ECOLOGY OF *NOORDA BLITEALIS* (WALKER) (LEPIDOPTERA: CRAMBIDAE) AND ITS MANAGEMENT USING BOTANICALS IN KONSO SPECIAL WOREDA

BY

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TABLE OF CONTENS

PAGE

LIST OF TABLES

PAGE

LIST OF FIGURES

* all pictures taken by Kai Sonder

LIST OF APPENDICES

PAGE

ABSTRACT

Some ecological aspects of *Noorda blitealis* as the major defoliating pest of *Moringa stenopetala*, were studied in Konso area, Ethiopia. The density of immature stages of *Noorda blitealis* on Moringa trees were investigated in different months of the year. In addition, the host range, major predators of the pest and control aspect of this pest using botanical extract from seeds of *Melia azedarach* has been conducted

The result showed significant ($P < 0.05$) difference on the egg densities of the pest on the host trees during the study period, with maximum and minimum numbers recorded during March and February, respectively. The difference in the number of caterpillars per host plant in different months was significant ($P < 0.05$), where heavy infestation was recorded in April and relatively minimum infestation in February. Pupal density of the pest showed significant ($P < 0.05$) difference during the study period, where the maximum number was found during February and the minimum number during April. The relationship between pest density and weather factors was significant ($P < 0.05$) and positive correlations ($r = 0.899$; $r = 0.823$) of rainfall and relative humidity respectively with larval density. In the contrary, significant ($P < 0.05$) but negative correlations ($r = -0.992$; $r = -0.885$) of rainfall and relative humidity respectively with pupal density was observed. *Noorda blitealis* was found to have only one host plant, *Moringa stenopetala* in the study area. In this study, *Myrmicaria* sp. and praying mantids were found to be the larval predators of the pest where significant ($P < 0.05$) difference was observed in the number of larvae between *Myrmicaria* sp. nested trees and trees where this species were not nested. However, the number of larvae recorded between the Hymenopodidae nested and the Hymenopodidae non nested host trees was not significant ($P > 0.05$). Melia seed water extracts of different concentrations; (the 50g L^{-1}, the 75g L^{-1}) and 2ml L^{-1} (Dursban 48% EC) showed significant ($P < 0.05$) difference from the untreated control, for their oviposition deterrence on the moths, and repellent activities against the caterpillars. However, there was no significant difference ($P > 0.05$) among the Melia and insecticide treatments. Melia seed extracts at 25g L^{-1} was not found to be significantly different ($P > 0.05$) from the control. The toxicity effects of all the concentrations of these extracts on filter paper showed no significant difference from the control while the chemical pesticide showed significant ($P < 0.05$) difference. All the concentrations of the Melia seed extracts were not significantly different from the control in causing mortality on the predatory ants, where as significantly ($P < 0.05$) different mortality of the predatory ants was observed on the insecticide treated filter paper.

Key words: Botanicals, Extract, *Melia azedarach*, *Moringa stenopetala*, *Noorda blitealis*, Predators,

DECLARATION

This thesis is my original work, has not been presented for a degree in any university and that all sources of material used for the thesis have been duly acknowledged.

Name: ___________________________

Signature: ________________________

Date: ___________________________

This work has been presented with our approval as a supervisor.

1) Name: Dr. ____________________

   Signature: ____________________

   Date: ________________________

2) Name: Dr. ____________________

   Signature: ____________________

   Date: ________________________

1. INTRODUCTION

Moringa stenopetala (Baker f.) (Crambidae) is a multipurpose tree, which is endemic to East Africa. It is reported in Djibouti, the Sudan and Uganda. The tree is widely distributed in Ethiopia and northern Kenya and is often referred to as the African Moringa tree (Demuelenaere, 2001; Olson, 1998). *Moringa stenopetala* is an important multi purpose plant. The foliage and fruit pods of this tree are rich sources of vitamins and protein including considerable amounts of the sulfur-containing amino acids, methionine and cystine (Rams, 1994).

The tree grows to a 6-10 m height with trunk diameter of about 60cm in at breast height. It has a crown, which is strongly branched sometimes with several branches. The tree is thick at the base and the bark is smooth, white to pale grey or silvery in color with soft wood. The leaves are up to 55cm long and it has a pubescent, dense many-flowered inflorescence with panicles 60 cm long (Edwards *et al.*, 2000).

Moringa stenopetala is known by vernacular names as shelaqta and halako in the Konso area. The leaves are used in the preparation of dama, the main Konso dish, and the tree is widely grown for its edible leaves (Demuelenaere, 2001). This tree is popular for its importance as a source of basic nutrition for the rural population in the southern region of Ethiopia, mainly in the areas around Konso as well as the zones along the main road from Sodo-Wolyta to Arbaminch (Jiru, 1995). Steiz and Mayer (1990) described the importance of the pods of *M. stenopetala* tree as a feed plant for goats, sheep and cattle in the Southern regions of Ethiopia.

The use of crushed seeds of *M. stenopetala* as a bioflocculant and antibacterial agent to clear muddy water for human consumption has been reported by Meyer (1999). This tree is also described to be useful in the agroforestry system of Konso agriculture (Demuelenaere, 2001). The tree is densely planted within the villages and generally more widely spaced in the fields and terraces between 1600 and 1800m altitude (Engels and Goettsch, 1991).

Despite the various benefits the Konso people are offered from the cultivation of this tree, problems caused by insect pests which attack the leaves of this tree and cause considerable damage were reported. Demuelenaere (2001) reported that the main problems the Konso people have to deal with are attacks by the larvae of *Noorda blitealis* Walker, which devour leaves of the trees of an entire village in just a week. According to this report, no treatment has been found to prevent this very swift and complete destruction of mida (leaves of Moringa tree) by this caterpillar. The conventional chemical insecticides are not usually used as control options due to economic constraints and contamination problems that limit the continuous use of tree leaves as daily fresh food. Apart from reports about the potential damage on *Moringa stenopetala* by *Noorda blitealis* in Ethiopia, there is no substantial information about the pest’s life history, population density on the host plant, host range, natural enemies and an environmentally and economically feasible control options

This study is therefore, initiated to bridge these gaps and has the following objectives.

1. To determine the density of *Noorda blitealis* as a pest on *Moringa stenopetala* tree
2. To study the host range of *Noorda blitealis* in the study area.
3. To identify predators of *Noorda blitealis* that could be useful for biological control of the pest.
4. To evaluate the effect of *Melia azedarach* seed extracts against *Noorda blitealis*

2. LITERATURE REVIEW

2.1 Insect pests of Moringa

Several insect pests have been reported on Moringa trees. These include the bark-eating caterpillar, *Indarbela quadrinotata* Walker; the hairy caterpillar, *Eupterote mollifera* Wlk.; the green leaf caterpillar, *Noorda blitealis* Wlk.; and the budworm, *Noorda moringae* Tams, which can cause serious defoliation (Parrotta, 1993).

Morton (1991) reported that species of scale insects *Ceroplastodes cajani* and Diaspidotus sp., and an aphid *Aphis caraccivora* have severely infested trees and greatly reduced fruit production in India. It was reported by the same author that the stem borers *Indarbela tetraonis* (Moore), *Diaxenopsis apomecynoides* were found attacking the tree while Fruitflies (*Gitonia sp*.) infesting the fruits, which then dried out at the tip and rotten. According to the report by Duke (1983), leaves of young plants and freshly planted stumps of the tree are attacked by several species of weevils (*Myllocerus discolor* var. variegates, *M. tenuiclavis*, *M. viridanus* and *Ptochus ovulum*), and caused considerable damage on the tree.

The same species of weevils were reported by Jahn (1986) as they nibble from leaf margins of Moringa trees, but it was stated that the loss they caused on the tree was negligible. She also described a beetle, the white grub *Holotrichia insularis* Brenske, which is known as a serious leaf defoliator of a drumstick tree (*Moringa oleifera*) feeding voraciously at night during the time between the early and heavy monsoon rains in

Rajhastan, India. The author also mentioned the white fly *Trialeurodes rara* Singh, a Pentatomid bug *Cyclopelta siccifolia* Westwood, and the slender orange-yellow thrips *Ramaswamiahiella subnudula* Karmy, which have been reported to suck the sap from the ventral surface of the leaflets and tender twigs and are considered as a minor pests of Moringa plant.

As Parrota (1993) reported, the larvae of *Tetragonia siva*, *Metanastiva hyrtaca*, *Heliothis armigera* and *Helopeltis antonii* Sign. (Lepidoptera) were observed to feed on Moringa plant.

Jahn (1986) mentioned the larvae of *Pericallia ricinii* Fabricius, *Prodenia litura* Fabri. and *Dasychira mendosa* Hubner defoliating the tree. However, according to feeding laboratory experiments, caterpillars of *Pericallia ricinii* Fabricius preferred castor plants, and they are said to attack bananas in southern India. Although the preference for Moringa tree is very small, the caterpillars like more to feed on Moringa leaves, but as a pest, they cause only minor damage to this plant. *Noorda moringae* was reported by the same author to be a minor pest that attacks buds of the Moringa tree. Here buds are mainly affected by the pest that feeds on the inner content and infected buds, then do not blossom, but fall off.

In Puerto Rico, the tree was reported to be highly susceptible to termites attack and it was not recommended by the local authorities for planting the trees in areas of heavy infestations (Morton, 1991).

2.2 Identifying features, biology and economic importance of *Noorda blitealis*

2.2.1 Identifying features

Noorda blitealis Walker is a moth that belongs to the Order Lepidoptera, Superfamily Pyraloidea, Family Crambidae and Subfamily Noordinae. The moths are medium sized and the male moth of this pest is basically identified by having 6 metallic black dots on the lateral sides of the 3^{rd}-7^{th} or 3^{rd}-8^{th} abdominal segments that becomes blue dorsally, medium sized of 19-21mm wing span, top of abdomen is brownish and yellowish but having no metallic scales. The labial and maxillary palpi are shiny metallic and more golden and silvery while scales on the body being silvery and golden brown (Amsel, 1965).

Little differences for the female moth were described by the author: only 5 black metallic dots on the same lateral segments are available, but the dots on the 3^{rd} segment being strongly blue due to possession of excess blue scales, and is relatively with larger size of 22- 24 mm.

2.2.2 Life history and bionomics

The pest *N. blitealis* was reported to feed on leaves of one of the best known of 13 species of Moringa tree, *Moringa oleifera* (Rachapa *et al.*, 2002). According to these authors, the female moth lays creamy, oval eggs on leaves of the tree, which hatch in 2-3 days. Larvae of the pest will feed on leaflets of the tree in a thin silken web on the lower surface. Therefore, the leaves appear papery and dry up.

If the pests are left free and no control measure is taken, the whole tree will be defoliated. After the larvae finish their growth stages, they pupate in the soil around the tree. Adult moths emerge in 6-9 days after pupation and the lifecycle continues.

2.2.3 Host plants, damage and distribution of *Noorda blitealis*

Different reports stated Moringa trees to serve as host plants for the pest *Noorda blitealis*, but not other plant species. According to Fuglie (2000), *Moringa oleifera* is the best known of the 13 species of Moringa trees (Family Moringaceae) distributed in the tropics and sub-tropics. This tree species was reported by Parrotta (1993), Duke (1983), Morton (1991) and Jahn (1986) as a host plant for the pest *Noorda blitealis*. According to these authors, the pest can exist and feed on the host plant all the time, but the level of infestations varies from time to time or season to season depending on the environment.

According to the study made by Demuelenaere (2001) at different parts of southern Ethiopia, particularly in the Konso area, *Noorda blitealis* which is commonly called Seetayta in the Konso language was reported to be widely hosted by the close relative of *Moringa oleifera*: *Moringa stenopetala*. She reported that, this tree species has been serving the pest as a host plant for a long time in the Konso region, and no control options were developed for the pest.

2.2.4 Economic importance

Kalia and Joshi (1997) stated that *Noorda blitealis* is the major pest of the Indian-native *Moringa oleifera* plant on which the pest could cause 100 per cent defoliation.

Noorda blitealis Walker is reported as a defoliating pest on the multi purpose Moringa tree, which is grown in the tropical and sub-tropical regions. It is the larva (caterpillar) of this species, which causes economic losses to the farmers that often use Moringa spp. as food plant as well as animal feed (Rachapa *et al*., 2002). According to Simon Shibru (2002), this pest seriously affects the food value of the tree as a result of the feeding activity of the caterpillar and subsequent defoliation. Damage caused by *N. blitealis* reduces food production and even undermines the social status of the growers in some parts of southern Ethiopia, especially among the Konso people, and the abundance of Moringa trees in the home garden or on farmland of a household indicates the social status of the owner in the community (Demuelenaere, 2001).

Noorda blitealis and the whole members of the family Crambidae (Snout moths) are intimately associated with their plant hosts either as external or concealed feeders and have developed a broad array of concealed feeding strategies: folding, rolling, webbing, or trying of leaves; making tunnels or tubes of silk or frass; mining leaves; and boring in to stems, roots, buds, and fruits (Marjorie *et al*., 1997). According to these authors, the concealed feeding strategy makes them tolerate unfavorable situations and control actions targeted against them and causing economical damage.

The potential of *Moringa stenopetala* could not be fully exploited mainly due to the serious damage caused by the unchecked feeding of the caterpillar either on the young or mature tree leaves, which inevitably impedes the benefits to be obtained from the different parts of the tree, as the leaves of this tree as well as other green plants serve as the site of food synthesis**.** The complete defoliation of the tree due to the feeding activity of this caterpillar primarily leaves the farmers without options to find food, particularly during seasons when the cultivated food crops fail because of natural calamities like drought. On the other hand, the absence of an appropriate and effective control measure developed and applied against this pest in the Konso area has created suitable condition to a steady increment on the host plant (Demuelenaere, 2001).

In the southern India, the caterpillars of this pest have been reported to cause sporadically great damage on Moringa plant from March to April and December to January (Jahn, 1986).

2.3 Control of *Noorda blitealis*

2.3.1 Biological control

Biological control is the use of beneficial organisms, or natural enemies, for the control of pests. There are three types of natural enemies: predators, parasitoids and diseases, and in east Africa, these natural enemies are common in agricultural fields often more than we realize, keeping insect pests below damaging levels, while without the pressure of those beneficial organisms, the pest would become a problem (Berg and Cock, 1993).

Fantahu Assefa *et al*. (2003) described this method of pest control as the most desirable, and potentially the most sustainable approach to pest management, which attempts to put in place biological regulatory mechanism that mimic those to be found in nature, but shift the balance of population equilibrium levels such that pest numbers are contained at levels that do not cause economic losses.

A study has been conducted to test the efficacy of three varietal toxins of the microbial pesticide i.e., *Bacillus thuringiensis* Berliner against the defoliator pest, *Noorda blitealis* in a field trial of Moringa seedlings. All the treatments of *B.t.* were most effective in causing a significant mortality of the larvae; where as an increase in larval population was observed in plants which have not been sprayed with *B.t.* (Kalia and Joshi, 1997).

Other groups of organism, spiders were reported by Rachapa *et al*. (2002) to have inhabiting in large numbers on the host trees (*Moringa oleifera*) that exert natural control on the increasing population of the caterpillars of the pest *Noorda blitealis*.

Ants (Formicidae) are one group of insects which are reach in most agricultural fields where several studies have shown their importance in tree crops that they play an important role in reducing insect pest populations (Berg and Cock, 1993). These authors reported that on the field of Sunflower, ants were observed to reduce a lepidopteran caterpillar (bollworm) by as much as 85%.

2.3.2 Botanical control

The effects of methanolic extracts of *Melia azedarach* seeds on the oviposition behavior and hatchability of eggs of *Earias vittella* Fabricius (Lep., Noctuidae) were investigated under laboratory conditions. Different extract concentrations of the treatments were compared with nimbecidine and untreated control. Adults preferred to lay a greater number of eggs on the untreated portion of the oviposition substrate (muslin) compared with the extract-treated portion (Gajmer *et al*., 2002).

It was reported from the same study that the extracts manifested repellent activity by reducing the number of eggs laid even when the ovipositing females were not in direct contact with the extracts. In addition, eggs laid on extract-treated oviposition substrate exhibited reduced hatching, and marked adverse effects on hatching were noticed when the eggs were dipped in different concentrations of extracts. However, adults fed on an extract-containing diet laid significantly fewer eggs with poor hatching. But there was no egg laying when the moths were fed on a diet containing different concentrations of *Melia azedarach* seed extracts.

The importance of botanicals as a pest control agents, as it was studied and reported by Bekele Jembere (2002), has shown a significantly toxic effect on *Sitophilus zeamais* (Motsch.), when treated by seed powder extracts of *Milletia ferruginea* (Hochest) using polar solvents.

A preliminary field test which was held in 1993/94 showed that application of extracts of fruits of chinaberry (*Melia azedarach* L.), significantly reduced the levels of leaf infestation and dead heart injury due to larvae of the maize stalk borer, *Busseola fusca* (Fuller), and resulted in increases in crop yield (Ferdu Azerefegne *et al*., 2001). Extracts of both leaves and fruits of chinaberry (either fresh or dried) were effective in reducing the number of larvae.

Many other plant materials which have long been used in pest control activities. This includes nicotine, rotenone, pyrethrum cow urine among others, which have long history in pest control (Ahmed *et al*., 1983). Most of these materials break down rapidly and do not pose the danger of persistence in the environment and have relatively low mammalian toxicity, a short period of activity, and a fairly broad spectrum of control compared with many chemical pesticides (Habte Tekie, 1999).

Similar reports on the use of plant and animal-origin pesticides for the suppression of caterpillars of most lepidopteran insects were made. The major materials from which the extracts made available includes garlic, neem, melia, pyrethrum, tobacco, cow urine and endod extracts to kill the larvae of most of members of this group (Fantahun Assefa *et al*., 2003).

2.3.3 Cultural control

Cultural method in pest control is the manipulation and assemblage of agronomic practices that are used consciously or unconsciously by farmers to prevent pest attack and improve yield (Fantahun Assefa *et al*., 2003). Ploughing around the trees during winter so as to expose and kill the hibernating pupae of *Noorda blitealis*, and other defoliating insect pests of Moringa plant is the common and recommended cultural practice in India (Jahn, 1986).

Other traditional control methods were report by Jahn (1986), like burning of the gregarious caterpillars with torches which has been suggested for controlling the defoliating caterpillars of Moringa tree. She also stated a method of hand picking of the caterpillars from the host trees, which so far has been the best way to get rid of defoliating pests, according to the experience from Philippines and India.

Fantahun Assefa *et al*. (2003) stated some of the cultural methods used in combating such lepidopteran caterpillars, such as destroying caterpillars by hand picking, use of light traps to capture and destroy adult moths. They have also suggested burning of affected plant parts, as a feasible control option. The authors further suggested methods like destroying trash, which harbors caterpillars and acts as a source of re-infestation, proper ploughing and removing/avoiding the surrounding grasses which may serve as alternate hosts, as an appropriate control options for caterpillars of our garden.

Rachapa *et al.* (2002) also advices simple and practical method where we go for collection and destructions of the leaves of Moringa trees with silken webs and caterpillars of *Noorda blitealis* in the initial stages of infestation.

Hand picking or light trapping of adult moths, burning of stubbles and trash, which harbor caterpillars, and act as a source of infestation for the next season, proper ploughing and removing/avoiding the surrounding grasses which may serve as an alternate hosts were some of the traditional agronomic practices used in controlling lepidopteran/Crambid caterpillars (Fantahun Assefa *et al*., 2003). In addition, growing of resistant varieties and intercropping with non host plants were some of the suggested practices in the control of the pest.

It was also suggested that agronomic practices including manipulation of crop residues and alternate hosts, soil tillage, adjustment of planting dates, simultaneous planting in the surrounding, crop spacing and crop rotation can be important means of controlling the caterpillars (Habte Tekie, 1999).

2.3.4 Chemical control

Chemical control of insect pests is the conventional, simple and most widely used method of pest control. This method of pest control is essential as a last resort for integrated pest management, as in many cases the application of pesticides is the only means of effective and advantageous method of control (Fantahun Assefa *et al*., 2003). Some of the advantages of this method as described by the authors are their fast action and easiness to apply, their knock down effect, and their relative cost effectiveness for individual farmers.

Insecticides like sprays of 1-2 times of malathion (2ml L^{-1}), dichlorvos (0.04 %) and fenthion (0.05 %) could be applied to reduce infestations and were found effective in combating caterpillars of *Noorda blitealis* (Rachapa *et al*., 2002). In addition, Cypermethrin 1% granule, Karate 5% EC 1L ha^{-1}, Carbaryl 85% WP 1.5kg ha^{-1} and Endosulphan 35% EC 2L ha^{-1} were also suggested to be effective in the control of the pest.

In Niger, farmers use DDT to fight against the seriously attacking caterpillar of the pest on Moringa plant, despite the fact that the product is forbidden officially. In addition, it was also stated that spraying with 0.05 % Endosulphan, Quinalphose or fish oil resin soap are recommended for the control of lepidopteran pests of Moringa tree (Jahn, 1986).

Rajangam *et al*. (1992) mentioned some pesticides which are currently in use at different regions of southern India. This includes Fenthion 80 EC 0.04 percent to be applied during the vegetative and flowering stages, Nimbecidine 0.03 percent at 150 ppm during 50 percent fruit set. Spraying with 0.1 percent Diazinone at most stages of caterpillars of Moringa pests was found effective, according to the report by Butani and Verma (1981).

3. MATERIAL AND METHODS

3.1 Description of the study area

The research was conducted in the Southern Nations, Nationalities and Peoples Regional State (SNNPRS), Konso special woreda, Gersalle village, which is situated at about 589 km South-Western Ethiopia at latitude of 5.15° N and longitude of 37.30° E and with an altitude of 1350 meters above sea level. The temperatures of the area ranges from below 15 °c at night to 32 °c during the day at the hottest time of the year. There are two rainy seasons: the heavy rains concentrated in March and April, the short rains fall around October and November. The mean annual rainfall of the area is 731 mm (NMSA, 2005). Location of the project area is indicated in Fig. 1.

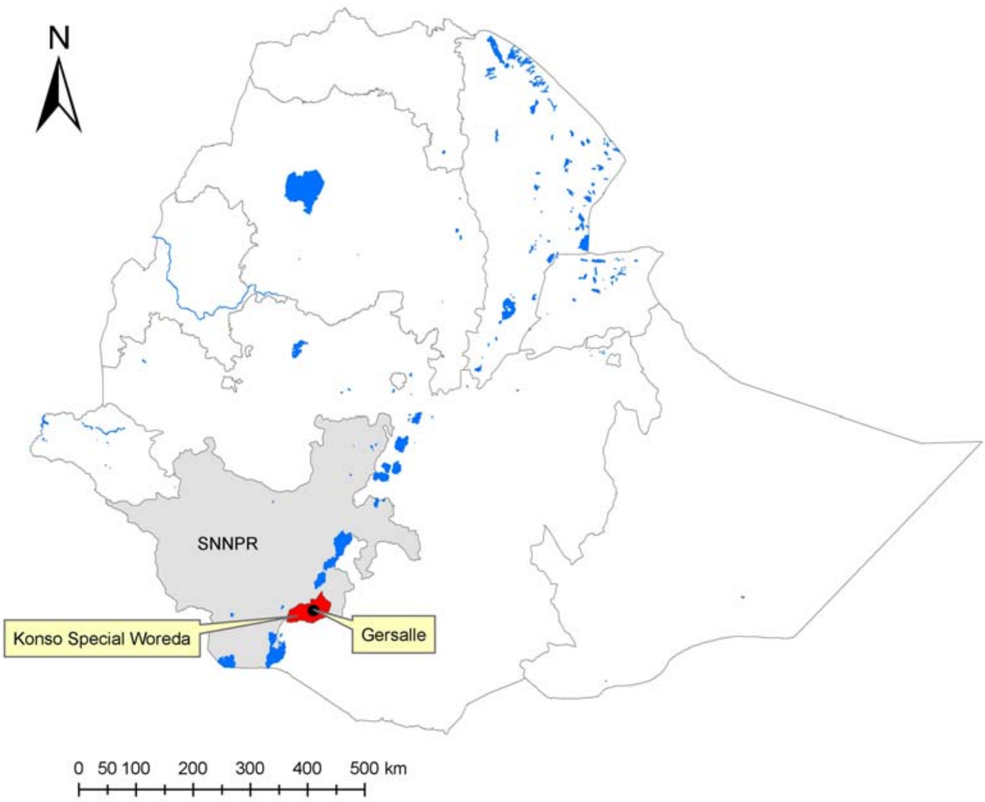


Fig. 1. Location of the project area

3.2 Density of *Noorda blitealis* on *Moringa stenopetala*

At the initial stage of the study, a preliminary study was conducted to determine the diurnal activity of *Noorda blitealis* larval feeding activities on Moringa trees. In this survey, four home gardens were selected randomly with the consent of the growers. Five Moringa trees that lie diagonally N-S direction at about 5 meters interval were selected in each garden using systematic sampling (Gomez and Gomez, 1984).

To determine the diurnal activity of the pest sampling for larvae of *Noorda blitealis* was conducted during three intervals between: 6.00 am - 10.00 am, 10.00 am - 2.00 pm, and 2.00 pm - 6.00 pm for a period of 7 days

To determine the density of the pest the eggs and caterpillars of *Noorda blitealis* on 20 pre-marked host trees were counted at a weekly interval at each of the four home gardens. A total of 20 man-hours per week in which 1man-hour per tree on 4 host trees for 5 working days in a week were spent to sample the immature stages on marked host trees during the study period

Each of the selected and marked host trees were visually classified into three canopy positions. Ten leaves were randomly selected from the different canopy positions of the trees included in the study and visually examined for the presence of *Noorda blitealis* eggs

Counts of caterpillars of the pest were made on the whole visible parts of the marked trees at a weekly interval and the caterpillars were collected by hand-picking as well as using forceps for further identification. The collected caterpillars were then killed and preserved in a 75% ethyl alcohol (Mbata, 1997). The collected data were recorded on a data-recording format for each marked host tree

Sampling to determine pupal densities in the four home gardens were conducted following systematic sampling (Gomez and Gomez, 1984). In this sampling a 7 meters interval zigzag (left and right) walking into each home garden from four ends, just following 5 meters straight entry in to the middle of the gardens was applied. At each 7 meters interval, a $1m^2$ area quadrant with a 5 cm depth was dug and all the soil was sieved by a wire mesh. A total of 132 sample points were used from each home garden over the study period and all the pupae and/or pupal cases obtained from each sample units were collected

The collected pupae were put in glass beakers allowing aeration into, and allowing for moths to emerge. Emerged moths were identified using identification keys developed by Amsel (1965). Accordingly, data (counts) were taken in a monthly interval of the sampling periods from each the 4 home gardens.

To assess the effect of weather on the density of the pest rainfall, relative humidity and temperature of the study area were obtained from National Meteorological Service Agency (NMSA).

3.3 Determination of cultivated host plants of *Noorda blitealis*

All the plant species grown in the study home gardens were identified (Hedberg and Eduards, 1989) and recorded. Different plant species were selected randomly (Gomez and Gomez, 1984) to be examined for infestation by the pest. Visual examination of plant parts for infestation by the pest was carried out twice in a day, on a weekly interval of the project period. Close and extended observations per sampled plant for the infestation of *Noorda blitealis* were made.

All the insect species found on Moringa trees were collected using the appropriate collecting materials like forceps, insect sweep nets, a small paint brush and by hand-picking depending on the species as recommended by Mbata (1997) preserved and later on identified using keys (Hill, 1991). Identifications of the preserved insects were made in the Entomology Research Laboratory of the Department of Biology of Addis Ababa University

3.4 Determination of Arthropod predators of *Noorda blitealis* on Moringa tree

Three Moringa trees, which were found nesting other insect species, were selected randomly from the pre-marked Moringa trees. Similarly, 3 Moringa trees that did not nest other insect species were selected randomly for each species. Counts of these nested insects on the host trees were taken in a weekly interval over the study period. Similarly, counts of the caterpillars of *Noorda blitealis* on the Moringa trees where the other insect species were found nested and non nested were conducted in a weekly interval over the study period.

Close observations for an hour per each Moringa trees was made for observing insects and other organisms while feeding or attacking the caterpillars of *Noorda blitealis*. Insects that were found feeding or attacking the caterpillars on the host trees were recorded, photographed and collected with sweep net and a small paint brush depending on the species

The collections were then killed with the help of chloroform and preserved by pinning in an insect box. Identification of the insects that were collected from the Moringa trees was done using keys (Hill, 1991) in the Entomology Research Laboratory of the Department of Biology of Addis Ababa University.

Counts on numbers of the nested insects on the sampled Moringa trees and/or their egg cases were taken because species like praying mantids are very difficult to locate by just looking at plants, because of their behavior to camouflage or tending to move away to other plants (Watkins and Bessin, 2003).

3.5 Crude preparations of Melia extract on immature stages of *Noorda blitealis*

An experiment was conducted to test the effect of water extracts of *Melia azedarach* seed powder against the pest *Noorda blitealis.* The extracts at different concentrations were tested for their effects on egg density of the pest and larval infestations in the field; as well as their toxicity on the caterpillars of *N. blitealis* on filter papers at room temperature in the study area

Melia fruits of the current production season (2004/2005) were collected and depulped manually. The seeds were dried under shade and ground manually, and the powder was soaked in water at rates of 25, 50 and 75g L^{-1} as recommended by Mohamed (2000) for 24 hours stirred at intervals and filtered with cheesecloth. A chemical insecticide Dursban 48% EC at a rate of 2ml L^{-1} was also used as standard check. Untreated trees were also used as controls in this experiment. Hence, 3 treatments of Melia seed extract concentrations, 1 insecticide treatment and 1 untreated control; a total of 5 treatments were used

The field and filter paper experiments were arranged in completely randomized block design (CRBD) and completely randomized design (CRD) respectively with three replications (Gomez and Gomez, 1984). The field study was conducted on three new home gardens, which are located adjacent to each other, and each of the three home gardens, in which the marked host trees were selected, has been used as a replicate of treatments.

Ten Moringa trees were selected randomly from each of the three home gardens as described by Gomez and Gomez (1984). The three concentrations Melia seed extracts and the insecticide standard check were applied each on 2 host trees. A total of 30 host trees were included in the study. The application of treatments was made on 10 Moringa trees in each replication. The treatments were applied at a rate of 1 L/Moringa tree using knapsack sprayers. The treatments were applied five times at a weekly interval

Ten leaves were randomly selected from each Moringa tree and visually examined to evaluate the effect of treatments on egg density. Counts of eggs on these 10 leaves were made just before and after application of treatments on the host trees. Similarly, counts of the number of larvae were conducted on the trees just before and after applications of treatments to evaluate the treatments against larval infestation

All the treatments used in the field experiment were applied on Whatman filter paper of 90 mm diameter at room temperature to test their toxicity on the larvae of *Noorda blitealis*. Three replications of the 5 treatments were used, and each Petri dish served as one experimental unit. One ml of each treatment was applied on the filter paper using medical syringes followed by placing 5 freshly collected live *Noorda blitealis* caterpillars of similar size into each Petri dish.

Data on the number of mortalities (%) of caterpillars was taken in a 4, 8 and 12 hours intervals after applications of treatments from each Petri dish.

These treatments were also tested for their effect on ants, which were the major insect predators of the pest. Ten freshly collected live predatory ants were subjected to the same treatments on filter papers in Petri dishes as for the caterpillars in 3 replications.

Data on the number of mortalities (%) of ants was taken in 24 hours, 48 hours and 72 hours intervals after applications of treatments from each Petri dish

3.6 Data analysis

The collected data on eggs and larvae per host tree and the pupal density as well as the data on the effect of the treatments on the pest and its insect predators were subjected to one way analysis of variance (ANOVA) using SPSS 10.0 for Windows standard version (University of Colorado, 1999). Whenever significant differences were detected, mean comparisons were made using Tukey's Studentized Range Test procedures. Mean monthly counts of the different stages of *Noorda blitealis* were correlated with mean monthly weather data and Pearson correlation analysis was used to relate pest density with weather factors (Gomez and Gomez, 1984). The collected data (count) on the number of caterpillars of *Noorda blitealis* found on the predatory insects nested and not nested Moringa trees were statistically tested for significance using Chi square test (χ^2).

4. RESULTS

4.1 Density and occurrence of *Noorda blitealis* on *Moringa stenopetala*

Eggs of the pest were found to occur throughout the study period at fluctuating numbers. Number of eggs declined steadily from November on wards reaching bottom in February. It rose drastically and reached peak in March (Table 1).

As it can be seen from the table there was no significant difference observed on the mean number of eggs between December and January. However, the mean number of eggs during November, February, March, April and December or January were significantly ($P < 0.05$) different from each other.

The mean numbers of the caterpillars of *Noorda blitealis* in relation to their diurnal activity on Moringa trees is given in Table 2. The density of the caterpillar of *Noorda blitealis* on the host plant was found to vary at different durations. From the counts made at three time intervals the highest number of caterpillars were observed in the first period, while the list number in the second period. The self concealing behavior of the caterpillars of *Noorda blitealis* that brought differences in numbers is indicated in Fig.2 A & B. The caterpillars of *Noorda blitealis* on newly infested and on defoliated Moringa trees are indicated in Fig. 3 (A&B).

Noorda blitealis larval caterpillars were encountered throughout the study period and fluctuating in numbers. The density of caterpillars was relatively low per host plat from November to February, and tended to increase in March and April

No significant differences (P > 0.05) were observed on the mean numbers of larvae between November and December. Similarly, there was no significant difference between January and February. On the contrary, there was significant (P < 0.05) difference between mean numbers on March and April. In addition, the mean number on the month of April was significantly (P < 0.05) different from all months (Table 1).

Pupae of *Noorda blitealis* were recorded almost throughout the study period. Number of pupae increased from November to February, and declined in April

As can be seen from the Table there was no significant difference (P > 0.05) observed on mean numbers of pupae between November, March and April. Similarly, no significant difference (P > 0.05) was seen on the mean numbers of pupae between December and January. In addition, no significant difference on the mean numbers was observed between January and February. However, the mean number pupae on February was found significantly (P < 0.05) different from November, December, March and April.

Table 1. Mean numbers eggs, larvae and pupae of *Noorda blitealis* per 10 leaves of Moringa tree, per Moringa tree and per quadrant (in the soil) respectively

Months	Eggs/10 leaves ± SE	Larvae/host tree ± SE	Pupae/quadrant ± SE
November	131.8 ± 8.6 a	44.8 ± 3.1 bc	1.16 ± 0.1 a
December	61.2 ± 7.1 b	39.0 ± 3.7 bc	2.33 ± 0.2 b
January	57.2 ± 3.8 b	22.2 ± 2.5 ab	3.00 ± 0.0 bc
February	15.6 ± 1.3 c	9.60 ± 1.2 a	3.50 ± 0.2 c
March	192 ± 7.5 d	60.8 ± 4.4 c	1.00 ± 0.2 a
April	98.2 ± 4.5 e	117 ± 11.2 d	0.33 ± 0.2 a

Means within column followed by the same letter (letters) are not significantly different from each other by Tukey's Studentized Range Test; $P < 0.05$

Table 2. Number of caterpillars of *Noorda blitealis* on *Moringa stenopetala* trees at three time intervals

Time-ranges	Mean ± SE
6am-10am	44.8 ± 1.0 c
10am-2pm	15.2 ± 0.8 a
2pm-6pm	24.4 ± 1.3 b

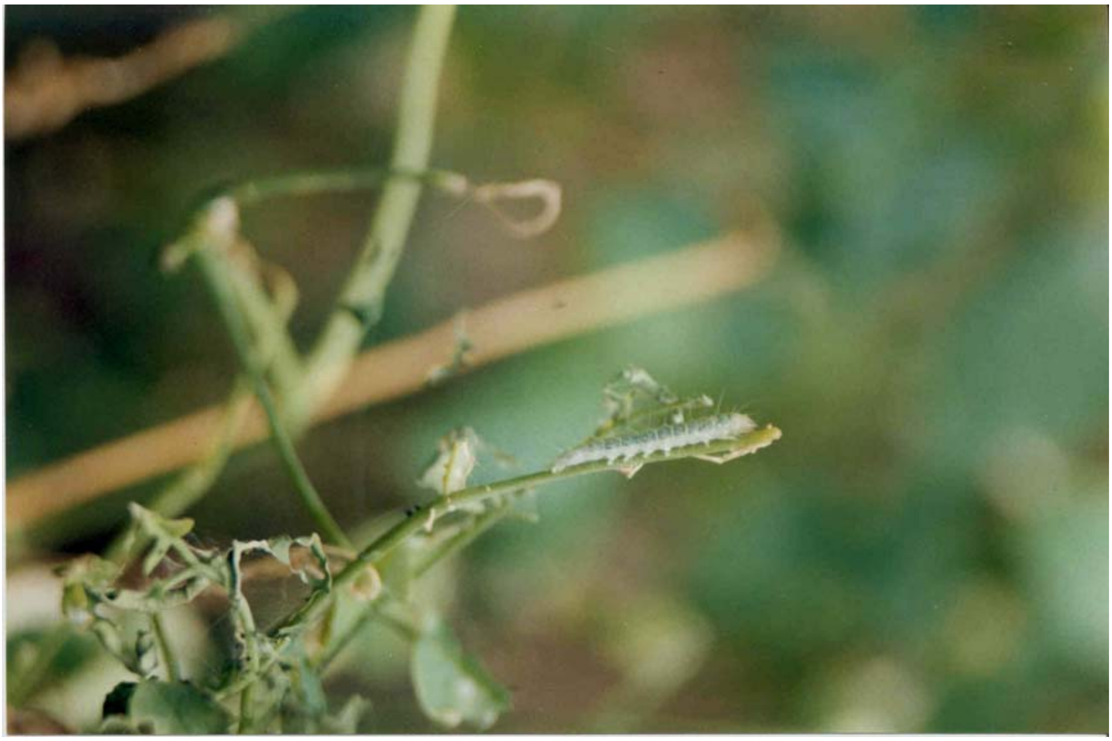
Mean separations was made using Tukey's Studentized Range Test; $P < 0.05$

B)


A)


B)
Fig. 2 (A & B). Caterpillars of *Noorda blitealis* concealed in the bark of Moringa trees

A)



B)

Fig. 3. *Noorda blitealis* caterpillars on newly infested (A) and on defoliated Moringa trees after feeding (B).

4.2. Effect of weather on population density of the pest

Data on the density of the immature stages of *Noorda blitealis* and the prevailing weather in terms of rainfall and relative humidity are presented in Table 3. Correlation analysis of these factors showed a marked influence on the density of immature stages. The correlation analysis indicated that rainfall was significant ($P < 0.05$ and $P < 0.01$) and correlated ($r = 0.899$ and $r = -0.992$) to larval and pupal populations, respectively (Figs. 4 & 5). Relative humidity was significant ($P < 0.05$ and $P < 0.01$) and correlated ($r = 0.823$ and $r = -0.885$) to larval and pupal populations, respectively (Figs. 6 &.7).

Table 3. Multiple correlation analysis between *Noorda blitealis* and weather factors

Stage	Weather factor	r	p
Egg	RF	0.748	0.087
	T^0	-0.311	0.548
	RH	0.435	0.389
Larva	RF	0.899	0.015
	T^0	-0.671	0.144
	RH	0.823	0.04
Pupa	RF	-0.992	0.000
	T^0	0.737	0.095
	RH	-0.885	0.019

Key

RF = rainfall (mm)
T = Temperature (c^0)
RH= relative humidity (%)

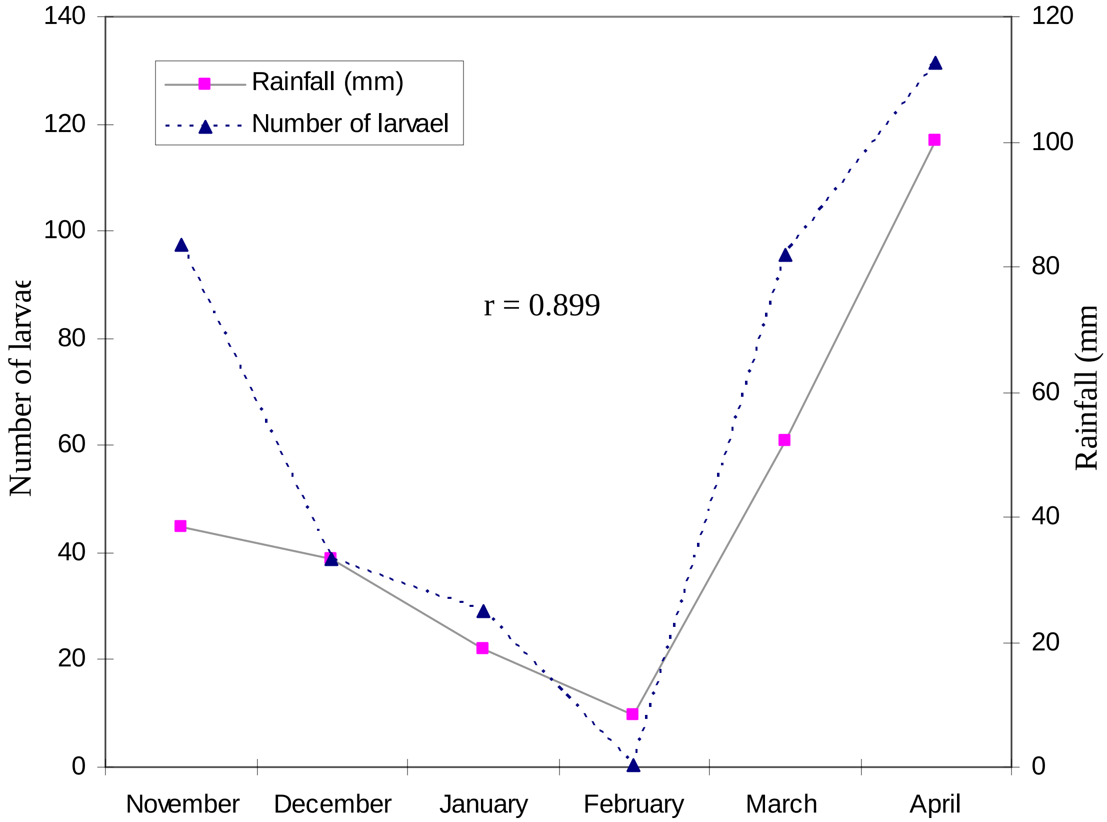


Fig. 4. Correlation of larval density and rainfall

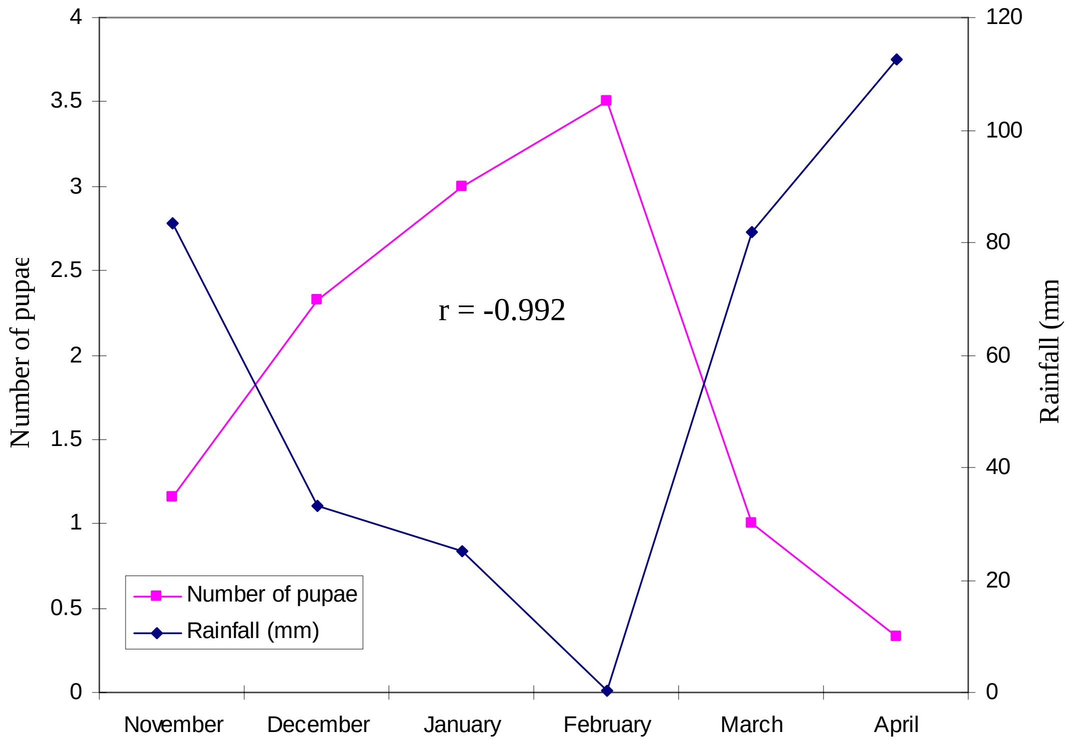


Fig. 5. Correlation of pupal density and rainfall

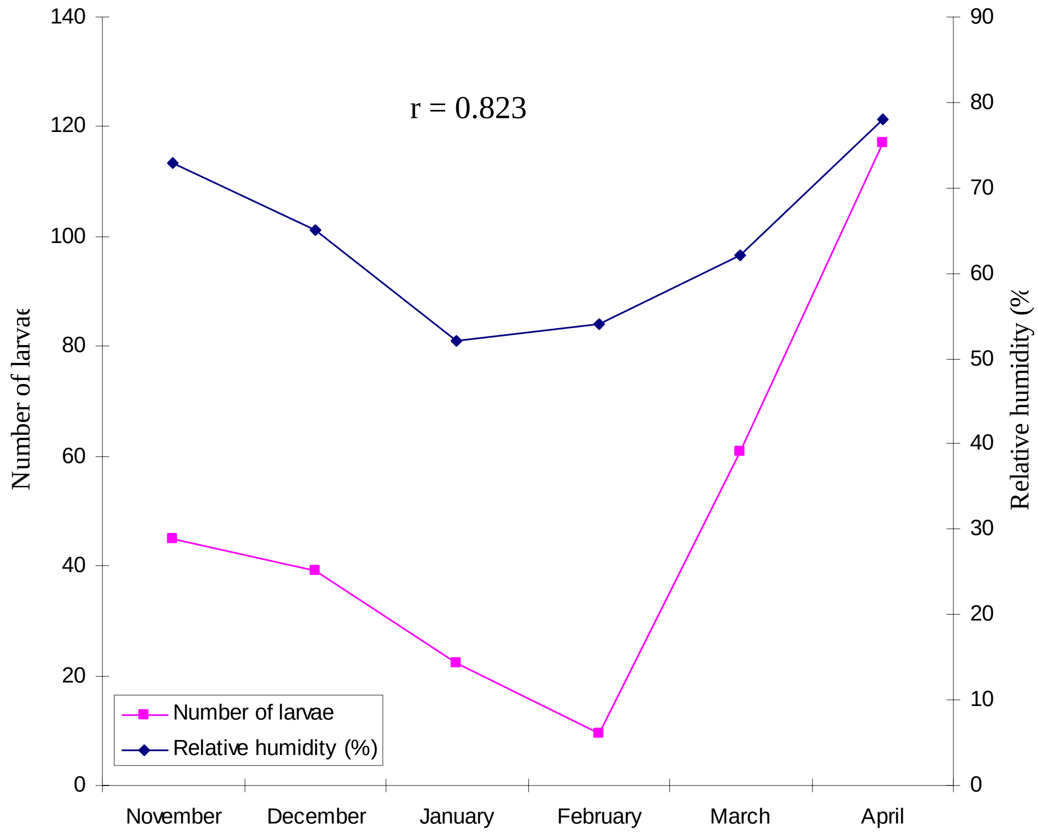


Fig. 6. Correlation of larval density and relative humidity

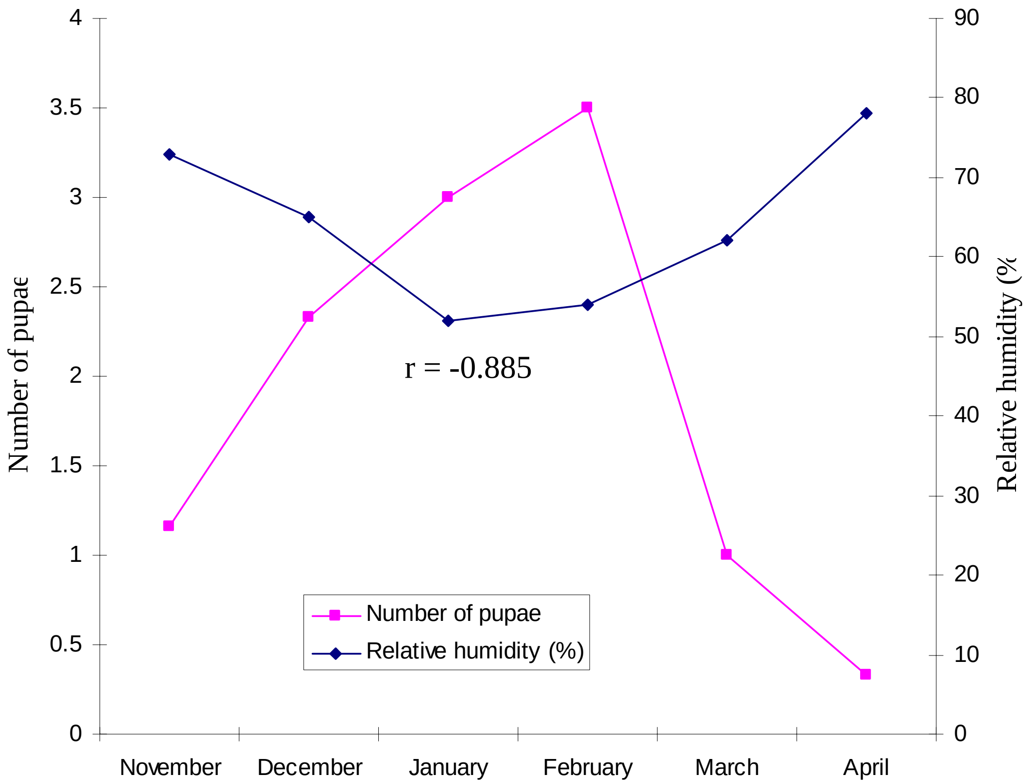


Fig. 7. Number of pupae and relative humidity

4.3. Cultivated host plants of *Noorda blitealis,* and insects associated with them

The plant species on which pest assessment was conducted mainly for identifying the host plants of the *Noorda blitealis* (if any) were Sorghum (Sorghum sp.), Moringa (*Moringa stenopetala)*, Maize (*Zea mays)*, Haricot bean (*Phaseolus vulgaris)*, Pigeon pea (*Cajanus cajan*), Hot pepper (*Capsicum frotescene*), Cotton (*Gossypium hirsutum*). In addition, Papaya (*Carica papaya)*, *Terminalia brownii*, Sweet potato (*Ipomoea batatas*), Coffee (*Coffea arabica*), Sunflower (*Helianthus tuberosus*) and Cabbage (*Brassica oleracea*) were assessed for hosting/sheltering *N. blitealis* (Table 4).

All the above plant species were grown mixed in the home gardens of the study area, having variations in land cover as presented on Table 4 where the estimation of planted area by different crops was made using PRA (Participatory Rural Appraisal) method stated by Kejela Gemtessa (1999).

During the observations for the pest on each and all the plant species grown in the home gardens, which were conducted throughout the study period, no plant species other than *Moringa stenopetala* was found to host/shelter the pest *Noorda blitealis* (Table 4).

Table 4. Plant species assessed for *Noorda blitealis* in the home gardens and insects found associated with them identified using keys (Hill, 1991).

Plants	Planted area (%)	Insects
Sorghum	65.0	*Aphis sp* *Busseola fusca* (Stalk borer)
Moringa	20.0	*Noorda blitealis* Metarbelidae (Stem borer) *Myrmicaria sp*. (Formicidae) Hymenopodidae (Praying mantids)
Cotton	5.0	*Aphis sp*. *Helicoverpa armigera* (Bollworm)
Coffee	3.0	Erotylidae (Beetles)
Maize	1.5	Busseola fusca (Stalk borer)
Pigeon pea	1.0	*Aphis sp*.
Sun flower	1.0	No insect
Haricot bean	1.0	Hymenopodidae (Praying mantid)
Hot pepper	0.7	No insect
Sweet potato	0.6	*Cylas sp*. (Potato weevil)
Papaya	0.5	No insect
Terminalia	0.5	Hymenopodidae (Praying mantid)
Cabbage	0.2	*Aphis sp*.

4.4. Arthropods implicated as predators of *Noorda blitealis*

Two insect species were found to be predators of the pest *Noorda blitealis*: *Myrmicaria sp*. of the family Formicidae (Ants), and praying mantids of the family Hymenopodidae using identification keys (Hill, 1991) during the observations made in attempt to see the predator-pest interactions on the sampled host trees. These two predatory insect were observed while attacking/feeding on the caterpillars of *Noorda blitealis* that are found on *Moringa stenopetala* trees (Fig. 8 A1& A2; B1 & B2)

The two predatory species have not been found together on *Moringa stenopetala* trees where the pest *Noorda blitealis* lives, and the variation in the numbers of these two predatory species on the host trees throughout the study period was not significant as shown on Table 5.

Significantly different caterpillar mean numbers of the pest were observed between *Myrmicaria* sp-nested Moringa trees and on the non *Myrmicaria sp*.-nested Moringa trees ($P < 0.05$, $\chi^2 = 68.23$), as indicated in Table 6. On the contrary, there was no significant difference ($P > 0.05$) between the mean number of caterpillars on the host trees where families of Hymenopodidae and/or their egg cases were found, and on the host trees where none of the same species and/or their egg cases were available ($P > 0.05$, $\chi^2 = 1.34$) as indicated in Table 7.

Table 5. Number of the predatory insect species per *Moringa stenopetala* tree

Months	Mean ± SE *Myrmicaria sp*. (Ants)	Mean ± SE Hymenopodidae (Preying mantid)
November	70.00 ± 2.7	1.2 ± 0.4
December	63.2 ± 4.6	1.2 ± 0.6
January	6 6.0 ± 2.9	1.40 ± 0.5
February	65.0 ± 2.00	2.00 ± 0.6
March	65.6 ± 3.3	1.40 ± 0.7
April	64.2 ± 2.3	1.20 ± 0.2

Means within column are not significantly different from each other

Table 6. Number of Noorda caterpillars on *Myrmicaria* sp. nested and non nested Moringa trees

Parameters	Mean ± SE
Caterpillars on *Myrmicaria sp*-nested host trees	10.40 ± 0.74
Caterpillars on the non *Myrmicaria sp*-nested host trees	35.40 ± 0.92
Chi- square (X^2)	68.23
P value	0.001

Table 7. Number of caterpillars of the pest on Hymenopodidae nested and non nested Moringa trees

Parameters	Mean ± SE
Caterpillars on Hymenopodidae-nested host trees	33.8 ± 1.5
Caterpillars on the non Hymenopodidae -nested host trees	38.2 ± 1.1
Chi- square (X^2)	1.3
P value	0.2

Fig. 8 A1. Predatory insects (*Myrmicaria* sp.) attacking larvae of *Noorda blitealis* on the host plant

Fig. 8 A2. Predatory insect (*Myrmicaria* sp.) attacking larvae of *Noorda blitealis* on theHost plant

Fig. 8 B1. Predatory insect (Hymenopodidae) attacking larvae of *Noorda blitealis* on the Host plant

Fig. 8 B2. Predatory insect (Hymenopodidae) attacking larvae of *Noorda blitealis* on the Host plant

4.5 Effect of Melia seed extracts on *Noorda blitealis* and their insect predators

4.5.1 Effects on egg density of *Noorda blitealis*

As presented in Table 8 the mean number of eggs between the 50g L^{-1}, 75g L^{-1} concentrations treated and the 2ml L^{-1} chemical insecticide (Dursban 48% EC) treated leaves were not significantly different from each other. Similarly, the mean number of eggs between the 25g L^{-1} treated leaves and the untreated control was found not significantly different from each other. However, the mean number of eggs on the 50g L^{-1}, 75g L^{-1} and the 2ml L^{-1} concentrations treated leaves were significantly ($P < 0.05$) different from the mean numbers on the 25g L^{-1} concentration treated and on the untreated control

Table 8. Number of eggs of *Noorda blitealis* per 10 leaves of Moringa trees treated with the different treatment

Treatment	Mean (Numbers) ± SE Eggs/10 leaves
25g L^{-1}	144.83 ± 5.2 b
50g L^{-1}	56.83 ± 3.2 a
75g L^{-1}	51.66 ± 6.6 a
2ml L^{-1} (Dursban 48% EC)	49.16 ± 5.9 a
Untreated control	161.5 ± 9.4 b

Means within column followed by the same letter are not significantly different from each other by Tukey's Studentized Range Test; $P < 0.05$

4.5.2 Effects on larval density of *Noorda blitealis*

As presented in Table 9 it was observed that the mean number of caterpillars between the 50g L^{-1}, 75g L^{-1} concentrations and the 2 ml/L insecticide treated host trees were not significantly different from each other. Similarly, the mean number of caterpillars between the 25g L^{-1} concentration treated host trees and the untreated control were not significantly different from each other. On the other hand, the mean number of caterpillars on the 50g L^{-1}, 75g L^{-1} and 2 ml/L insecticide (Dursban 48% EC) treated host trees were found significantly ($P < 0.05$) different from the mean numbers on the 25g L^{-1} treated and on the un treated control

Table 9. Number of larvae of *Noorda blitealis* per Moringa trees treated with different treatments

Treatments	Mean ± SE
25g L^{-1}	59.00 ± 3.5 b
50g L^{-1}	42.33 ± 5.0 a
75g L^{-1}	36.00 ± 3.6 a
2m L^{-1} (Dursban 48% EC)	35.83 ± 3.4 a
Untreated control	62.00 ± 3.9 b

Means within column followed by the same letter are not significantly different from each other by Tukey's Studentized Range Test; $P < 0.05$

4.5.3 Toxicity of Melia seed extracts on larvae of *Noorda blitealis*

As indicated on Table 10 only the mean numbers of mortalities (%) on the 2ml L^{-1} chemical insecticide (Dursban 48% EC) treated filter paper was found significantly ($P < 0.05$) different from the untreated control. On the contrary, all the other mean number of caterpillars (%) on the 25g L^{-1}, 50g L^{-1}, 75g L^{-1} treated filter papers and on the untreated control were not found significantly different from each other during the first 4 hours after treatment

In the next 4 hours (8 hours after treatment), the mean number mortalities on the 2ml L^{-1} chemical insecticide treated filter paper was significantly ($P < 0.05$) different from all others including the untreated control. While the mean numbers of mortalities on all the treatments other than the 2ml L^{-1} treated filter papers were not significantly different from each other

During the final 4 hours (12 hours after treatment), mean number of caterpillars on the 2ml insecticide treated filter papers were significantly ($P < 0.05$) different from all others including the untreated control.

Table 10. Toxicity of different concentrations of Melia seed extracts on larvae of *Noorda blitealis* evaluated at three intervals of time

Treatments	Mean mortality (%) ± SE after 4 hours	Mean mortality (%) ± SE after 8 hours	Mean mor.% ± SE after 12 hours
25g L^{-1}	8.66 ± 6.6 a	14.00 ± 3.3 a	26.6 a
50g L^{-1}	13.33 ± 6.6 a	20.00 ± 4.0 a	44.35 a
75g L^{-1}	20.00 ± 3.3 a	23.66 ± 4.6 a	51. 7 a
2ml L^{-1}	40.00 ± 6.6 b	66.0 ± 6.6 b	83.9 b
Control	3.66 ± 6.6 a	9.33 ± 2.3 a	17.5 a

Means within column followed by the same letter are not significantly different from each other by Tukey's Studentized Range Test; $P < 0.05$

4.5.4 Toxicity of Melia seed extracts on predatory ants

Mean number mortality (%) on the 2ml L^{-1} chemical insecticide (Dursban 48% EC) treated filter papers were significantly ($P < 0.05$) different from all other mean numbers of mortalities (%) on all concentrations treated and the untreated control filter papers. On the other hand, the mean numbers of mortality (%) between the 25g L^{-1}, 50g L^{-1}, 75g L^{-1} concentrations treated and on the untreated control filter papers were found not significantly different from each other (Table 11).

During the second period (48 hours after treatment), mean number mortality (%) on the 2ml L^{-1} chemical insecticide treated filter paper was significantly ($P < 0.05$) different from all other mean numbers of mortalities (%) on all concentrations treated and the untreated control filter papers. On the other hand, the mean numbers of mortality (%) between the 25g L^{-1}, 50g L^{-1}, 75g L^{-1} concentrations treated and on the untreated control filter papers were found not significantly different from each other (Table 11).

During the final period (72 hours after treatment) again only the 2ml chemical insecticide treated filter paper that showed a significant ($P < 0.05$) difference from all other treatments and from the control (Table 11).

Table 11. Toxicity of different concentrations of *Melia azedarach* seed extracts on predatory ants evaluated at three intervals of time

Treatments	Mean mortality (%) ± SE After 24 hours	Mean mortality (%) ± SE after 48 hours	Mean mor.% ± SE after 72 hours
25g L^{-1}	2.5 ± 1.1 a	10.00 ± 2.7 a	35.6 ± 2.6 a
50g L^{-1}	3.33 ± 3.3 a	13.33 ± 3.3 a	44.8 ± 4.0 a
75g L^{-1}	3.33 ± 3.3 a	16.66 ± 3.3 a	59.3 ± 4.8 a
2ml L^{-1}	16.66 ± 3.1 b	43.33 ± 4.5 b	87.7 ± 5.3 a
Control	1.20 ± 0.0 a	6.00 ± 1.0 a	18.2 ± 2.1 a

Means on the column followed by the same letter are not significantly different from each other by Tukey’s Studentized Range Test; $P < 0.05$

5. DISCUSSION

In this study, considerable variations in the number of caterpillars of the pest *Noorda blitealis* were observed at different time interval of the day time on the host trees. This variation in numbers was due to the preference on time to feed on the host tree leaves in response to external environment. This is similar to the report by Marjorie *et al*. (1997) who described their concealed feeding strategies in situations where their external environment, like weather factors becomes not conducive.

These strategies that brought about variations on the number of caterpillars on the leaves of the host trees can largely be attributed to some of the strategies developed by this pest, as stated by Marjorie *et al.* (1997) mainly using mechanisms of hiding themselves on the host trees through folding, rolling, webbing leaves or boring in to stems of the host plants.

The current study has clearly shown the correlations of different stages of the pest to weather factors, where the density of the populations of the pest were seen to vary with variations in the amount of weather factors, which were manifested in the course of the study period.

This observation on the variations of population numbers following weather factors reconciles with what Price (1984) stated on the same area, where factors external to the population influence population numbers.

As observed in this study, there were marked differences in relative abundance of the egg populations of the pest in the study period. It was only between the months of December and January that insignificant differences in the egg populations were observed.

The variation in the abundance of the eggs on the host plants during the study period was found positively correlated with some weather factors. Rainfall and relative humidity are the major weather factors that indicated strong positive correlations with egg density, though the effect of these weather factors on the egg density were not significant

In the current study, there were marked differences in the number of larvae of the pest with in the study period, which were significant ($P < 0.05$).

Strong positive and significant correlations were clearly seen between larval density and weather factors. In this regard, variations in the numbers of caterpillars of the pest were seen as rainfall and relative humidity specific. i.e. an increase in rainfall was strongly correlated ($r = 0.899$) with an increase in caterpillar numbers over the study period. Relative humidity was also positively correlated ($r = 0.823$) to larval numbers and caused significant differences on the pest density during the study period.

Similarly, there has been significant variation in the pupal density of the pest with in the study period. This variation was highly influenced by rainfall and showed a highly significant and negative correlation with rainfall ($P < 0.01$; $r = -0.992$), where the highest amount of monthly rainfall, which was recorded in April coincided with the least number of pupal numbers of the study period. Conversely the minimum amount of monthly rainfall was coincided with the highest numbers of pupae. Similarly, a considerable relationship was formed between pupal density and relative humidity where a significant and negative correlation were observed between the two factors ($P < 0.05$; $r = -0.885$).

On the other hand, temperature unlike the above weather factors was not significant in terms of associations to the different stages of the pest, and no significant relation was established between temperature and populations of egg, larva and pupa during the study period

The caterpillars of the pest *Noorda blitealis* were found intimately associated with its host plant *Moringa stenopetala.* This host specificity of the pest is the common characters of the family Crambidae (Snout moths). The above result is supported by Marjorie *et al*. (1997) who described the family to have developed a broad and strong array of host specificity assisted by concealed feeding strategies. This result of host specificity manifested by the pest in the current study is again in agreement with the report by Marjorie *et al*. (1997) who described the family Crambidae in general, to have demonstrated plant specificity at different taxonomic levels. Hence, no plant species other than *Moringa stenopetale* tree was found to host the pest *N. blitealis* in the current study

However, moths of this species were not found associated to the host plants, where similar reports were made by Marjorie *et al*. (1997) who described the moths (Snout moths) in general to have shown a rapid response to environmental disturbance, because of the close association of the immature stages with the plants

The current study has clearly shown the significant ($P < 0.05$) predatory effect of *Myrmicaria sp*. on the caterpillars of the pest. This is similar to the report by Berg and Cock (1993) who demonstrated an important predatory action of this ant species on caterpillars of tree crops. This showed the importance of the species, therefore, it is imperative to protect this ant species.

In the current study, this species of ants was found to be one of the most closely associated predatory insect species on the host trees of the pest, where considerable reduction on the number of the caterpillars of the pest were observed. This idea was supported by Sekamattee *et al*. (2001) who stated the close association to host plants and predatory actions exerted by the same ant species on termites that has resulted in population regulation.

On the other hand, the Family of Hymenopodidae of praying mantid was observed to feed on the caterpillars of the pest, even though there number on the host trees of *Moringa stenopetala* was very low. Despite predatory actions made by these praying mantids, there was no significant difference observed on the number of the prey (caterpillars of the pest) on the host trees. This idea of low level of predatory action by praying mantids has also been supported by Watkins and Bessin (2003) who demonstrated the overall value of such insects to be relatively small compared with other predatory insects like lady beetles and green lacewings, because of their cannibalistic nature, which limits their number in an area.

On the other hand, this low predatory effect on their prey on a certain host plants was because of their behavior that they tend to move away to find suitable coverage and food sources (Watkins and Bessin, 2003; Huffaker and Rab, 1984).

In this study, the botanical extracts obtained from *Melia azedarach* seeds were found competently effective with the chemical insecticides. In the experiment to test this botanical against the number of egg density of the pest, significant ($P < 0.05$) difference was found between the numbers of eggs on the Melia extract treated and the untreated host trees that reconciles with the report by Gajmer *et al*. (2002) who demonstrated the deterrent effect of such Melia extracts against oviposition.

The Melia seed water extracts of concentrations (50g L^{-1} and 75g L^{-1}) that indicated comparable result to the synthetic insecticide (Dursban 48% EC) are preferred for use. This idea is supported by Prakash and Rao (1996) who suggested the preference of botanical pesticides because of the prohibitive cost of synthetic pesticides and the problems of environmental pollution caused by continuous use of synthetic pesticides. This idea of preferring botanicals to synthetic insecticides has also been supported by Weinzierl and Henn (1991) who stated some of the advantages of botanicals over the synthetic insecticides like less persistence in the environment, reduced risk to non target organisms, rapid action on the pest, low mammalian toxicity, high selectivity and low toxicity to plants.

On the other hand, it can be clearly understood that the 50g L^{-1} concentration is more economical than the 75g L^{-1} concentration, while both concentrations are equally significant. In the contrary, the deterrence effect observed on the 25g L^{-1} concentration sprayed host trees was not significantly different from that of the untreated control.

Similar result was obtained from the sprays of the same concentrations against larval infestations of the pest in the current study. Promising result has been obtained where relatively low number of larval infestation on the leaves of host trees was observed as stated by Ferdu Azerefegne *et al*. (2001) that the same Melia extract to have been effectively reducing the number of larvae on the host plants. Similarly, the encouraging result of Melia extracts against larval density has also been supported by Juan *et al*. (2000) who stated the strong antifeedant activity of this botanical extract against larvae of most lepidoptera.

Even if comparable results were seen between the *Melia azedarach* extracts (both concentrations) in one hand, and the chemical insecticide on the other hand, the Melia extracts of those concentrations could be given priority in views of the comparative advantages offered by this Melia extract like the environmental, economic, and many other considerations (Prakash and Rao, 1996; Weinzierl and Henn 1991). On the other hand, when we compare the two Melia extract concentrations, the 50g L^{-1} is more economical than the 75g L^{-1} concentrations and is preferred for use

All the Melia extract concentrations which were used to test their toxicity effect were not significantly different from the untreated control. In another study, Bounechada *et al*. (2004) reported that water extracts of *Melia azedarach* seeds with concentrations of 50g L^{-1} and 80g L^{-1} were significant ($P < 0.05$) in causing mortality on insects of order orthoptera.

This poor toxicity effect of Melia seed extracts of the entire concentrations does not reconcile to the report by Wandscheer *et al*. (2004) who stated the effectiveness of the same botanical plant material extract that posed better lethal effect on larvae of dengue mosquito. Similar encouraging report regarding insecticidal actions on larvae of lepidoptera was made by Schmidt *et al*. (1998) unlike the poor toxicity result of the current study

In the present study, all the Melia extract concentrations were observed to pose little or no mortality effect on the predatory ants as opposed to the synthetic insecticide, which was highly toxic to the ants with in short periods of time. Hence, the extracts were found to have an added advantage of protecting the major predators of the pest. This result of low toxicity against non target organisms by the Melia concentrations was mentioned to be one of the advantages of botanicals as pest control agent (Prakash and Rao, 1996; Weinzierl and Henn, 1991).

6. CONCLUSION AND RECOMMENDATION

CONCLUSION

It was known that 53.08% of the caterpillars of the pest were found on the host tree leaves during the 6.00 am – 10.00 am time interval, while 18.01% and 28.91% during the 10.00am – 2.00pm and 2.00pm – 6.00pm time interval respectively. This provides information for conducting pest monitoring before taking control measures against the pest, though these operations of monitoring and taking control actions could be constrained by the self concealing behavior of the caterpillars on the host trees

On the other hand, weather factors like rainfall and relative humidity markedly influenced the density of *Noorda blitealis* at different stages. Hence these weather factors should be considered in forecasting and monitoring of the pest as well as when planning to use the appropriate control strategy against the pest

The major predator of the pest, *Myrmicaria* species of ants that was found to play a significant role in predation on the caterpillars of *Noorda blitealis*, is highly vulnerable to synthetic insecticides as compared to the botanical pesticide. Even if synthetic insecticide use on the host tree is not advised, attention has to be give in using the relatively least toxic chemical groups (like botanicals) on the natural enemies of the pest when this control measure is decided for use as a last resort

The pest *Noorda bitealis* is found to have only a single host plant. This could be attributed to the perennial nature of the *Moringa stenopetala* tree where the pest gets continuous food and shelter supply that facilitates conducive environmental condition for recycling. On the other hand, the primitive crop production condition in the study area is in favor of this pest but it takes longer time to improve the backward crop production practices currently underway in the study area from pest control point of view

RECOMMENDATION

The life history of *Noorda blitealis* should be studied under laboratory condition so that further field study on the pest could have much better result. On the other hand, the effect of cultural practices on the distribution and infestation level of *Noorda blitealis* in Konso area should be studied

The use of Melia extracts for the control of the pest has to be given attention as one control option since this plant material is cheaply available locally

Survey and identification of the potential natural enemies of *Noorda blitealis* has to be given due attention in the future

Further study in relation to host plant (*Moringa stenopetala*) phenology and infestation of the pest has to be considered

Detail study on the effect of biotic and non biotic factors on the population dynamics of the pest should be given attention

Any pesticide use against the pest should consider the natural enemies of *Noorda blitealis*

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Appendix 1. Mean monthly data of density of eggs and mean monthly values of weather factors in different months

Parameters	**Eggs**	**Rainfall (mm)**	**Relative Humidity (%)**	**Temperature (c^0)**
November	131.8	83.5	73.0	22.5
December	61.20	33.2	65.0	23.65
January	57.20	25.0	52.0	24.5
February	15.60	0.4	54.0	26.25
March	192.0	81.8	62.0	25.0
April	98.20	112.6	78.0	22.35
r		0.748	0.435	-0.311
p		0.087	0.389	0.548

Appendix 2. Mean monthly data of density of larvae and mean monthly values of weather factors in different months

Parameters	**Larvae**	**Rainfall (mm)**	**Relative Humidity (%)**	**Temperature (c^0)**
November	44.8	83.5	73.0	22.5
December	39.0	33.2	65.0	23.65
January	22.2	25.0	52.0	24.5
February	9.6	0.4	54.0	26.25
March	60.8	81.8	62.0	25.0
April	117.0	112.6	78.0	22.35
r		0.899	0.823	-0.671
p		0.015	0.04	0.144

Appendix 3. Mean monthly data of density of pupae and mean monthly values of weather factors in different months

Parameters	**Pupae**	**Rainfall (mm)**	**Relative Humidity (%)**	**Temperature (c^0)**
November	1.16	83.5	73.0	22.5
December	2.33	33.2	65.0	23.65
January	3.00	25.0	52.0	24.5
February	3.5	0.4	54.0	26.25
March	1.0	81.8	62.0	25.0
April	0.33	112.6	78.0	22.35
r		-0.992	-0.885	0.737
p		0.000	0.019	0.095