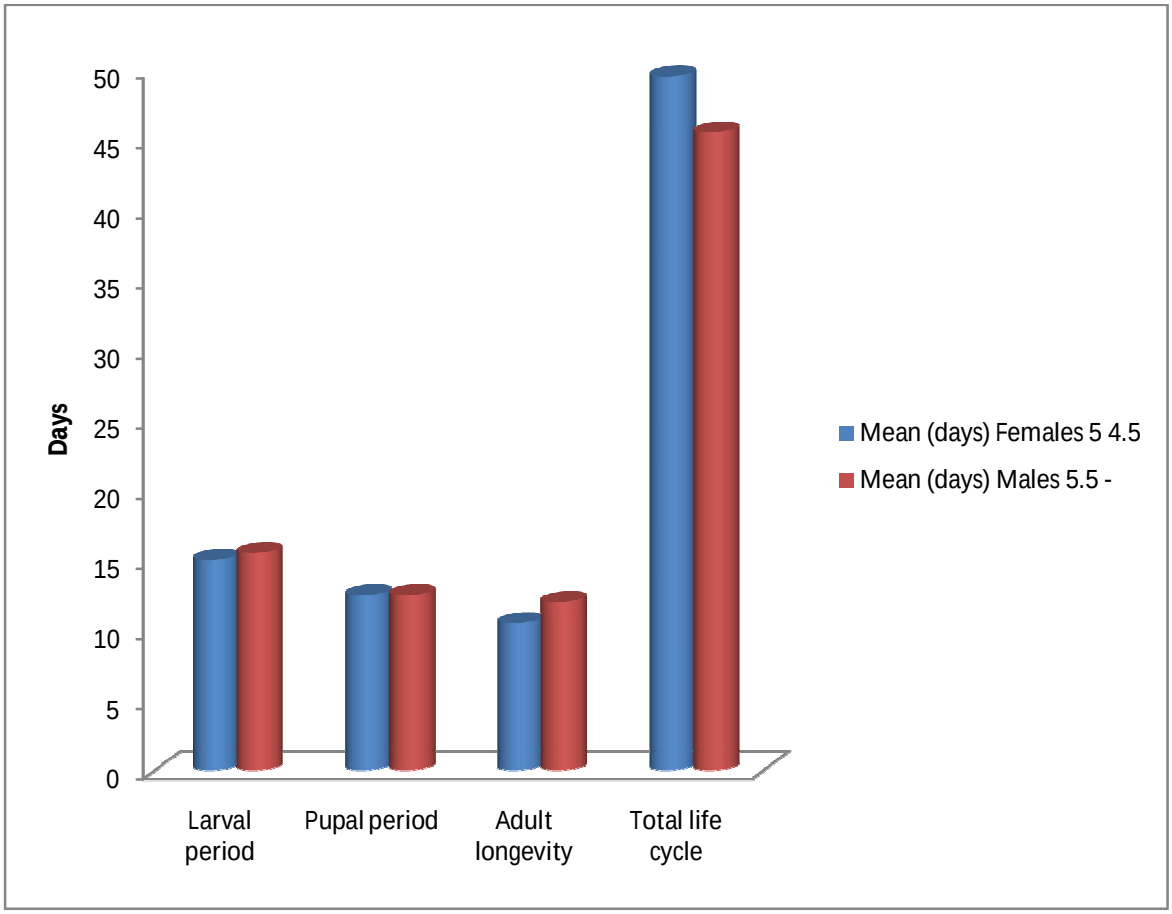

Figure 3. Development period of *Caryedon serratus* from egg to the adult

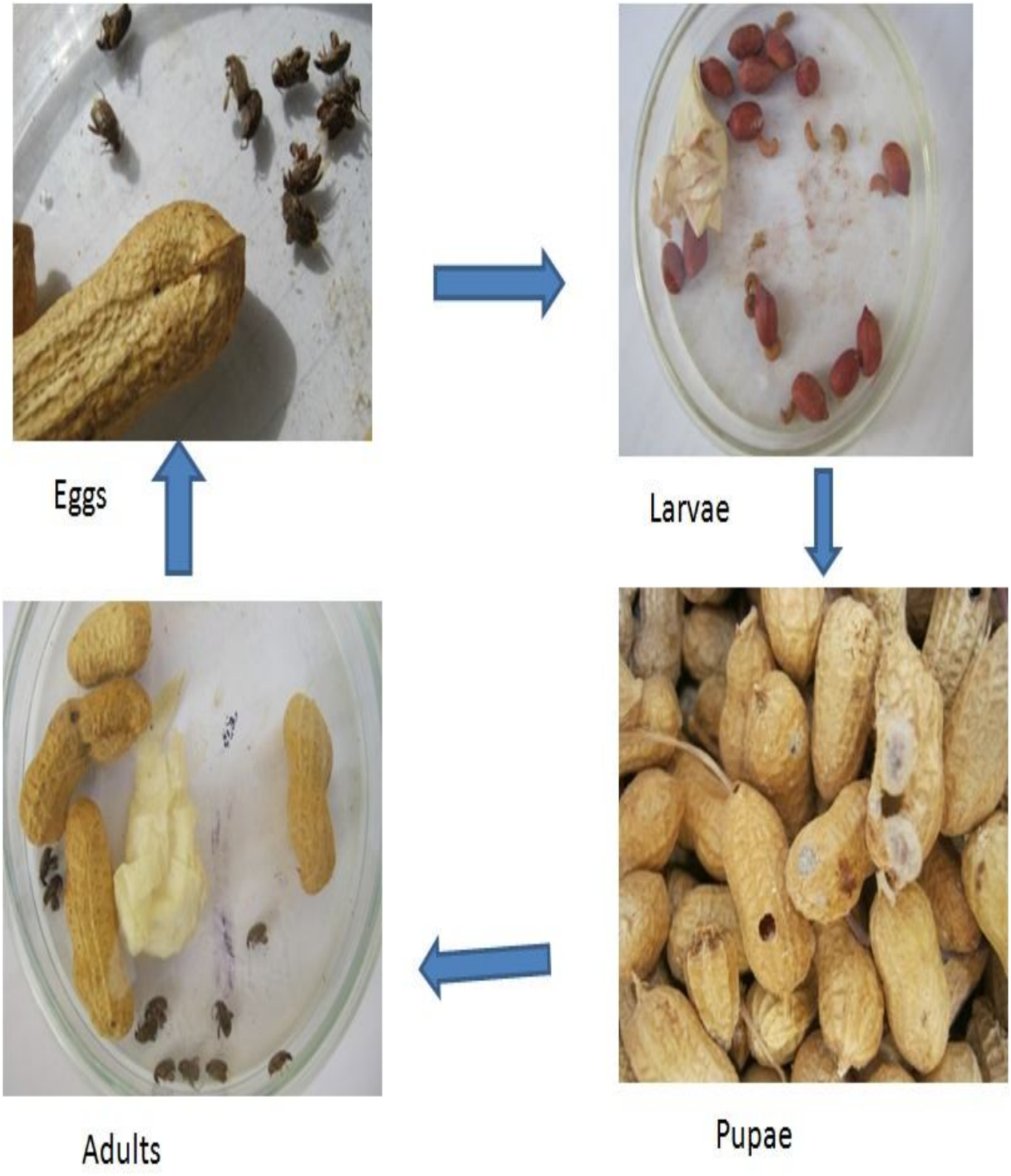

Plate 14. Life cycle of groundnut seed beetle

4.3 Mortality test

4.3.1 Adults mortality

The results exhibited in table (3) figure (4) showed that all tested concentrations of Neem seeds ethanolic extract gave significantly higher mortality percentages than the control after 24, 48 and 72 hrs of exposure. The data also showed that there was no significant difference in the mortality generated by the Malathion 57%EC and the highest concentration of Neem Seed ethanolic extract (5%) after 72 hrs of exposure. This result suggests that Neem seed ethanolic extract was effective against groundnut beetle. Also the mortality (%) increased by increasing of exposure period and concentrations.The Malathion 57%EC gave significantly higher mortality percentage than all tested concentrations immediately after 24hrs of the application.

4.3.2 Larvae mortality

As seen in table (4) and figure (5) all concentrations of Neem seeds ethanolic extracts gave higher mortality percentage of Larvae than the control after 24, 48 and 72 hrs of exposure. The data also showed that there was no significant difference in the mortality generated by the Malathaion 57%EC and the highest concentration of Neem seed kernel Ethanolic extract (5%) after 72 hrs of the treatment. While there were significant difference between Malathion and concentrations (2.5% and 1.5%) of Neen seed ethanolic extract after 24 and 48 hours of the exposure.

4.4. Repellency test

4.4.1 Adults repellency

Table (5) and figure (6) showed that all concentrations of Neem Seed ethanolic extracts gave significantly higher repellency effect (%) of

adult's percentages than that of the control after 24, 48 and 72 hrs of application. The result also showed that there was no significant difference in repellency (%) among the highest concentration 5% after 48 and 72 hrs and that one generated by Malathion 57% EC. The Malathion 57% EC gave significantly highest repellency (%) than lower tested concentrations (1.5% and 2.5%) after 24, 48 and 72 hrs of exposure.

4.4.2 Larvae repellency

Table (6) and figure (7) showed that all concentrations of Neem seeds ethanolic extract gave significantly higher repellency (%) of larvae than that obtained by the control after 24, 48 and 72 hrs of exposure. Moreover, the repellency percentage generated by the highest concentration (5%) after 48 & 72 hrs of application were not significantly different from the standard, however there was significant difference between all other concentrations and Malathion 57% EC after 24, 48 and 72 hrs of exposure.

4.3.1Table 3. Mortality (%) of Groundnut Seed beetles (Adults) treated with Neem seeds ethanolic extract.

Concentration (%)	Exposure time (hrs.)			
	24 hrs.	48 hrs.	72 hrs.	Mean
1.5	45 (6.7)c	57.5 (7.6)c	65 (8.1) d	55.8 (7.5)
2.5	52.5 (7.3) c	67.5 (8.3) b	72.5 (8.6) c	64.2 (8.1)
5	70 (8.4) b	77.5 (8.9)b	82.5 (9.3)ab	76.7 (8.9)
Malathion 57% EC.	100 (10.0) a	100 (10.0) a	100 (10.0) a	100 (10.0)
Control	0 (0.7) d	0 (0.7) d	0 (0.7) e	0 (0.7)
LSD	0.98	1.32	0.35	0.88
SE±	0.33	0.44	0.12	0.10
CV (%)	9.82	12.72	3.20	8.58

- Means followed by the same letter are not significantly different at ($P<0.05$).
- Data or means between the two brackets were transformed according to $\sqrt{x + 0.5}$.

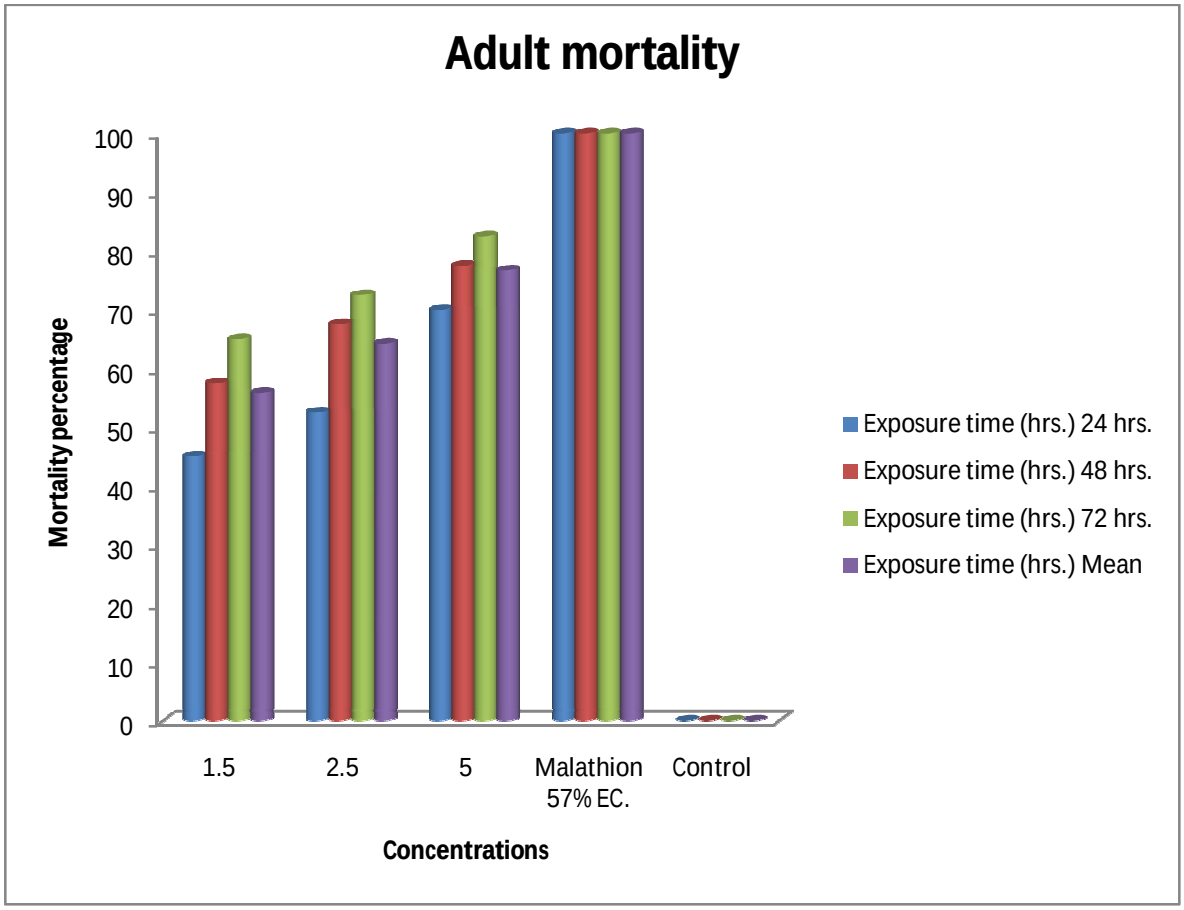

Figure. 4. Mortality (%) of Groundnut Seed beetles (Adults) treated with Neem seeds ethanolic extract.

4.3.2 Table 4. Mortality (%) of Groundnut seed beetle (larvae) treated with Neem seeds ethanolic extract.

Concentration (%)	Exposure time (hrs.)			
	24 hrs.	48 hrs.	72 hrs.	Mean
1.5	60 (7.8) c	72.5 (8.6) c	77.5 (8.9) c	70 (8.4)
2.5	67.5 (8.3) c	80 (9.0) b	87.5 (9.4) b	78.3 (8.9)
5	80 (9.0) b	87.5 (9.4) b	90 (9.5) ab	85.8 (9.3)
Malathion 57% EC.	100 (10.0) a	100 (10.0) a	100 (10.0) a	100 (10.0)
Control	0 (0.7) d	0 (0.7) d	0 (0.7) d	0 (0.7)
LSD	0.61	0.40	0.27	0.43
SE±	0.20	0.13	0.09	0.14
CV (%)	5.65	3.54	2.27	3.82

- Means followed by the same letter are not significantly different at ($P<0.05$).
- Data or means between the two brackets were transformed according to $\sqrt{x + 0.5}$.

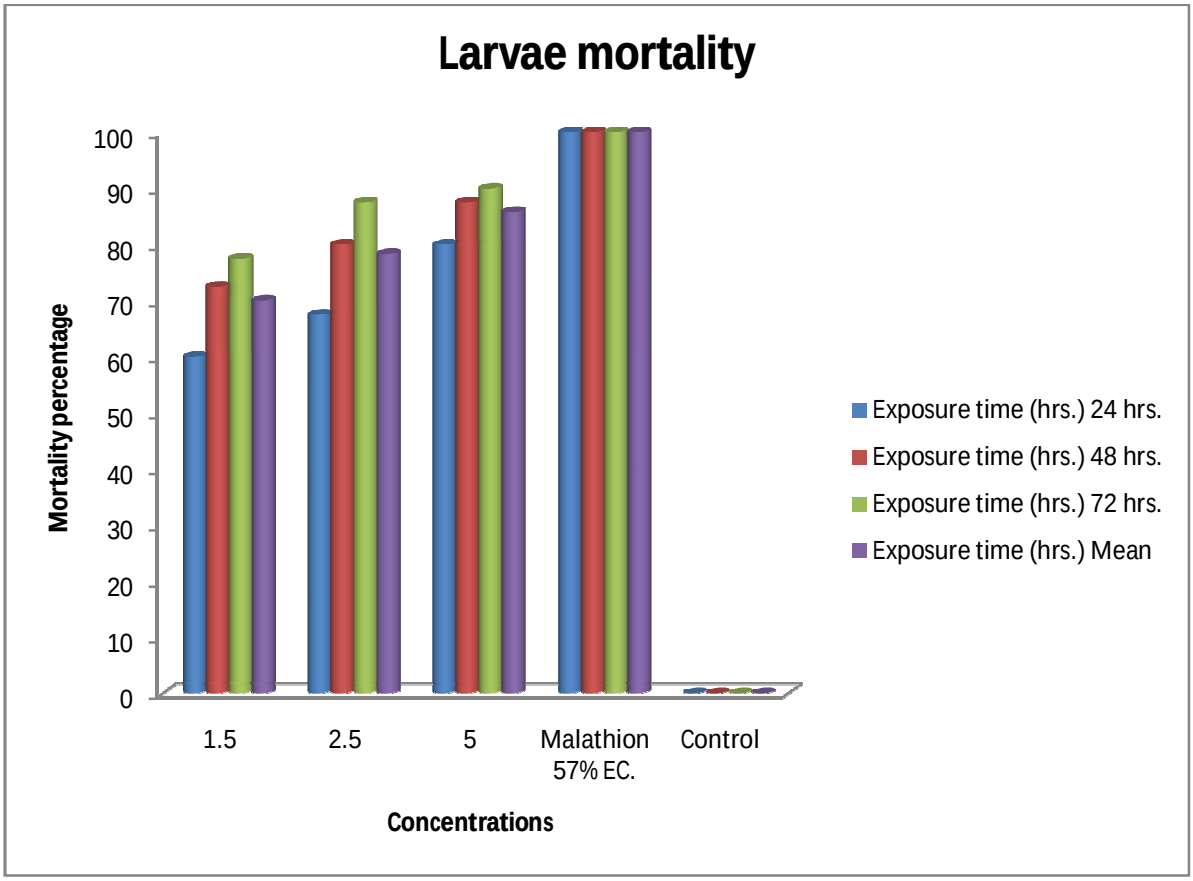

Figure. 5. Mortality (%) of Groundnut seed beetle (larvae) treated with Neem seeds ethanolic extract

4.4.1 Table 5. Repellency (%) of groundnut seed beetle (Adult) treated with Neem seeds ethanolic extract.

Concentration (%)	Exposure time (hrs.)			
	24 hrs.	48 hrs.	72 hrs.	Mean
1.5	65 (8.1) d	75 (8.7) d	77.5 (8.9) c	72.5 (8.6)
2.5	75 (8.7) c	82.5 (9.1) c	85 (9.3) b	80.8 (9.0)
5	80 (9.0) b	90 (9.5)ab	90 (9.5)ab	86.7 (9.3)
Malathion 57% EC.	100 (10.0) a	100 (10.0) a	100 (10.0) a	100 (10.0)
Control	0 (0.7) e	0 (0.7) e	0 (0.7) d	0 (0.7)
LSD	0.38	0.29	0.28	0.32
SE±	0.13	0.10	0.09	0.11
CV (%)	3.46	2.51	2.43	2.8

- Means followed by the same letter are not significantly different at ($P<0.05$).
- Data or means between the two brackets were transformed according to $\sqrt{x + 0.5}$.

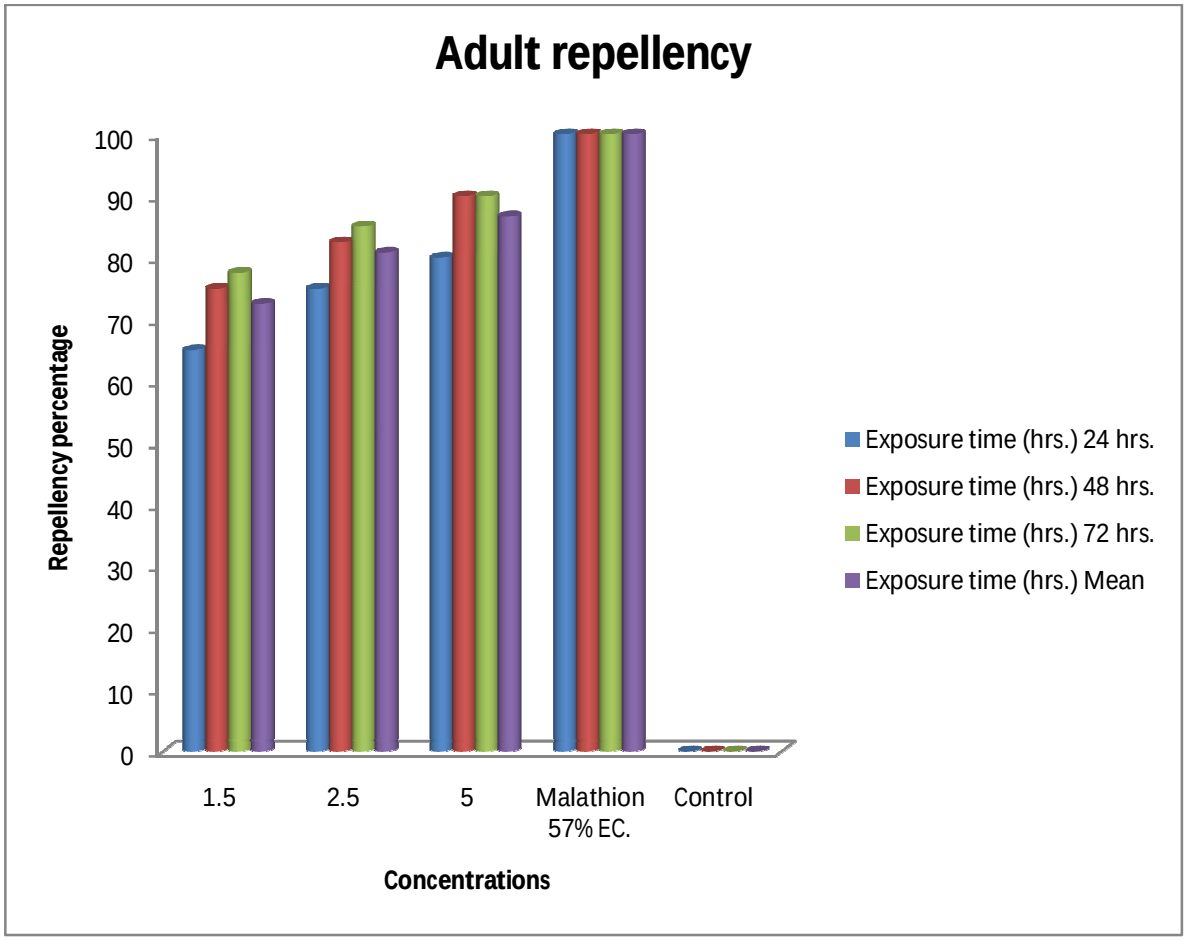

Figure. 6. Repellency (%) of groundnut seed beetle (Adult) treated with Neem seeds ethanolic extract

4.4.2 Table 6. Repellency (%) of groundnut seed beetle (larvae) treated with Neem seeds ethanolic extract.

Concentration (%)	Exposure time (hrs.)			
	24 hrs.	48 hrs.	72 hrs.	Mean
1.5	55 (7.4) c	67.5 (8.3) d	72.5 (8.6) d	65 (8.1)
2.5	70 (8.4) b	77.5 (8.9) c	85 (9.3) c	77.5 (8.9)
5	82.5 (9.1) b	87.5 (9.4)ab	90 (9.5)ab	86.7 (9.3)
Malathion 57% EC.	100 (10.0) a	100 (10.0) a	100 (10.0) a	100 (10.0)
Control	0 (0.7) d	0 (0.7) e	0 (0.7) e	0 (0.7)
LSD	0.76	0.33	0.28	0.46
SE±	0.25	0.11	0.09	0.15
CV (%)	7.05	2.96	2.45	4.15

- Means followed by the same letter are not significantly different at ($P<0.05$).
- Data or means between the two brackets were transformed according to $\sqrt{x + 0.5}$.

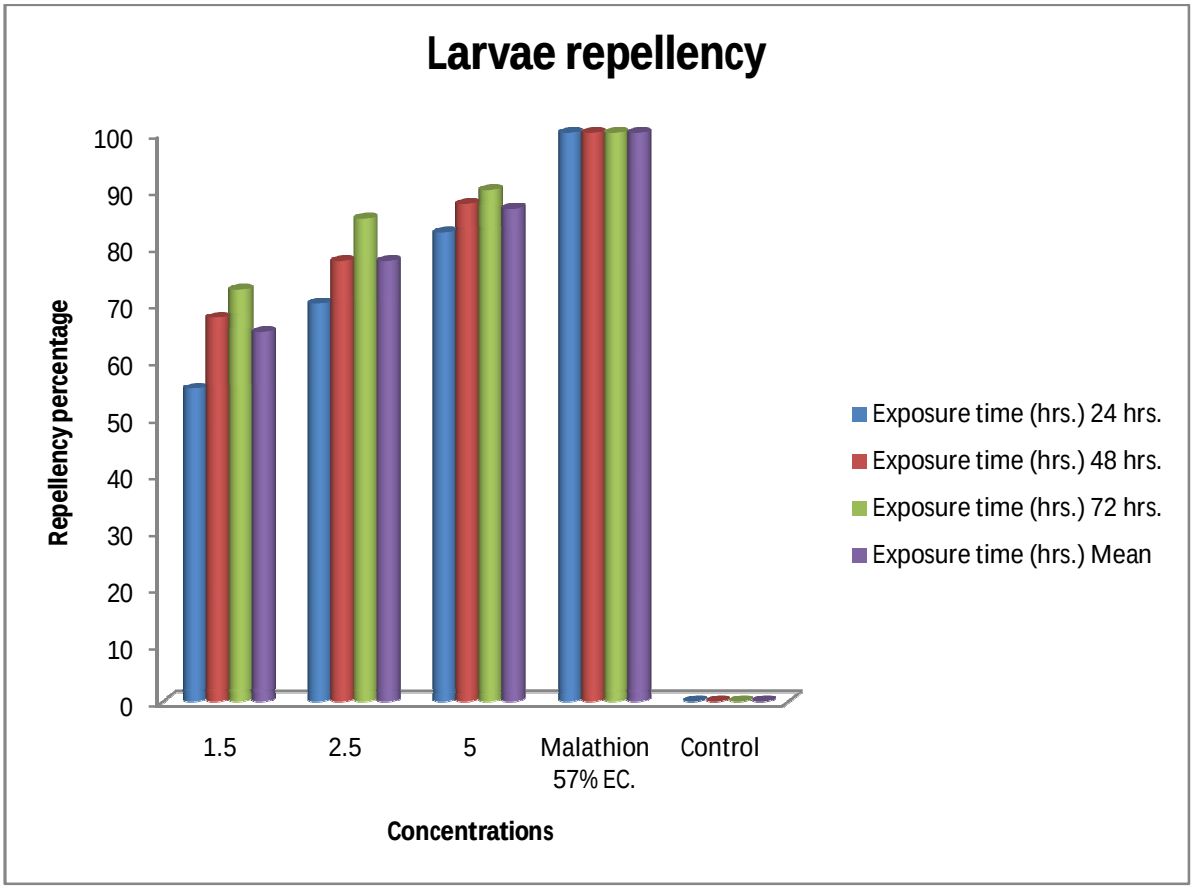

Figure. 7. Repellency (%) of groundnut seed beetle (larvae) treated with Neem seeds ethanolic extract

CHAPTER FIVE

DISCUSSION

Cayedon serratus is a serious pest of stored groundnuts (*Arachis hypogaea* L.), in some parts of the world. It causes heavy damage and losses in the stores in North Darfur especially Alliet Jar Elnabi locality. The survey revealed that there was an infestation in the stores and become severe with time.*C. serratus* occurrence in the store was very much common, especially during summer period, there were exit holes, eggs and other stages were observed during the first and second survey. The present result agreed with those of Southgate (1979), Singal and Toki (1990), whom reported that some bruchids occur at very low level in the field, but multiplies during storage and may cause 80% damage within 6-8 months.

The first and second survey revealed the presence of *C. serratus*, it seems that higher infestation took place in stores found in Alliet locality table (1) showed the number of larvae 45, pupae 46, adults 32 and exit holes 82 taken from five different areas. This result agreed with Davey *et al*., (1959) reported that 151 and 288 adult's emeged from two samples of groundnut of 100 gm after 12 – 13 weeks of infestation.

The highest concentration of Neem seed ethanolic extract used in the study was (5%) induced high mortality 82.5%, 90% on adults and larvae respectively. Neem seed ethanolic extract was highly effective and induced repellency 90% against adult and larvae. Also showed that the Neem seed ethanolic extract contains active compounds which are capable of controlling groundnut Seed-beetle. These results agreed with

Ivbijaro (1983) who reported that when Cowpea seeds were treated with Neem seeds powder, such seeds carried viable eggs of *C. maculates*, but no adults have emerged and only dead larvae were found inside them when softened and dissected. This result also agreed with Ahmed (1995) who stated that Neem seed oil exhibited toxicity against the larvae of *C.serratus*. Also the result agreed with Adam (2011), Elhaj (2011) and Abrahim and Abdifatah (2013), who reported that Neem & Jatropha seeds and leaves contain active compounds which can be used as alternative insecticides for controlling insect pest. Also agreed with Raja (2006) who reported that Neem Oil at doses of (1.5, 2.5 and 5%/50 gram) exhibited very good ovicidal effect against *Caryedon serratus* and caused mortality ranged from 78.8% to 100%.

These clearly demonstrate that the Neem seed kernel ethanolic extract is very effective against the *Caryedon serratus* groundnut seed beetle Adult and Larvae stages.

CONCLUSION

Caryedon serratus is a serious pest of groundnut (*Arachis hypogaea*) in some parts of the world. It causes heavy losses in stored groundnut in North Darfur State specially Alliet Jar Elnabi locality.

In this study the survey covered five different stories and the result indicated that there was infestation in all surveyed stores and become severe with time.

The result of this study revealed that Neem seed ethanolic extracts was exhibited highly mortality (%) and repellency against adult and larvae of groundnut seed beetle.

From above mentioned results we recommended that Neem seeds ethanolic extract could be used as alternative compound for controlling groundnut seed beetle in the future.

Recommendations:

- The Neem Seed Kernerl ethanolic extract was effective for control of groundnut seed beetle and it can be serve as biocontrol agent against this pest in production areas in Sudan.
- Farmers should be encouraged to use the local plants which have an insecticidal effect against pests.
- Further research on plant product and its formulations and other bio agents against pests.
- Farmers should be advised to clean and spraying their stores before the storage.
- In harvest all seeds must be kept in clean or new sacks.
- Farmers and persons who worked in the field of groundnut production should be well trained in pest control.

REFERENCES

Abdalla, S.M. (1986). Studies on *C. serratus* (Olivier) (Coleoptera; Bruchidae). A pest of stored groundnts in Sudan. M.Sc. Thesis U of K Fac of Agric. pp. 40 – 47.

Abott, W.S. (1925). Method of computing the effectiveness of insecticides.J.Ecol.Entomol.18:267-273.

Abdifatah, I.A. (2013). Effect of Neem Jatropha Seeds Ethanolic extracts on mortality of Asian Fruit Fly (*Bactrocera invadens*) new Tsrust and White (Diptera: Tephritidae). Athesis submitted in partial fifullment of the requirement for the M.Sc. Degree in Plant Protection. Faculty of Agricultural Studies, University of Sudan Science and Technologhy.

Abrahim.A.A. (2013). Biology and Control of Mediterranean fruit flies *Ceratitis capitata* (Diptera: Tephritidae) on Guava in North Kartoum State. M.Sc. Thesis, Faculty of Agriculture, Department of Plant Protection, Sudan University of Science and Technology.

Adam, A.I. (2011). The Effect of Neem (*Azadirachta indica* A.Juss). Seeds Aqueous Extracts on the Mango Fruit Fly (*Bactrocera invadens*) (Tephritidae: Diptera). B.Sc. Thesis, Faculty of Agriculture, Department of of Plant Protection, Sudan University of Science and Technology.

Ahmed. E.E. (1995). The effect of some Bruchid Seed borers on the viability of seeds of *Acacia nilotica, Prosopis chilensis* and their control. M.Sc. Thesis Univ of Khartoum- Faculty of Forestry. pp168-170.

Allison, A.H. (1981). Agronomic recommendations and procedures. Peanut production guide for Virginia. MA. 197. VPI and SU, pp 3-8.

Arora GL and Singal, S.K. (1978). *Oryza sativa* Linn. (Paddy) as a new host plant record of *Caryedon serratus* (Olivier) (Coleoptera: Bruchidae) fron India. Indian J. Ent. 40(1):86.

Augstburger, F.; Berger, J.; Censkowsky, U., Heid, ., Milz, J., and Streit, C. (2002).*Organic Farming in the Tropica and Subtropics: Peanuts*, Grafelfing, Germany: Naturland e.v.

Beghnin, J. and Sewdah, M. (2003). The impact of Groundnut Trade Liberilization. Tin Hill Publishing Company Limited, India. pp. 241-242.

Biswas K; Chattopadhyay I, Banerjee RK and Bandopadhyay U. (2002). Biological activities and Medicinal properties of NEEM (*Azdirachta indica*). Current Sci 82(11): 1336-1345.

Bowers, W.S. (1983). The search of fourth generation pesticides, Natural Products for Innovative Pest Management (Current Themes in Tropical Science; V.2). 1st edition Programme Press Ltd 47-58.

Calderon, M, Donahye, E and Navarro, S. (1966) The life cycle of groundnut seed beetle *C. serratus* (OL) in Israel. J-Agric. Research. 17: 145-148.

Cancella da Fonseca, J.P. (1964). Oviposition and length of adult life in *Caryedon gonagra* (F) (Coleoptera, Bruchidae.). Bull. Ent. Res. 55: 97 – 707.

Casida, J.E. (1983) Development of synthetic insecticides from natural products; case history of Innovative Pest Management (Current Themes in Tropical Science; V.2). 1ST.ed. Programme Press Ltd.

Corby, H.D.C. (1941) Aphanns (Hemi-lygaeidae) in stored groundnuts-Bull. Eont. Res. 37: 609 – 617.

Cunningham, D.C and Wallsh, K.B. (2002)- Establishment of the peanut bruchid (*Caryedon serratus*) in Australia and two new host species, *Cassia brewsteri* and *C. tomentella*, - *Australian Journal of experimental Agriculture*, 42: 57—63.

Davey, P.M (1958). The groundnut bruchid *Caryedon serratus* (F) Bull.Ent. Res.49:385-404.

Davey, P.M.; Hall, D.W.; Conveny, D.L.C.; Raymonds, W.D. and Squires, J.A. (1959). The effect of insect infestation on the quality of decorticated groundnuts with

special reference to storage at high and low humidities. Tropical Science. 1: 296 – 307.

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 Khartoum, Department of Plant Protection, Sudan.

Dayal, Davi; Basu, M.S., and Reddy, P.S. (1987). Weel control in groundnut. Page 16 in Technologies for better crops. Technical Bulletin no. 32. New Delhi: Indian Council of Agricultural Research.

De Jangh d'Ardoye, E. (1935). Note surla Bruche de L' arachide Pachymoerus acaciae (Gill). Bull. Ann. Soc. Ent. Belg. 75:421-422.

De Waal, A. (2005).Famine that Kills: Darfur, Sudan. Revised Edition. Oxford University Press: New York.

Delobel A. (1989). Effect of groundnut pods (*Arachis hypogaea*) and imaginal feeding on oogenesis, mating and oviposition in the seed beetle, *Caryedon serratus* (OI.). Entomol. Exp. Appl., 52 (3): 281-289.

Dharmalingam, C., and Ramakarishna, V. (1981). Studies on the relative performance of seed size in peanut (Arachis hypogaea L.) CV Pol.2. Seed Research 9(1): 57-66.

Diaollo, A. and Huignard, J. (1993). Oviposition of four strains of *Caryedon serratus* (Olivier). (Coleoptera: Bruchidae) in the presence of pods or seeds of their wild and cultivated host plants. Journal Africa Zoology, 107 (2), 113 – 120.

Dick K.M. (1987) Losses caused by insects to groundnuts stored in a warehouse in India. Trop. Sci., 27: 65-75.

Drame, S.L. (1997). The neem tree. Arid lands information Network.

Dreyer, M. (1984). Effect of agueous neem extracts and neem oil on the main pest of cucurbita pepo in Togo. Proc. 2nd . Int. Neem Conf., Rauischholzausen, 435-444.

El Atta, H.A. (1993).The effect of *C. serratus* (Olivier) (Coleoptera: Bruchidae, on viability and germination of seed of *Acacia nililotica* (L) wild ex. Del) in the Sudan-Forest Ecology and management. 57: 169 – 177.

Elhaj, W.E. (2011). The Effect of Jatropha (*Jatropha curcas* L.) Seeds and Leaves ethanolic extracts against the African melon ladybird (*Henosepilachna elaterii*), B.Sc. Thesis. Faculty of Agriculture, Department of Plant Protection Sudan University of Science and Technology.

Fageer, T.M.O. (1999). Evaluation of usage various plant products on broad bean beetle Bruchidiae in cernatus. (Boh) Baruchidae; Coleoptera) M.Sc. Thesis Fac of Agric. Univ of Khartoum. Sudan, 98pp.

Feakin, S.D. (1973). Pest Control in groundnuts. PANS Manual No. 2, 3rd Ed. Overseas Development Adminitrations, London: Centre for Overseas Pest Research.

Fletcher, T.B. (1914). Some South Indian Insects and Other Animals of Importance Considered Especially from an Economic Point of View. Madras: Government Press. 565 pp.

Ganguli, S. (2002). "Neem A Therapeutic for all seasons" Current Science; - 82 (11), June, pp- 1304 (AL JAZEERA. Report on neem treatment in Senegal).

Ghanekar AM, Ranga Rao, G.V; Murthy, K.S; Surender, A, and Shaik, Babu Saheb. (1996). Seed protectant for healthy exports. Indian Journal of Plant Protection 24: 37-43.

Golob, P. and Webley, D.J. (1980). The use of plants and minerals as traditional protectents of stored produce. Trop. Prod Inst., 138:32pp.

Green, M.B., Harley, G.S. and West, T.F., (1979) Chemical for Crop Protection and Pest Control. Pergamon Press, Oxford.

Green, A. A. (1959). The control of insects infesting groundnuts after harvest in Gambia. Study of groundnuts borer *C. serratus* (F) under field condition. Trop Sci.1:200-205.

Hall, D.W. (1954). The quality of the groundnuts from Gambia with special reference to insect infestation. Colon. PI. Animal Production, 4:227 – 235.

Handbook of the Bruchidae of the United States and Canada Kingsolver J.M. (2004). USDA, Technical Bulletin 1912 (2 vols.).

Henning, Ronald, J; Allison, A.H; and Trip, L.D. (1982). Cultural Practices. Pages 123 – 138 in Peanut Science and Technology (Pattee, H.E., and Young, T., eds). Yoakum, Texas, USA: American Peanut Research and Education Society.

Higgins, B. (1951). Origin and early history of the peanut' in The Peanut, Washington, D.C: National Fertilizer Association.

Howe, R.W., (1952). Entomological Problems of Food Storage in Northern Nigeria. Bull of Entomol. Res., 43: 111 – 114.

Ivbijaro, M.F. (1983) Toxicity of neem seed, *Azadirachta indica* A. Juss., to *Sitophilus oryzae* (L) in stored maize. *Prot*. Ecol. 5: 353-357.

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

Jilani, G. (1983). Laboratory studies on several plant materials as insect repellents for plant protection of cereal grains, J. econ. Ent, 76: 154-157.

Jotwani, M.G. and Srivastava, K.P. (1981). Neem-insecticide of the future. I-As protectant against stored grain pests. Pesticides 15: 19-23.

Khalil. A.R. (1970). Pests of Stored Products in Sudan. Report No. PPD/G Agric/50 pp.27.

Kingsolver, J.M. (2004). Insects not known to occur in the continental United States. Groundnut bruchid, *Caryedon serratus* (OI.). US, Crop Deptt. AGR. Coop Econ. Ins. Rpt., 20 (18): 803 – 804.

Lale, N.E., and Igwebuike, J.U.(2002). Field infestation of *Faidherbia* (*Acacia*) *albida* (Del.) A. Chew. Pods by stored products Coleoptera in the Nigeria savanna and effect of infestation on nutrient quality. *Journal of arid Environment*, 51: 103 – 112.

Makie, F.R. (1946). Ntes on biology of the groundnut Bruchid, *C. serratus*, Goze.B.Sc. Thesis, Univ Glasgow.

Mamta, L.; Ganesh, P.; Om, P.; Sudha, K.; Kanaujiaa, K. R. and Prasuna, A. L. (2010). Ovipostion Deterrence by Egg Extract of *Caryedon serratus* (Olivier). Journal of Biopesticides 3(1 Special Issue): 400-404.

Mittal, V.P. And Khanna, S.S. (1974). A note on tamarind bruchid, *Caryedon gonagra* (Fabricius) (Bruchidae: Coleoptera) a serious pest of stored tamarind (*Tamarindus indica*. L.) and other leguminous seeds of economic importance. Agra University J. Research 16:99-101.

Mohamed, E.S. (2002). Towards an Integrated Pest Management (IPM) Programme on okra, *Aldeoschus esculentus* L. (Malvaceae) Ph.D. Degree, Thesis, Faculty of Agricalture, University of Khartoum Department of Plant Protection, Sudan.

Morton, J. (2005).''A Darfur Compendium. A Review of Geographical, Histirical and Economic Background to Developmen in the Rehion. '' First published 1985 (re-ssued 2005). HTSPE, Hemel Hempstead, UK.

Mucunguzi, P. (1995). Bruchids and survival of Acacia seeds. – African *Journal of Ecology*, 33: 175 – 183.

Musa, A.K., Dike, M.C. and Onu, I. (2009). Evaluation of Nitta (*Hyptis suaveolens* Poit.) Seed and Leaf Extract and Seed Powder for the Control of *Trogoderma granarium* Everts (*Coleoptera: Dermestidae*) in Stored Groundnut. American-Eurasian Journal of Agronomy, 2(3): 176-179.

Nageswar Rao, R.C.; Sardar Singh, Sivakumar, M.V.K., and Sarivastava, K.L., and Williams, J.H. (1985). Effect of Water deficit at different growth phases of peanut I. Yield responses. Agronomy Journal 77:782-786.

Nageswar Rao, R.C., Williams, J.H., Sivakumar, M.V.K., and Wadia, K.D.R. (1988). Effect of water deficit at different growth phases of peanut II. Responses. Agronomy Journal, 80: 431-438.

Nandagopal V and Prasad TV. (2004). Management of *Caryedon serratus* (Bruchidae: Coleoptera), a major storage insect pest of groundnut. Pages 417 – 426 in Groundnut Research in India (Basu MS and Singh NB, eds.).

Nautiyal, P. (2002). Groundnut: Post –harvest Operations, New Delhi, India: ICAR-National Research Centre for Groundnut.

Nongonierma, A. (1978). Contribution a I'etude biosystematique du genre Acacia Miller (Mimosaceae) en Afrique occidentale. These Doctorate e's- Sciences Univ. Dakar, 4 vol.

Norman, M.J; Person, C.J and searle, P.G (1996). Tropical Food Crops in their environment. Australian National University. Cambridge University. Press pp. 193-207.

Oaya, C.S., Malgwi, A.M. and Samaila, A.E. (2013). Insecticiadal Effecacy of Africa Rock Fig Leaf Powder (*Fiscus congensis* Engl.) Against the Groundnut Bruchid (*Caryedon serratus* Olivier) on Stored Groundnut in Yola. Journal of Agriculture and Veterinary Science, volume 2, issue 1, Pp. 24-27.

Okito, P. (2009). Peanut Assessment Value China, Washington, D.C: CNFA.

Orr, E. (1972). The Use of Protein-Rich Foods for the relief of Malnutrition in developing countries: An Analysis of Experience. G73, Trop. Prod. Inst., London.

Pattee, H. and Young, C. (1982). Peanut Science and Technology, Yoakum, Texas: American Peanut Research and Education Society.

Peake, F.G.G (1952). On abruchid seed borer of Acacia Bull of Ent. *es*. 34: 317 – 324.

Pedigo, L.P (1999) Entomology and Pest Management: Prentice Hall. New Jersey 742 pp.

Prevett, P.F. (1954). Studies on the fecundity and longevity groundnut bruchid *Caryedon fascus*, (Goeze) and the extend morphology of the immature Stages B.Sc. Thesis Univ of London.

Putnam, D., Oplinger, E., Teynor, T., Oelke, E., Kelling, K., & Doll, J. (1991) 'Peanut' in *Alternative Crops Manual*, St. Paul, Minnesota: University of Minnesota

Raja, A.A.A. (2006). Studies on the Biology and Control of Groundnut borer *C. serratus* (Olivier), A thesis submitted in partial fulfillment of the degree of M.Sc. Faculty of Agricultural studies, University of Sudan, Department of Plant Protection.

Ranga Rao, G.V and Wightman, J.A. (1999). Status of the integrated management of groundnut pests in India. Pages 435-459 in IPM systems in agriculture (Upadhyay Rajeev K, Mukherji KG and Rajak RL, eds.). New Delhi, India: Aditya Books Pvt. Ltd.

Rao, G., Rao, V., and Nigam, S. (2010). Post-harvest Insect Pests of Groundnut and their Management, Information Bulletin No. 84, Andhra Pradesh, India: International Crops Research Institute for Semi-Arid Tropics.

Saad, A. (1978). Pests of stored grains in the Sudan. Crop pest management in the Sudan, Proceeding of symposium on integrated pest management Khrtoum, p: 27 – 30.

Sagot, R. and Boufill, F. (1935).Eaudes Surata bruche de L' arachnid (Pachymoerus acaciae). Bull. Com.A.O.F., 18: 79 – 91.

Sahrawat, K.L.; Srinivas Rao, B., and Namblar, P.T.C. (1988). Macro and micronutrients uptake by nodulating and non-nodulating peanut lines. Plant and soil 109 : 291 – 293.

Salih, S.H.; Ageeb, O.A.; Saxena, M.C.; and Solh, M.B. (1995). Poduction and improvement of cool-season food legumes in the Sudan. Proceedings of the national research review workshop. Agric.Res. Crop, Wad Medani, Sudan, 250 pp.

Savage, G. P. and Keenan, J. I. (1994). The composition and nutritive Value of Groundnut Kernels, In: The Groundnut Crop: Scientific Basis for Improvement (Chapman and Hall, Smart) J. ed.) London. pp. 173-193.

Schilling, R. (1996). Groundnut- The Tropical Agriculturalist pp 1-21.

Schmutterer, H. (1990). Properties and Potencial Natural Pesticide from neem tree, *Azadirachta indica* Annual reviewing Entomolo. 35: 2797.

Schmutterer, H. (1995). Which insect pest can be controlled by application of neem seed kernel extract under field conditions Z. Angew. Entomol. 100: 468-475.

Schmutterer, H. (ed) (1995). The neem tree *Azadirachta indica* A. Juss and other meliaceous plants: Source of unique natural products for integrated pest management, medicine, industry and other purposes. VCH, Weinheim, Germany, 696p.

Schumutterer, H; Ascher, K.R.S; Isman, M.B.; Jacobson, M.; Ketkan C.M.; Kraus, W.; Rembold, H.; and Saxena, R.C. (1995). The neem tree (*Azadirachta indica* Juss) and other meliaceous plants. Tokyo, 2-10.

Schuutterer, H. (Editor) (2002). The Neem tree: source of Unique natural product for Integrated Pest Management mediaine, industry and other purpose. (Hard over). 2nd Edition, Weinheim, Germany: VCH Verlags gesllschaft. ISBN3- 527-200546.

Siddig, A.S. (1991). Evaluation of neem seed and leef Water extracts and powers for the control of insects pest in the Sudan. (Technical Bulletin NO. 6 pp 39).

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.

Silvain, J.F., and Delobel, A. (1998). Phylogeny of West Africa *Caryedon* (Coleoptera: Bruchidae): congruence between molecular and morphological data. – Molecular phylogenetics and Evolution, 9: 533 – 541.

Singal, S.K., and Toki, O.P. (1990). Carry over of the bruchid, *Caryedon serratus* (Olivier) from the field to stores through seeds of *Acacia nilotica* (L.) Willd. In India. – *Tropical Pest management*, 36: 66 – 67.

Singh J. (1977). A key to the North. West India Bruchidae. Ent. Mon-Mag. 113:219 – 231.

Southgate, B. (1979). Biology of the Bruchidae. Annual Review of Entomology. 24:449-473.

Suliman, A.A.M. (2002). Evaluation of potential use of three cucurbits extracts in the control of *Tribolium castanneum* (Herbst) (Tenebrionidae: Coleoptera) and *Musca domestica* L. (Muscidae; Diptera). M.Sc. Thesis. Fac. of Agric. Univ. of Khartoum, 91pp.

Talukder, F.A and Howse. (1993). Deterrent and insecticidal effects of extracts of pithraj, Aphanamixis polystachya (Meliaceae) against, *Tribolium castaneum* in storage. J.Chem. Ecol., 19:2463-2471.

Wightman, J.A, and Ranga. Rao, G.V. (1993). A groundnut insect identification handbook for India. Information Bulletin no. 39. Patancheru, AP 502324, India: International Crops Research Institute for the Semi-Arid Tropics. 64pp.

Woodroof, J. (1973). Peanuts: Production, Processing, Products, Westport Connecticut: The AVI Publishing Company, Inc.

Yadava, T.P. (1985). Groundnut, sesame, castor, and sunflower. ICAR Extension Bulletin no.2. Rajendranagar, Hyderabad, India: Directorate of Oilseed.

APPENDICES

ANOVA TALES ANALYSIS

Appendix 1. Adult Mortality, Analysis of (One way ANOVA table)

	Degree of Freedom (DF)	Sum of Squares (SS)	Mean Square (MS)	F - value	Prob.	Time hours
Between	4	203.282	50.820	118.971	0.0000	24 hrs
Within	15	6.408	0.427			
Total	19	209.690				
Coefficient of Variation = 9.82						
	Degree of Freedom (DF)	Sum of Squares (SS)	Mean Square (MS)	F - value	Prob.	Time hours
Between	4	214.998	53.749	70.062	0.0000	48 hrs
Within	15	11.508	0.767			
Total	19	226.505				
Coefficient of Variation = 12.72						
	Degree of Freedom (DF)	Sum of Squares (SS)	Mean Square (MS)	F - value	Prob.	Time hours
Between	4	225.532	56.383	1034.551	0.0000	72 hrs
Within	15	0.817	0.054			
Total	19	226.439				
Coefficient of Variation = 3.20						

Appendix 2. Larvae Mortality, Analysis of (One way ANOVA table)

	Degree of Freedom (DF)	Sum of Squares (SS)	Mean Square (MS)	F - value	Prob.	Time hours
Between	4	218.623	54.656	335.311	0.0000	24 hrs
Within	15	2.445	0.113			
Total	19	221.068				
Coefficient of Variation = 5.65						
	Degree of Freedom (DF)	Sum of Squares (SS)	Mean Square (MS)	F - value	Prob.	Time hours
Between	4	273.127	59.282	834.954	0.0000	48 hrs
Within	15	1.065	0.073			
Total	19	238.192				
Coefficient of Variation = 3.54						
	Degree of Freedom (DF)	Sum of Squares (SS)	Mean Square (MS)	F - value	Prob.	Time hours
Between	4	216.628	61.657	2021.539	0.0000	72 hrs
Within	15	0.458	0.031			
Total	19	247.086				
Coefficient of Variation = 2.27						

Appendix 3. Adult Repellent, Analysis of (One way ANOVA table)

	Degree of Freedom (DF)	Sum of Squares (SS)	Mean Square (MS)	F - value	Prob.	Time hours
Between	4	228.960	57.240	885.155	0.0000	24 hrs
Within	15	0.970	0.065			
Total	19	229.930				
Coefficient of Variation = 3.46						
	Degree of Freedom (DF)	Sum of Squares (SS)	Mean Square (MS)	F - value	Prob.	Time hours
Between	4	242.062	60.515	1657.958	0.0000	48 hrs
Within	15	0.548	0.037			
Total	19	242.609				
Coefficient of Variation = 2.51						
	Degree of Freedom (DF)	Sum of Squares (SS)	Mean Square (MS)	F - value	Prob.	Time hours
Between	4	244.988	61.247	1766.739	0.0000	72 hrs
Within	15	0.520	0.035			
Total	19	245.508				
Coefficient of Variation = 2.43						

Appendix 4. Larvae repellent, Analysis of (One way ANOVA table)

	Degree of Freedom (DF)	Sum of Squares (SS)	Mean Square (MS)	F - value	Prob.	Time hours
Between	4	220.650	55.162	218.465	0.0000	24 hrs
Within	15	63.787	0.252			
Total	19	224.437				
Coefficient of Variation = 7.05						
	Degree of Freedom (DF)	Sum of Squares (SS)	Mean Square (MS)	F - value	Prob.	Time hours
Between	4	233.478	58.369	1203.495	0.0000	48 hrs
Within	15	0.727	0.048			
Total	19	234.205				
Coefficient of Variation = 2.96						
	Degree of Freedom (DF)	Sum of Squares (SS)	Mean Square (MS)	F - value	Prob.	Time hours
Between	4	242.420	60.605	1748.220	0.0000	72 hrs
Within	15	0.520	0.035			
Total	19	242.940				
Coefficient of Variation = 2.45						

Appendix 5.

Plate 15. Stored groundnut (in plastic sacks).

Appendix 6.

Plate 11. *Caryedon serratus* dorsal view

Plate 16. *Caryedon serratus* adult side view.

Appendix 7.

Plate 17 *Caryedon serratus* adult abdomenal view.

Appendix 8.

Plate 18. *Caryedon serratus* head and antennae.

Appendix 9.

Plate 19. *Caryedon serratus* adult leg.

Appendix 10.

Caryedon serratus

Plate 20. *Caryedon serratus* adult.