



# College of Natural Science

## Department of Zoology

Distribution, Prevalence and Management Options of White Mango Scale  
(*Aulacaspis tubercularis* Newstead) in Aberamo Woreda, Assosa Zone,  
Beneshangul Gumuz, Western Ethiopia

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## Thesis Approval Sheet

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## **List of Abbreviations**

As ARC	Australian Smooth and Rhythm Community
A. s.l	Above sea level
CABI	Centre for Agriculture and Bioscience International
CSA	Central Statistics Agency
IPM	Integrated Pest Management
Km	Kilometer
M	Meter
NGOs	Non-governmental organization
PCIT	Parent-Child Interaction Therapy
WMS	White Mango Scale
SPSS	Statistical Package for the Social Sciences

## Summary

Mango (*Mangifera indica L.*) is grown commercially on a great scale throughout the world's tropical and subtropical lowland areas. It contains a lot of carbohydrates, potassium, and phosphorus and is a strong source of vitamins A and C and also it is the main fruit crop grown in western Ethiopia's Beneshangul Gumuz Region for family use and sale. However, a number of insect pest prey on this significant crop, with the white mango scale (WMS) insect, *Aulacaspis tubercularis* Newstead, being one of the most destructive. WMS damage causes significant yield losses due to defoliation, fruit abortion, poor flowering and drying of twigs, and fruit rejection due to blemish marks on fruits. As a result, a study was conducted in Aberamo Woreda, Western Ethiopia, to determine the distribution, prevalence, and Management options for the White Mango Scale. In ten Kebele of Aberamo Woreda, the study was carried out between September 2022 and June 2023. Preliminary Survey on the prevalence of white mango scale on mango trees was collected from the Office of Agriculture of Assosa Zone. Data sheet was prepared to record the presence or absence of pest incidence and pest density. After the existence of the pest confirmed, the level of leaf infestation was measured by using a hand lens and visual estimation of the proportion of infested leaves. From each Kebele Randomly select five mango trees and from each trees ten leaves was taken for eight consecutive months and eighty (80) people selected for questionnaire from ten Kebeles which means eight (8) people was selected from each Kebele. The acquired data were then analyzed using SPSS software. The research findings revealed that farmers noted a high infestation of the pest, which is a new pest that is specifically transferred by planting materials, due to the nature of the mango tree's massive size and backyard farm production made management difficult, resulting in output decline. A white mango scale insect pest infestation was much greater in the study location, and it first affects the plant's leaf, then the stem. The fruit's commercialization is also severely harmed because it loses its original color. Infestation status varied significantly throughout study months, with the lowest and greatest records occurring in December and April, respectively. The infestation became serious due to ideal rain fall, relative humidity, and mismanaged mango orchard conditions. As a result, it is advised to conduct regular inspections and monitoring, establish a robust domestic quarantine, explore resistant mango varieties, and conduct further screening of IPM suitable insecticides in order to provide a sustainable management approach for the white mango scales insect pest.

**Keywords:** Mango, Distribution, Management practice, Pests, White mango scale

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# CHAPTER ONE

## BACKGROUND OF THE STUDY

### 1. INTRODUCTION

Mango (*Mangifera indica* L.) is a tropical evergreen tree fruit indigenous to the Indian subcontinent, most likely in the Burma-Malaysia region, from whence it spreads to other tropical and subtropical nations (Crane *et al.*, 2006; Stovold., 2004; Ubwa *et al.*, 2014). In the tropics, the crop was the third most significant fruit after citrus and banana (Louw *et al.*, 2008). It has appealing aesthetics in terms of color, sweetness, flavor, and taste as well as high nutritional content and health-promoting properties. Mangoes are used to make juices, jams, and other preserves, or they can be consumed raw as a dessert (Tsegaye *et al.*, 2017). Additionally, it contains significant amounts of protein, sugar, fat, and all known vitamins (Nabil *et al.*, 2012). Ascorbic acid, carotenoids, and particularly phenolic compounds are all effective sources of dietary antioxidants in it (Ma *et al.*, 2011).

Stone beetles, seed weevils, mealy bugs, fruit flies, different scale insects, termites, red-banded thrips, mango tip-borers, and mites are just a few of the insect pests that target this significant crop (Balock and Kozuma, 1963; FAO, 2010; Griesbach, 2003; Halteren, 1970; Jackson *et al.*, 1985). One of the most damaging scale insects in the world is the white mango scale (WMS) insect, *Aulacaspis tubercularis* Newstead (Abo-Shanab, 2012; Borchsenius, 1966; Cunningham, 1996; Daneel & Dreyer, 1998; Germain *et al.*, 2010; Hodges and Hamon, 2004; Iqbal, 2018; Miller and Gimpel, 2002; SRA, 2006; Temesgen; 2011).

According to Kondo and Muoz-Velasco (2009), the white mango scale is a Hemiptera insect from the Diaspididae family. Mango scale and cinnamon scale are some names for it (Iqbal, 2018). WMS is a pest of at least 30 genera and 18 families (Garca Morales *et al.* (2018)). Mango, a member of the Anacardiaceae family, is the primary host for WMS (Borchsenius, 1966; Daneel & Dreyer, 1998; Miller and Gimpel, 2002). Significant losses were reported in mango cultivation in Brazil, Mexico, China, India, Pakistan, Ethiopia, Egypt and South Africa (Abo-Shanab, 2012; Hodges and Hamon, 2004; Isiordia-Aquino *et al.*, 2011; Mohammed *et al.*, 2012; Temesgen, 2011). In addition to mango, WMS feeds on more than 40 plant species across 43 countries in tropical Africa, Oceania, South America, the Caribbean, Asian, North Africa, and East Africa (Kondo and Muñoz-Velasco 2009; Hodges

and Hamon, 2004). WMS also listed as a harmful organism in Costa Rica, Korea, Seychelles, Guatemala, and Ecuador (PCIT, 2019).

In Mexico, severe WMS infestation led to significant economic losses on 13,218 hectares in 2009 and 3,000 hectares in 2001 (Isiordia-Aquino *et al.*, 2011). It also caused a considerable damage on mangoes in South Africa (Colyn and Schaffer, 1993; Joubert *et al.*, 2000), in Australia, East and West Africa, North and South America, and the Caribbean Islands (Peña *et al.*, 1997). WMS has also been described as a financial problem in Egypt (Morsi *et al.*, 2002; Abo-Shanab, 2012), Ethiopia (Gashawbeza *et al.*, 2015; Mohammed *et al.*, 2012; Ofgaa and Eman, 2015; Temesgen, 2011); Tsegaye *et al.*, 2017); Costa Rica, Korea, Seychelles, Guatemala, and Ecuador (PCIT, 2019). Economic losses as a result of WMS damage are primarily attributable to mango fruit chlorotic patches, which lead to fruit rejection in the market. For instance, fruit rejection was blamed for 50 to 100% of losses recorded from Nayarit, Mexico in 2001 (Hodges *et al.*, 2005). In addition, it has been suggested that mango productivity is low because to significant WMS damage (Blackburn, 1984; Miller, 1990).

## **1.2 Statement of the problem**

Mango (*Mangifera indica* L.) is the third most important tropical and subtropical fruit crop after citrus and banana. It is consumed as a fresh fruit and in many forms of preparations due to its high sugar, vitamin, mineral, and protein content, among other things (Ofgaa Djirata *et al.*, 2017). Marketing fresh and processed fruit goods creates income that can act as an economic cushion and seasonal safety net for low-income farm households. It is also recognized to play a crucial part in export and import industry and is utilized as animal feed, which results in the creation of foreign currency. Mango in Ethiopia cultivated in different regions and it is preceded by citrus and banana and East wollega, particularly, Uke Kebele of Guto Gida district is commonly known in mango production (Tsegay, 2019). All phases of the mango's development are plagued by a number of diseases. Insect pests attach themselves to the entire plant, including the trunk, branches, leaves, petiole, flowers, and fruits. Among the insect pests infecting the mango, white mango scales are the devastating insect pests. *A. tubercularis* is one of the agriculturally important insect pest belong to order Hemiptera and characterized by having a piercing and sucking mouth parts hence it injures mango tree by feeding on the plant sap through leaves, branches and fruits. Recently it becomes a serious on

mango in all mango orchards in many countries (Tsegaye Babege *et al*, 2017). So, the aim of this study was to assess the distribution, prevalence and management option of WMS in Aberamo Woreda, Assosa zone, Western Ethiopia.

### ***1.3 Objectives***

#### ***1.3.1 General objective***

- To assess the distribution, prevalence and management option of WMS in Aberamo Woreda, Assosa Zone, and Western Ethiopia.

#### ***1.3.2 Specific objective***

- To determine prevalence of white mango scale infestation in Aberamo Woreda.
- To assess the loss of white mango scale on the mango cultivating farmers of the district.
- To identify management options of white mango scale that farmer's use in the study area.

### ***1.4 Significance of the study***

Low productivity as a result of defoliation, fruit abortion, inadequate flowering, and drying of twigs make up the first category of yield losses caused by WMS damage. Fruit rejection as a result of fruit blemishes makes up the second. This pest causes significant yield losses in mangoes, especially in Mexico, Ethiopia, Egypt, Brazil, India, and South Africa. There have been a number of attempts to manage WMS up to this point, but no ideal beat control solution has been established. This study was very significant since it informed the government about the distribution of WMS in Aberamo Woreda as well as which management approach is best for managing WMS.

## CHAPTER 2

### LITERATURE REVIEW

#### 2. BIOLOGY OF WHITE MANGO SCALE

White mango scale adult females are opaque white, circular, flat, thin, and often wrinkled (Figure 1), shed skins marginal. Exuviae is near the margin, and is yellowish-brown, with a median black ridge, forming a dark distinct median line. The body of adult female is red, eggs and crawlers are red or pink (1B) (Miller and Davidson 2005). Adult females have 3 to 5 pairs of well-developed lobes (Miller and Davidson 2005). Whereas, males are small, white, sides nearly parallel, and distinctly tricarinate. Crawlers are deep bright brick red (Figure 2B).



**Figure 1** White mango scale adult female; A. with armor, B. armor removed and crawlers, and male (Miller and Davidson 2005)



**Figure 2** White mango scale; A. male armors and B. Adult male (Miller and Davidson 2005)

Both the WMS females and males were randomly distributed on mango leaves, stems, and fruits (Bautista-Rosales *et al.*, 2013). As indicated in Figure 4, males were settling in colonies of 10 to 100 individuals, often near females; these groups are conspicuous due to the white scale covers they produce, which eventually allows them to occupy the entire leaf independent of the season (Bautista-Rosales *et al.*, 2013; van Halteren, 1970). Mostly males prefer the lower canopy of the mango trees, while females were distributed more homogeneously (Bautista-Rosales *et al.*, 2013). However, females were moved towards the lower canopy when the temperature becomes warmer (Bodenheimer, 1951; Carroll and Luck, 1984; Labuschagne *et al.*, 1995). Males can tolerate warmer temperature than females (Labuschagne *et al.*, 1995; Asplanato and García-Marí 2001).



**Figure 3** White mango scale insects on leaf and fruit

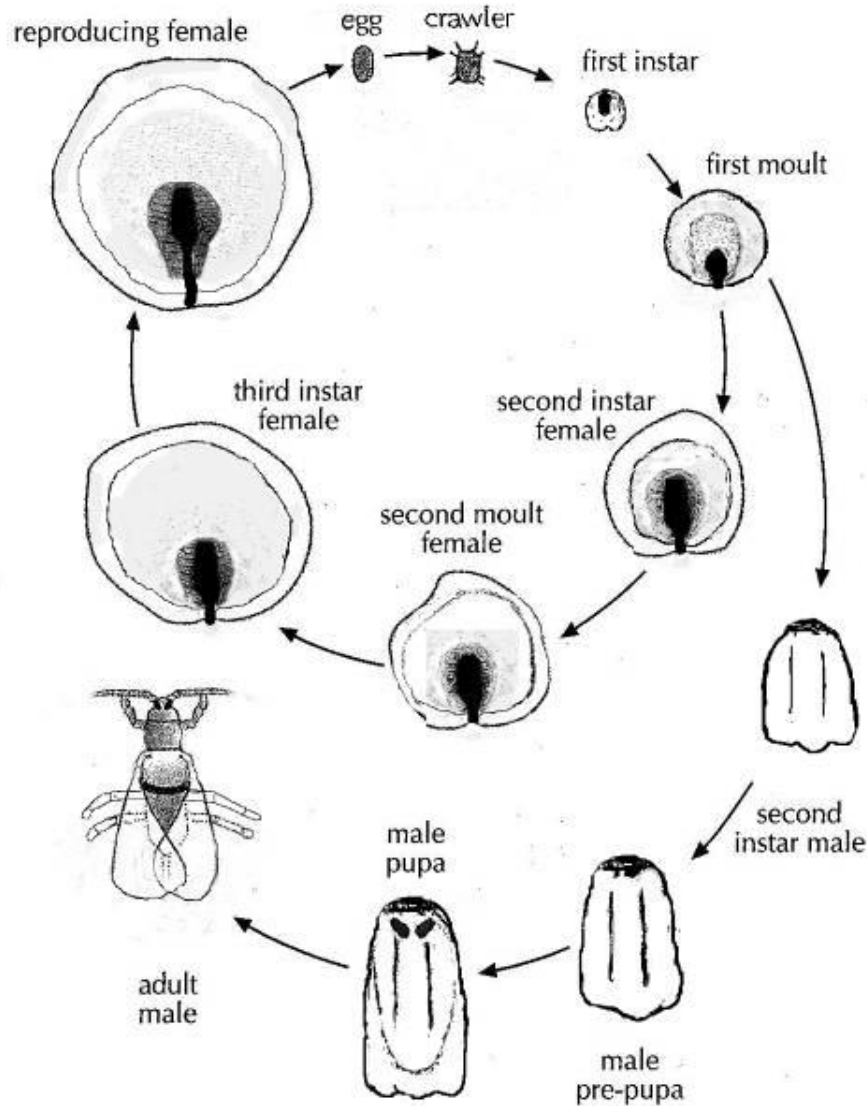


**Figure 4** WMS males grouped around females

### ***2.1 Life cycle of WMS***

WMS has a high reproductive rate with five to six generations per year (Miller and Davidson 2005). Adult WMS females can lay 80 to 200 eggs (Figure 1 B) depending on temperature (Miller and Davidson, 2005). As illustrated in Figure 5, the eggs hatch in 8 days, producing

very small, elongate, and oval red-orange nymphs or crawlers which are totally bare of any wax secretion (Bautista-Martinez 2006, Bautista-Rosales *et al.*, 2013; Urias-López 2006; van Halteren, 1970). The crawler moves to branches, leaves, and flowers and attaches themselves to a suitable place for feeding to grow and reproduce (Bautista-Martinez 2006, Urias-López 2006). After settling, fine threads of wax begin to exude from the body until the insect is completely covered with armored (van-Halteren, 1970).



**Figure 5** Life cycle of white mango scale insect (Miller and Davidson 2005)

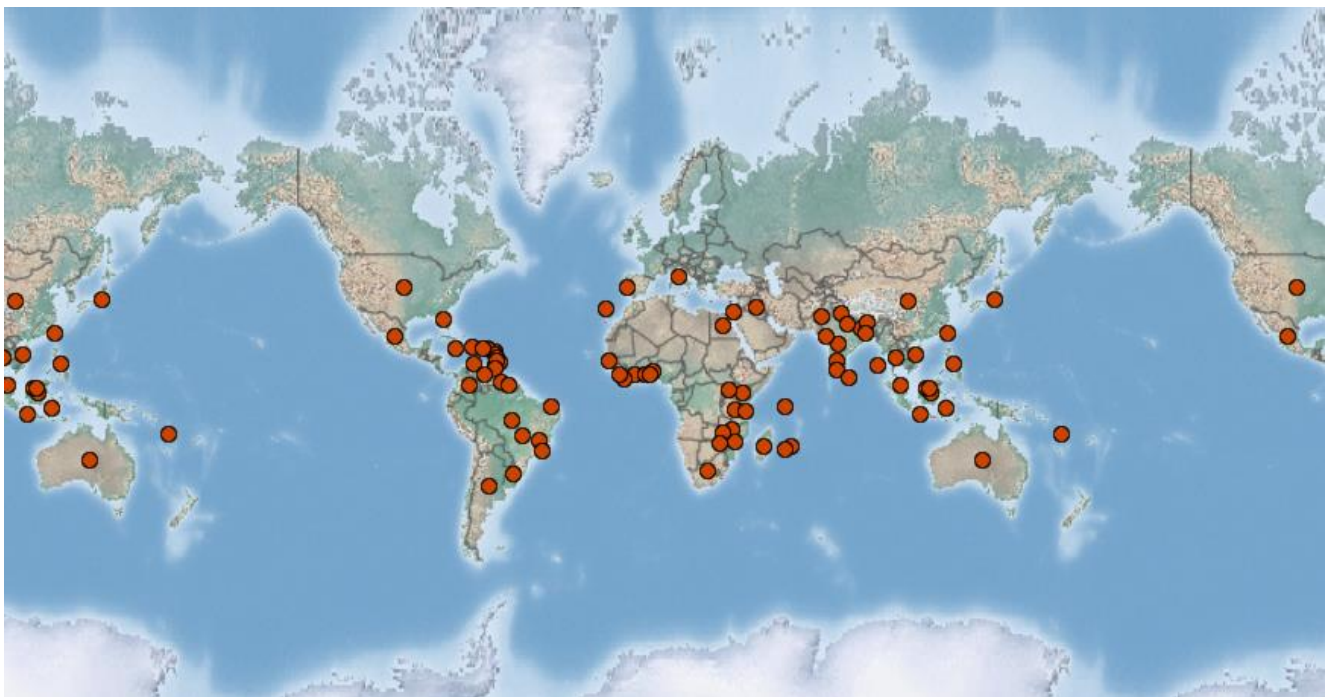
### ***2.2 Means of spread from place to place***

White mango scale may spread long distances through movement of infested mango plant parts and fruits (Abo-Shanab, 2012; Gashawbeza *et al.*, 2015; Iqbal, 2018; Mohammed *et al.*,

2012; Tsegaye *et al.*, 2017). Besides, WMS can be spread by wind or by hitchhiking on animal or equipment (Iqbal, 2018).

### ***2.3 Distribution of White Mango Scale***

White mango scale (*A. tubercularis*) is now widespread in 23 mango-growing countries in tropical Africa, including Benin, Côte d'Ivoire, Egypt, Ethiopia, Gambia, Ghana, Kenya, Liberia, Madagascar, Malawi, Mauritius, Mozambique, Réunion, Rodrigues, Sierra Leone, South Africa, Tanzania, Zanzibar, Togo, Uganda, Zambia, Zimbabwe (ETI BioInformatics, 2019; Hodges & Hamon 2016; Mohammed *et al.*, 2012; Ofgaa and Eman, 2015; Temesgen, 2011),. and most of the Neotropical region , namely in Aruba; Bermuda; Brazil; British Virgin Islands; Colombia; Dominican Republic; Grenada; Guadeloupe; Martinique; Puerto Rico & Vieques Island; Saint Croix; Trinidad and Tobago, Trinidad; U.S. Virgin Islands; Venezuela (ETI BioInformatics, 2019; Francia and Hugo, 2015; García Morales *et al.*, 2018; Hodges & Hamon 2016). In Asia it is reported from China, Japan, India, Indonesia, Malaysia, Pakistan, Philippine, Sri Lanka, Taiwan, Thailand, Egypt, Iraq and Israel (ETI BioInformatics, 2019; Hodges & Hamon, 2016).



**Figure 6** Global distribution of WMS, 2019 (CABI, 2019)

**Table 1** Distribution of white mango scale in Ethiopia

S/N	Region	Zone	Infestation status	Reference
1	SNNP	Benchi-Maji	Severe	Teshale et al., 2019; Tsegaye et al., 2017
		Majang	Severe	Teshale et al., 2019
		Sheka	Severe	Teshale et al., 2019
2	Oromiya	East Wellega	Mild to severe	Teshale et al., 2019; Temesgen, 2011
		West Wellega	Nil to Mild	Teshale et al., 2019; Temesgen, 2011
		Horo-guduru	Severe	Teshale et al., 2019
		Jimma	Nil to Mild	Teshale et al., 2019
		Buno-Bedele	Nil to severe	Teshale et al., 2019
		Iluabbabora	Nil to severe	Teshale et al., 2019
		West Shewa	Mild to severe	Teshale et al., 2019
3	Benishangul Gumuz	Assosa	Severe	Teshale et al., 2019
4	Gambela	Gambella	Mild	Teshale et al., 2019

#### ***2.4 Hosts for White Mango Scale***

Mango (*Mangifera indica*) is the preferred host of this pest, but it has been reported to feed on a wide variety of plants in at least 30 genera in 18 families including: Anacardiaceae, Annonaceae, Arecaceae, Burseraceae, Cucurbitaceae, Calophyllaceae, Iridaceae, Lauraceae, Loranthaceae, Meliaceae, Myrtaceae, Percidae, Pittosporaceae, Rhizophoraceae, Rosaceae, Rutaceae, Sapindacea and Zingiberaceae (García Morales *et al.*, 2018).

**Table 2** The eight host families of White mango scale hosts

S/N	Host family	Host species
1	Aceraceae	Acer kawakamii
2	Anacardiaceae	Mangifera indica (Preferred host)
		Mangifera sp.
3	Arecaceae	Cocos nucifera
4	Iridaceae	Dietes prolongate
5	Lauraceae	Cinnamomum camphora
		Cinnamomum ceylanicum
		Laurus nobilis
		Litsea laurifolia
		Litsea polyantha
		Litsea pungens
		Litsea sebifera
		Machilus sp.
Phoebe sp.		
6	Pittosporaceae	Pittosporum glabratum
7	Rutaceae	Citrus sp.
8	Sapindaceae	Dimocarpus longan

### ***2.5 Economic Importance of White Mango Scale Insect***

White mango scale hurt mangoes by sucking the plant sap from leaves, branches, and fruits that resulted in defoliation (particularly in young mango trees), drying up of young twinges, poor blossoming, premature fruit dropping, low productivity (Blackburn, 1984; Miller, 1990), retarded growth of severely infested mango seedlings in nurseries (Temesgen, 2011), and conspicuous pink blemishes on fruits (Figure 7); which reduce the marketable value of fruits and even cause fruit rejection in exports (Hodges *et al.*, 2005, Urias-Lopez 2006). According to Hodges *et al.* (2005) and Urias-Lopez (2006), fruit rejection because of WMS damage resulted in 50 to 100% losses on mangoes during 2001 in Nayarit, Mexico. Great economic losses were recorded on 3,000 hectares in 2001, which increased to 13,218 hectares in 2009

(Isiordia-Aquino *et al.*, 2011). Also, significant losses were reported on mango especially in Brazil, China, India, and Pakistan (Hodges and Hamon, 2004).



**Figure 7** WMS damage to mango fruit

Even though, the magnitude of economic losses is unknown, but WMS presented a significant damages to mango plantations in Colima, Jalisco, and Sinaloa states (SAGARPA, 2011), in different parts of Ethiopia (Ofgaa and Eman, 2015; Temesgen, 2011; Tsegaye *et al.*, 2017), in Egypt (Morsi, *et al.*, 2002; Abo-Shanab, 2012), in Kenya (Ofgaa and Eman, 2015), in South Africa (Colyn and Schaffer, 1993; Joubert *et al.*, 2000), in Australia, East and West Africa, North and South and North America, and Caribbean Islands (Peña *et al.*, 1997).



**Figure 8** Mango leaves lost their green colors due to WMS feeding



**Figure 9** Dried mango leaves and twigs due to WMS damage

## **2.6 White Mango Scale Management Strategies**

### **2.6.1 Cultural**

Farmers practiced pruning, smoking, and site clearing in order to minimize the risk of WMS in their mango plantations. Pruning of heavy infested twigs and dense branches can help to eliminate infestation when the WMS infestation is on limited parts of the mango plant (Temesgen, 2011). Pruning reduced the number of females from 1.8813 to 0.6456 per leaf (Bautista-Rosales *et al.*, 2013). Also, pruning increases scale mortality as a result sun light (heat) exposure and smoking using fallen leaves, grasses, weeds, and animal dung within mango trees reduces WMS population by chasing WMS away from the mangoes (Temesgen, 2011).

### **2.6.2 Biological**

Natural enemies can play a great role in regulating WMS abundance (Labuschagne *et al.*, 1995; Daneel and Dreyer, 1998; Joupert *et al.*, 2000). Some of the natural enemies of WMS includes the trash-carrying lacewing *Cereaochrysa* sp. (Neuroptera: Chrysopidae), *Chilocorus* sp., *Cybocephalus* sp. (Coleoptera: Coccinellidae) (Urias-Lopez and Flores 2005, Isiordia-Aquino *et al.*, 2011) and/or parasitoids such as *Encarsia citrina* Craw (Hymenoptera: Aphelinidae) (Abo-Shanab, 2012). In South Africa, *Encarsia* sp. (Hymenoptera: Aphelinidae) was averagely parasitized 17.7% of *A. tubercularis* females on mangoes (Schoeman, 1987). Also, hymenopterous parasitoids were common natural enemies of *A. tubercularis* in Ghana (Van Halteren, 1970).

The coccinellid predators *Rhyzobius lophanthae* Blaisdell and *Chilocorus nigrita* (Fabricius) (Coleoptera: Coccinellidae) are common in South Africa, where they have been introduced, but are generally not sufficient in themselves to keep WMS populations below economically damaging levels (Urias-Lopez and Flores 2005; Isiordia-Aquino *et al.* 2011).

### **2.6.3 Chemical**

According to Gashawbeza *et al.* (2015), five times spray of 1.7 ml Spirotetram (Movento 150 OD) mixed with 3 liters of water at biweekly basis was superior in controlling WMS. This insecticide belongs to the tetracyclic acid chemical class and it has a unique mode of action classified as a lipid biosynthesis inhibitor (Bayer, 2019).

### **2.6.4 Mineral oils**

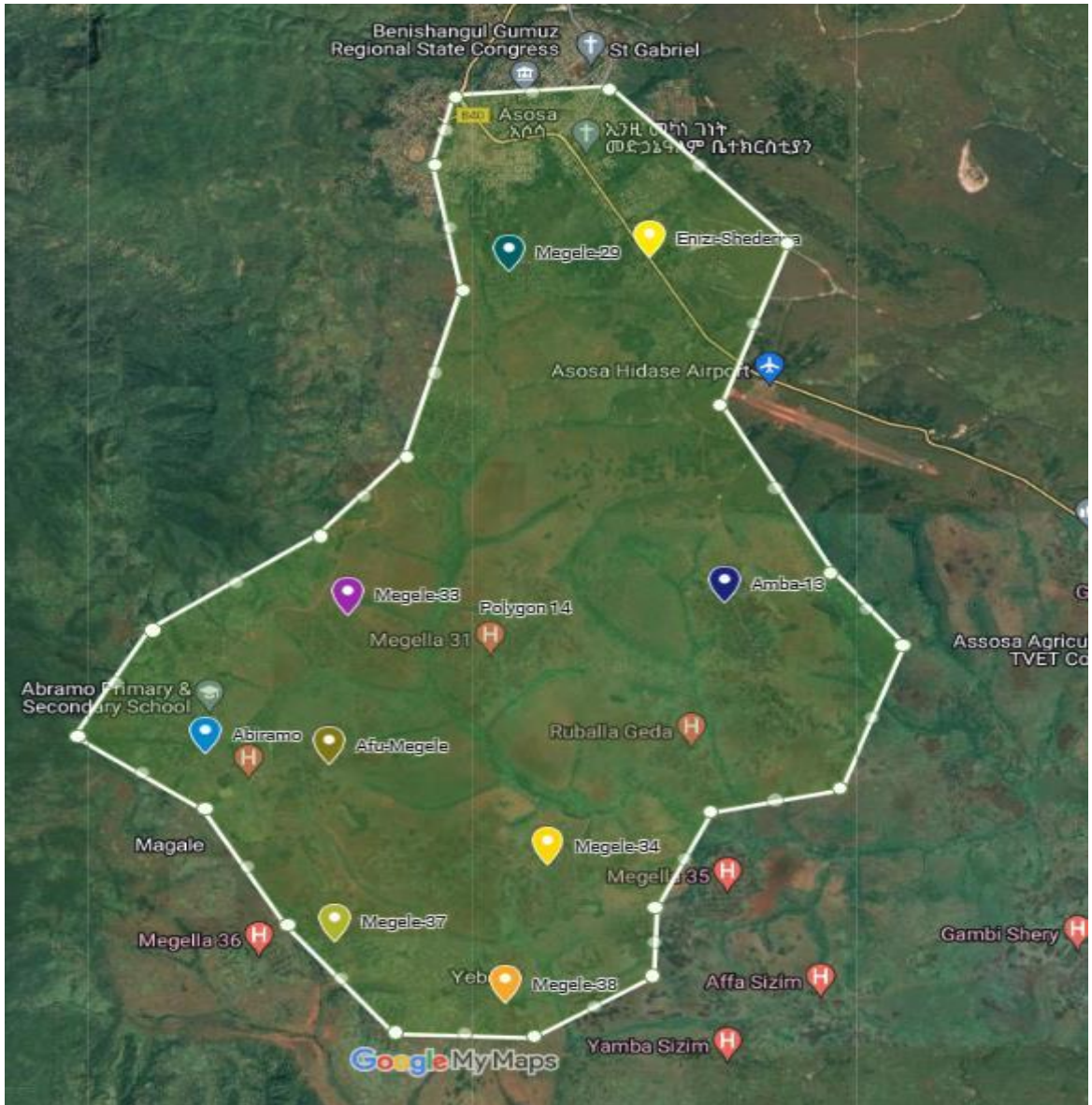
Diver oil® 97% was the most effective mineral oil that suppresses *A. tubercularis* population up to six months at Rasheed district, El-Beheira Governorate of Egypt (Abo-Shanab, 2012). Mineral oils are valuable because of their little residual toxicity for beneficial insects (Abo-Shanab, 2005; El-Halawany *et al.*, 1987; Helmy *et al.*, 2006; Moursi *et al.*, 1991).

## CHAPTER THREE

### MATERIALS AND METHODS

#### 3.1 Description of the Study Area

The elevations of the study area ranges from 1423 to 1600 m.a.s.l. and geographically the area is located in between 10° 19' 60.00" N latitude and 34° 39' 59.99" E longitude, with an elevation of 1570 M. Aberamo woreda is located 667 km to West of Addis Ababa. The region is bordered by Amhara regional state in the north and northeast, Oromia region in the south and southeast, and Gambella region in the south. It also shares an international boundary with both Sudan and South Sudan in the west. It has a population of 342,287; male 188,258 and female 154,029 (2007 census conducted by the CSA of Ethiopia). The four largest ethnic groups reported in the Asosa Zone were the Beneshangul (59.95%), the Amhara (23.86%), the Oromo (10.31%), and the Tigrayans (1.5%), 1.48% of the population was from Sudan; all other ethnic groups made up 2.9% of the population. Main languages are the Beneshangul (59.31%), Amharic (25.7%), Oromo (10.68%), and Tigrinya (1.07%). Abay, Dabus, and Tumet rivers are found in the zone. A mixed farming, crop, livestock production and artisan gold mining, are the major the livelihood of the population. Major crops grown in the areas are sorghum, maize, finger millet, soya bean and ground nut. Livestock species commonly kept are goats, cattle, chicken and donkeys in order of importance (AsARC, 2006).



**Figure 10** Study area

### **3.2 Study design**

For eight consecutive months, an entomological survey was carried out to collect WMS insects on every month. From September 2022 to April 2023 including both season (Dry and wet), the study was carried out in ten Kebele in Aberamo Woreda (namely, Afamegele, Aberamo, Megele-34, Megele-33, Megele-37, Megele-38, Roba geda, Amba-13, Enzy shedria, and Megele-29). The evaluation of WMS throughout the study area was conducted using a purposive sampling technique which means purposely select the Kebeles and the farmers based on the amount mango production.

### **3.3 Method of Data Collection and Sampling Procedures**

Ten Kebele in the Assosa zone, Aberamo Woreda were specifically chosen for this study based on their mango output. Eight households that grow mangoes from each Kebele made up a total of eighty (80) farmers who were specifically chosen for the study based on the number of mangoes they produce.

Preliminary survey on the prevalence of white mango scale on mango trees was collected from the Agriculture Office of Assosa Zone. To track the presence or absence of the WMS pest incidence and pest density, data sheets were prepared. After the existence of the pest was detected, the level of leaf infestation was assessed using a hand lens and a visual evaluation of the proportion of infested leaves by selecting ten leaves at random from each of five mango trees in each Kebele. The infestation and degree of damage were recorded using a scoring method ranging from 0 to 5 scale as free 5% of the panicle destroyed, minimal damage 5 to 24% of the panicle destroyed, moderate 25 to 50% damage, severe 51 to 70% damage, and extremely severe = 71 to 100% damage (Williams 2009). So severity status of the infestation as used by (Fita (2014)) was rated and categorized based on cluster number per leaf was related to each other as:  $<1 = < 5\%$  (Free or Zero for less than one cluster formation),  $>1.0 - 2.0 = 5$  to 24% (Minimal for greater than one and less than two clusters formation per leaf),  $>2.0 - 4.0 = 25$  to 50% (Moderate for greater than two and less than four clusters formation per leaf),  $>4.0 - 5.0 = 51$  to 70% (Severe for greater than four and less than five clusters formation per leaf) and  $>5 = 71$  to 100% (Very Severe for greater than 5 clusters formation) of leaves damaged. During the assessment, the coordinates of each assessed site was recorded with the help of Global Positioning System (GPS). The data was collect randomly from September (2022) to April (2023) from the mango farm lands and

Questionnaire was distributed for purposively sampled population. The Questionnaire was prepared for 80 participants, observation, and an interview was done for 30 participants. Focus group discussion also conducted with agricultural officers on the management option of white mango scale.

### **3.4 Data collection tools**

#### **Questionnaire and Interview**

Questionnaire was employed to collect quantitative and qualitative data from selected farmers. The questionnaire was prepared for respondent farmers. Through structured questionnaires by posing direct and information seeking open ended questions to the interviewer, qualitative and quantitative data was collected from the farmers. Information about their experience in mango production, distribution, severity, prevalence and management practices options of the farmers in the past and present situation of the pests would collect from sampled mango grower farmers and an interview would made for the Head of Agriculture Office of the district.

### **3.5 Data analysis**

Data organization, analysis and competence checked using Microsoft excels. Data were analyzed and interpreted by qualitative (descriptive method) and quantitative (percentage, frequency, tabulation) and methods using SPSS software (SPSS version 20). Calculation of the percentages and frequency of counts were used to arrive at a general conclusion and used as a tool for analysis of quantitative data. In general, close-ended questions were analyzed through tables (frequency) and percentages to compare results. Open-ended questions including interview and observations were analyzed using descriptivemethods.

## CHAPTER FOUR

### RESULT AND DISCUSSION

#### 4.1 Survey on farmers' knowledge and management practices of white mango scales

##### 4.1.1 Demographic Characteristics of the participant

From the total respondents, 87.5% were males and 12.5% were female, 93.75% were married, and 56.25% had completed primary education (Table 3). Furthermore, 31.5% of respondents did not attend school.

**Table 3 Demographic data of the participant**

Sex		N	%
	Male	70	87.5
	Female	10	12.5
Age	Below 25 years	4	5
	26-35 years	12	15
	36-45 years	48	60
	46- 55 years	9	11.25
	56-65 years	5	6.25
	Above 66 years	2	2.5
Marital status	Married	75	93.75
	Unmarried	3	3.75
	Divorced	2	2.5
Level of education	Never attend School	25	31.25
	Attended Primary School	45	56.25
	Attended High School	5	6.25
	Completed High School	5	6.25

The age structure of the participants shows that about 60% (48) were between the ages of 36 and 45, 15% (12) were between the ages of 26 and 35, and 11.25% (9) were between the ages

of 46 and 55, 5% (4) were under the age of 25, 6.25% (5) were between the ages of 56 and 65, and 2.5%(2) were over the age of 66 (Table 3).

#### 4.2 Information about white mango scale and its current status and its impact on mango

As indicated in Table 4, 100% (80) of the respondents from the study area were experienced about the impact of pests on mango farming. Concurrently, 100% (80) of respondents claimed that mango production was affected with pests and displayed various symptoms during a 10-year period. Furthermore, no governmental or non-governmental organizations provided any assistance to the respondents. The prevalence of mango infestation was still very high in the study area and the newly distributed improved mango seedlings were also infested with white mango scale.

**Table 4 Information about white mango scale and its current status and its impact on mango**

Did you experience on your mango farm the insect pest infecting mango before?	Yes	80	100
	No	0	
How many years old that you noticed that your mango get infected and show different symptoms?	10 years	80	100
	20 years		
	30 years		
	Above 35 years		
Did you have observation whether the pest was affected the local and the newly emerged varieties of the mangoes equally?	Yes	80	100
	No		
Have you ever received any external supports from Government, NGOs and other agencies?	Yes		
	No	80	100
Did you have any observation as to whether the newly distributed improved mango seedlings distributed to them by the project infected or not?	Yes infected	80	100
	No infected		
Have you seen any chance of survival on the new mango seedlings planted on their farms?	Yes		
	No	80	100
Currently, what is the prevalence of the infestation?	very high	80	100
	High		
	Moderate		
	Low		

### 4.3 Mango production and farmers experience about white mango scale

As shown in Table 5 respondents participated in this study were witnessed that mango production is a common farming practice in the study area. From the respondents 70% (56) for 10-20 years, 18.75% (15) for 21-30 years, 7.5% (6) for below 10 years, and 3.75% (3) were practice mangos farming production for above 31 years, respectively.

**Table 5 Mango production experience of the farmers**

For how long have you been producing mango	Number of farmers	Percentage
Below 10 years	6	7.5
10-20 years	56	70
21- 30 years	15	18.75
Above 31 years	3	3.75

### 4.4 Management Methods

As shown in the table below, 90% of respondents in the study area adopted cultural strategies to manage pest infestation on mango crop. Those methods are Smoking, Ash, Site clearing, and Pruning. Methods used to control insect pests were ineffective, and 56.25% (45) of respondents confirmed that the methods used to control insect pests were ineffective; while 25% (20) respondents justified that the methods used to control pests were efficient but those methods are not sustainable.

**Table 6 Management methods and effectiveness of the control method**

What methods did you practices to control the infestation?	0	Frequency	Percentage
	Cultural	72	90
	Chemical	5	6.25
	Both	3	3.75
	Others		
Did the method you used to manage the pest is efficient to control the pest?	Yes	20	25
	No	45	56.25
	To some extent	15	18.75

#### **4.5 Parts of mango attacked by WMS**

Leaves of mango plant 62.5 %(50) are primarily attacked by insect pest based on responses from the informants, which is followed by branches 18.75% (15). Both varieties (local and the newly emerged) of mango in the study area were affected by insect pest and the respondents were not familiar with such kind of pest infestation rather than white mango scale. Concomitantly, Tesfaye Hailu et al. (2014) revealed that the pests first infest the leaves and make the leaves to have whitish spot, which is dropped down to the stem and affect all the barks of tree. Furthermore, the infestation of pests makes the fruit of mango to have low quality and lost its original color. Additionally, the pest affects the root of mango plant by covering with white small fibers and enhances substantial infested to poor growth and finally drying out the tree. The study by Ofgaa Djirata *et al.* (2016) in Eastern and central Kenya also showed that the damages that the respondents believed to have been caused by the pest to mango plantation were spots on fruits, yellow spots on leaves, drying and falling off of leaves, and drying of young twigs.

**Table 7 Part of plant affected by WMS**

Part of plant affected	Frequency	Percentage
Leaves	50	62.5 %
Fruits	5	6.25 %
Branches	15	18.75 %
Others	0	0

#### **4.4 Distribution of white mango scale**

From Table 7 the four dry seasons (January, February, March and April) have high infestation in which it hits peak on April. The wet seasons (September, October, November and December) have low infestation and comparatively December have much lower infestation. The abundance of white mango scale mean cluster during the study period across orchards showed rapid decrease from August to October and during November and December were stayed low and being undetectable. The clusters were started progressive increase from January to February and rapid increase to peak from March to April (Buzayehu, 2019). Infestation status was significantly varied among study months; lowest and highest record during December and April respectively ( $P < 0.05$ ). Temperature influence the infestation positively; a maximum record during maximum temperature of the study month April. High amount and continued rain fall and relative humidity influence infestation negatively. Optimum rain fall and relative humidity and also unmanaged mango orchards condition made the infestation serious. In the case of the research area, the infestation status was insignificant since the area is kola (low-land), which has the same agro-ecological zone.

**Table 8 Distribution of white mango scale**

<b>Kebele</b>	<b>September</b>	<b>October</b>	<b>November</b>	<b>December</b>	<b>January</b>	<b>February</b>	<b>March</b>	<b>April</b>	<b>Average</b>
<b>Abramo</b>	4.7	2.3	1.2	0.9	6.86	10.9	13.62	19.38	7.48
<b>Megele 33</b>	5.4	3.32	2.02	0.92	6.76	10.28	14.88	23.16	8.34
<b>Megele 34</b>	3.5	2.4	1.9	0.92	5.26	8.4	17.3	25.26	8.12
<b>Afa megele</b>	5.44	2.38	1.22	0.54	5.16	8.04	11.74	18.66	6.65
<b>Megele39</b>	5.84	3.66	2.08	0.82	4.62	8.94	15.56	25.44	8.37
<b>Megele 38</b>	4.04	3.4	2.54	0.94	4.62	7.42	13.42	22.4	7.35
<b>Amba 13</b>	6.56	5	2.8	1.46	6.56	11.62	18.22	29.3	10.19
<b>Roba geda</b>	5.16	2.64	1.44	0.8	5	7.46	12.06	16.92	6.44
<b>Enzi shedria</b>	6.54	4.04	2.22	0.74	4.46	7.4	12.08	22.74	7.53
<b>Megele 29</b>	5.24	3.7	2.46	1.58	5.96	10.68	20.32	34.24	10.52
<b>Average</b>	5.242	3.284	1.988	0.962	5.526	9.114	14.92	23.75	8.10

## CHAPTER FIVE

### CONCLUSION

Mango is a significant crop with a number of health advantages. However, a number of insect pests prey on this significant crop, with the white mango scale (WMS) insect, *Aulacaspis tubercularis* Newstead, being one of the most destructive in Ethiopia. Farmers noticed that the white mango scale insect pest infestation ranged from medium to high incidence and severity status and affected all mango cultivars. It also affects the commercial value and export potential of the fruits made the trees by causing defoliation, drying up of young twigs, poor blossoming, whitish color canopy cover, stunting and distortion of fruits, and branches premature fruit drop and drying of flower, which results in a significant yield reduction. Mango growers believed that the pest was predominantly dispersed through planting materials, and that its management was difficult due to their uncontrollable mango size nature, and that the majority of mango trees were grown in backyard farms, making insecticide spraying and cultural management difficult. The infestation of white mango scale insect pests varied regionally and seasonally depending on mango orchard management, seasons, rain fall, temperature, and relative humidity. Higher density on upper leaf compared to lower leaf. Governmental and non-governmental organizations should be participated in pest research and management programs.

## **Recommendation**

Based on the study's findings, the following recommendation is made:

- Governmental and non-governmental organizations should be participated in pest research and management programs.
- WMS tolerant variety of mango should be identified and offered for mango grower farmers.
- Regarding the control of the white mango scale, Integrated Pest Management should be developed based on the local situation.

## REFERENCE

- Abo-Shanab, A. S. H. (2005). Efficacy of some IGRs/Insecticides. KZ oil and binary mixtures on mortality and enzyme activity of Egyptian mealybug *Icerya aegyptiaca* (Douglas) attacked Guava trees in Alexandria Governorate. *J. Pest Cont. and Environ. Sci*, 13(1), 73-85.
- Abo-Shanab, A. S. H. (2012). Suppression white mango scale, *Aulacaspistubercularis* Newstead (Hemiptera: Diaspididae) on mango trees in El-Beheira Governorate, Egypt. *Acad. J. Biolo. Sci*, 5(3), 43-50.
- Atnafu, Y. (2020). Management of white mango scale, *aulacaspis tubercularis* (homoptera: diaspididae) using pruning, oils and pesticides in eastern wellega, Ethiopia (Doctoral dissertation, Jimma University).
- Asplanato, G., & Farcía-Marí, F. (2001). Ciclo estacional de la cochinilla roja californiana, *Aonidiella aurantii* (Maskell)(Homoptera: Diaspididae) en naranjos del sur de Uruguay. *Agrociencia-Sitio en Reparación*, 5(1), 54-67.
- Ayalew, G., Fekadu, A., & Sisay, B. (2015). Appearance and chemical control of white mango scale (*aulacaspis tubercularis*) in central rift valley. *Science, Technology and Arts Research Journal*, 4(2), 59-63.
- Babege, T., Haile, B., & Hailu, A. (2017). Survey on distribution and significance of white mango scale (*Aulacaspis tubercularis*) in bench-Maji zone, Southwest Ethiopia. *Journal of Horticulture and Forestry*, 9(4), 26-32.
- Balock, J. W., & Kozuma, T. T. (1964). Notes on the biology and economic importance of the mango weevil, *Sternochetus mangiferae* (Fabricius), in Hawaii (Coleoptera: Curculionidae).
- Bautista Martínez, N. (2006). Insectos plagauna guía ilustrada para su identificación (No. C/632.60972 B3).
- Bautista-Rosales, P. U., Ragazzo-Sánchez, J. A., Calderón-Santoyo, M., Cortéz-Mondaca, E., & Servín-Villegas, R. (2013). *Aulacaspis tubercularis* Newstead in Mango Orchards of Nayarit, Mexico, and Relationship with Environmental and Agronomic Factors. *Southwestern Entomologist*, 38(2), 221-230.

- Blackburn, V. L., & Miller, D. R. (1984). Pests not known to occur in the United States or of limited distribution, No. 44: Black parlatoria scale. United States Department of Agriculture. *Plant Protection and Quarantine, Animal and Plant Health Inspection Service*, 81-45.
- Bodenheimer, F. S. (1951). Citrus entomology in the Middle East with special references to Egypt, Iran, Irak, Palestine, Syria, Turkey (No. BOD 634.3 (BR 533)). Dr., W. Junk, Publishers.
- Borkhsenius, N. S. (1966). A catalogue of the armoured scale insects (Diaspidoidea) of the world. *A catalogue of the armoured scale insects (Diaspidoidea) of the world*.
- Bayer, 2019. <https://www.bayercropscience.us/products/insecticides/movento>. Accessed on 10 December 2019.
- Carroll, D. P., & Luck, R. F. (1984). Within-tree distribution of California red scale, *Aonidiella aurantii* (Maskell)(Homoptera: Diaspididae), and its parasitoid *Comperiella bifasciata* Howard (Hymenoptera: Encyrtidae) on orange trees in the San Joaquin Valley. *Environmental entomology*, 13(1), 179-183.
- Colyn, J. (1992, July). The South African mango industry. In *IV International Mango Symposium 341* (pp. 60-68).
- Crane, J.H, Balerdi, C.F., and Maguire, I., 2013.. Mango growing in the Florida home landscape. University of Florida, IFAS Extension, <http://www.edis.ifas.ufl.edu> (accessed: 12January 2015).
- Daneel, M. S., & Dreyer, S. (1998). Biological control of the mango scale, *Aulacaspis tubercularis*, in South Africa. *Yearbook-South African Mango Growers' Association*, 18, 52-55.
- Dawd, M. (2012). Belay H/Gabriel. Lemma Ayele., Konjit Feleke., Seyoum Hailemariam., Teshome Burka.(2012a). White mango Scale: A new Insect Pest of Mango in Western Ethiopia, 257-267.
- El-Halawany, M. E., Metwally, A. M., & Nassar, M. E. (1987). Activity of albulium on the citrus brown mite biology and the sensitivity of different mite species to certain chemicals. *Agric. Res. Rev*, 65(1), 37-42.

- Fita, T. (2014). White mango scale, *Aulacaspis tubercularis*, distribution and severity status in East and West Wollega Zones, western Ethiopia. *Science, Technology and Arts Research Journal*, 3(3), 1-10.
- Food and Agriculture Organization of the United Nation (FAO), 2010. Technical guidelines on tropical fruit tree management in Ethiopia, FAO.
- García Morales, M., Denno, B. D., Miller, D. R., Miller, G. L., Ben-Dov, Y., & Hardy, N. B. (2016). ScaleNet: a literature-based model of scale insect biology and systematics. *Database*, 2016.
- Germain, J. F., Vayssieres, J. F., & Matile-Ferrero, D. (2010). Preliminary inventory of scale insects on mango trees in Benin. *Entomologia Hellenica*, 19(2), 124-131.
- Griesbach, J. (2003). *Mango growing in Kenya*. World Agroforestry Centre.
- Halteren, P. V. (1970). Notes on the biology of the scale insect *Aulacaspis mangiferae* Newst.(Diaspididae, Hemiptera) on mango. *Ghana Journal of Agricultural Science*, 3(2), 83-85.
- Helmy, E. I., Kwaiz, F. A., & Radwan, S. G. (2006). Mineral oils as safe alternative pesticides against *Russellaspis* (= *Asterolecanium*) *pustulans* (Cockerell)(Homoptera: Coccoidea: Asterolecaniidae) on apple at El-Nobarria district, Egypt. *Egypt J. of Appl. Sci*, 21(10), 786-793.
- Hodges, G., & Hamon, A. (2016). White Mango Scale, *Aulacaspis tubercularis* Newstead (Coccoidea: Diaspididae). Pest Alert, Florida Department of Agriculture and Consumer Services, Pest Alert Division of Plant Industry, Pest Alert.
- Iqbal, J., 2018. California pest rating for *Aulacaspis tubercularis* Newstead: Mango scale Hemiptera: Diaspididae.
- Isiordia-Aquino, N., García-Martínez, O., Flores-Canales, R.J., Díaz-Heredia, M., Carvajal-Cazola, C.R., and Espino-Álvarez, R., 2011. El cultivo de mango en Nayarit, acciones e impacto en materia fitosanitaria 1993-2010. *Rev. Fuente*. 2: 34-43.
- Joubert, P. H., Daneel, M. S., & Grove, T. (1999, April). Progress towards integrated pest management (IPM) on mangoes in South Africa. In *VI International Symposium on Mango 509* (pp. 811-818).

- Kondo, T., & Muñoz-Velasco, J. A. (2009). Nuevos registros de *Aulacaspis tubercularis* Newstead (Hemiptera: Diaspididae) en Colombia y experimentos de transferencia de hospederos. *Rev. Asiava*, 84, 18-20.
- Labuschagne, T. I., Van Hamburg, H., & Froneman, I. J. (1995). Population dynamics of the mango scale, *Aulacaspis tubercularis* (Newstead) (Coccoidea: Diaspididae), in South Africa. *Isr. J. Entomol.*, 29(34).
- Louw, C. E., Labuschagne, C., & Swart, S. H. (2008). Developing a mango programme for optimum mango yield and quality. *South African Mango Growers' Association Research Journal*, 28, 1-11.
- Miller, D. R., & Davidson, J. A. (1990). A list of the armored scale insect pests, pp. 299-306. *Armored scale insects: their biology, natural enemies, and control*. Elsevier, Amsterdam, The Netherlands.
- Miller, D. R., & Davidson, J. A. (2005). *Armored scale insect pests of trees and shrubs (Hemiptera: Diaspididae)*. Cornell University Press.
- Miller, D. R., & Gimpel, M. E. (2002). *Eriococcus coccineus* Cockerell, ScaleNet. USDA Systematic Entomology Laboratory. WEB site: [http://www. sel. barc. usda. gov/catalogs/eriococc/Eriococcus\\_coccineus. htm](http://www.sel.barc.usda.gov/catalogs/eriococc/Eriococcus_coccineus.htm) accessed 29 April 2003.
- Moursi, K. S., Gomaa, E. M., & Youssef, K. H. (1991). On the chemical control of the olive-tree scale, *Leucaspis ricca* targ. dry-farm system. *Mansoura Journal of Agricultural Sciences (Egypt)*.
- Nabil, H. A., Shahein, A. A., Hammad, K. A. A., & Hassan, A. S. (2012). Ecological studies of *Aulacaspis tubercularis* (Diaspididae: Hemiptera) and its natural enemies infesting mango trees in Sharkia Governorate, Egypt. *Egyptian Academic Journal of Biological Sciences*, 5(3), 9-17.
- Ofgaa, D. J., & Eman, D. G. (2015). Infestation of *Aulacaspis tubercularis* (Homoptera: Diaspididae) on mango fruits at different stages of fruit development, in western Ethiopia. *Journal of Biology, Agriculture and Healthcare*, 5(18), 34-38.

- Peña, J. E., Mohyuddin, A. I., & Wysoki, M. (1996, September). The current mango pests management in the tropics and subtropics. In *V International Mango Symposium* 455 (pp. 812-820).
- PCIT, 2019. USDA Phytosanitary Certificate Issuance & Tracking System (PCIT). Phytosanitary Export Database (PExD). Harmful organism report: *Aulacaspis tubercularis*. <https://pcit.aphis.usda.gov/pcit/>. Accessed 05 October 2019.
- Stovold, G. E., & Dirou, J. F. (2004). Blight diseases in mangoes. DPI-489 (First edition 2004). Alstonville: NSW Centre for Tropical Horticulture, 1-3.
- Tsegaye Ayana Weyessa (2019). Study on prevalence of white mango scale and their Management options in Alge Sachi district of Illu Aba Bora zone, Oromia regional state, Ethiopia
- Tsegaye Babege, Bewuketu Haile and Awulom Hailu (2017). Survey on Distribution and Significance of white mango scale, *Aulacaspis tubercularis* in Benchi –Maji Zone, Southern Ethiopia. *Journal of Horticulture and Forestry* 9(4): 27 *University college of Agriculture, Bahauddin and Zakariya University, Mutan Pp 17*
- Temesgen, F. (2011). Distribution, prevalence and farmers management practices of white mango scale (*Aulacaspis tubercularis* Newstead: Diaspididae) In Wollega, Western Ethiopia (Doctoral dissertation, M. Sc. Thesis, Addis Ababa University, Addis Ababa. 92pp).
- Ubwa, S. T., Ishu, M. O., Offem, J. O., Tyohemba, R. L., & Igbum, G. O. (2014). Proximate composition and some physical attributes of three mango (*Mangifera indica* L.) fruit varieties. *International Journal of Agronomy and Agricultural Research*, 4(2), 21-29.
- Williams, B. (2009). Integrated pest management and supply chain improvement for mangoes in the Philippines and Australia.

## Appendices

### Appendix I

#### Questionnaire

This questionnaire has been disposed to collect information from mango farmers of Assosa woreda regarding to their understanding about the prevalence of white mango scale, its effect on their production of mango and their management options they undertake.

I would like to thank in advance for your kind cooperation.

#### I. Demographic data

1 Sex: A. Male B. Female

2 Age: A. below 25 years\_\_\_ B .26-35years\_\_ C. 36-45 years D. 46-55 years\_ E. 56-65years  
F .above 66 years\_\_\_\_\_

3 Marital status: A .Married \_\_\_\_\_ B. Unmarried \_\_\_\_\_

#### 4 Level of Education

A. Never attended School\_\_\_\_ B. Attended primary School\_\_\_\_

C. Attended High School\_\_\_ D .Completed High School \_\_\_\_

#### II. Information about white mango scale and its current status and its impact on mango.

1 For how long have you been producing mango?

A. below 10 years\_\_\_\_ B. 10-20 years\_\_\_\_ C. 21-30 years\_\_\_ D. above 31 years\_\_\_\_

2 What kind of mango varieties are you cultivating currently?

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3 Did you experience on your mango farm the insect pest infecting mango before?

A .yes B. no

4 How many years old that you noticed that your mango get infected and show different symptoms?

A, 10 years B, 20 years C, 30 years D, above 35 years

5 What damage do the (mango fruit pests) white mango scale caused to your mango?\_\_\_\_\_

6 Did the damage with the insect pest increase or decrease your annual income?

A. increases B. Decreases C. no change

7 If it affect your income in what aspects?

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8 What methods did you practices to control the infestation?

A. Cultural B. Chemical C. Both D. Others

9 If you used cultural method to manage the pest what are the major onces? \_\_\_\_\_

10 Did the method you used to manage the pest is efficient to control the pest?

A. yes B. No C. To some extent 33

11. Which parts of the plants were first attached by the pest?

A. leaves B. Fruits C. Branches D. Others

12 How do you describe the effect of the pest on the infected mango trees, right starting from its symptom on mango trees and its subsequent manifestation?  
\_\_\_\_\_

13 Did you have observation whether the pest was affected the local and the newly emerged varieties of the mangoes equally?

A Yes B No C If no why?

14 Have you ever seen such kind of pest or diseases affecting the mango trees in such magnitude in your life in this area?

A. yes B. no

15 Have you ever received any external supports from Government, NGOs and other agencies?

A yes B .no

16 If yes what were the types of support and the result obtained?  
\_\_\_\_\_

17 Did you have any observation as to whether the newly distributed improved mango seedlings distributed to them by the project infected or not?

A. Yes infected B. No not infected

18 Have you seen any chance of survival on the new mango seedlings planted on their farms?

A. yes B. No

19 What protection measures did you take for the new mango seedlings not to be affected by the pests?  
\_\_\_\_\_

20 Currently, what is the prevalence of the infestation?

A. very high B. High C. Moderate D. low

**Appendix II**

**Multiple Comparisons**

Dependent Variable	(I) Month	(J) Month	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
T1	April	Decmeber	22.5100 <sup>*</sup>	1.08483	.000	20.3474	24.6726
		February	14.4400 <sup>*</sup>	1.08483	.000	12.2774	16.6026
		January	18.0000 <sup>*</sup>	1.08483	.000	15.8374	20.1626
		March	8.0200 <sup>*</sup>	1.08483	.000	5.8574	10.1826
		November	21.3100 <sup>*</sup>	1.08483	.000	19.1474	23.4726
		October	20.2700 <sup>*</sup>	1.08483	.000	18.1074	22.4326
		September	18.4000 <sup>*</sup>	1.08483	.000	16.2374	20.5626
	Decmeber	April	-22.5100 <sup>*</sup>	1.08483	.000	-24.6726	-20.3474
		February	-8.0700 <sup>*</sup>	1.08483	.000	-10.2326	-5.9074
		January	-4.5100 <sup>*</sup>	1.08483	.000	-6.6726	-2.3474
		March	-14.4900 <sup>*</sup>	1.08483	.000	-16.6526	-12.3274
		November	-1.2000	1.08483	.272	-3.3626	.9626
		October	-2.2400 <sup>*</sup>	1.08483	.043	-4.4026	-.0774
		September	-4.1100 <sup>*</sup>	1.08483	.000	-6.2726	-1.9474
	February	April	-14.4400 <sup>*</sup>	1.08483	.000	-16.6026	-12.2774
		Decmeber	8.0700 <sup>*</sup>	1.08483	.000	5.9074	10.2326
		January	3.5600 <sup>*</sup>	1.08483	.002	1.3974	5.7226
		March	-6.4200 <sup>*</sup>	1.08483	.000	-8.5826	-4.2574
		November	6.8700 <sup>*</sup>	1.08483	.000	4.7074	9.0326
		October	5.8300 <sup>*</sup>	1.08483	.000	3.6674	7.9926
		September	3.9600 <sup>*</sup>	1.08483	.000	1.7974	6.1226
	January	April	-18.0000 <sup>*</sup>	1.08483	.000	-20.1626	-15.8374
		Decmeber	4.5100 <sup>*</sup>	1.08483	.000	2.3474	6.6726
		February	-3.5600 <sup>*</sup>	1.08483	.002	-5.7226	-1.3974
		March	-9.9800 <sup>*</sup>	1.08483	.000	-12.1426	-7.8174
		November	3.3100 <sup>*</sup>	1.08483	.003	1.1474	5.4726
		October	2.2700 <sup>*</sup>	1.08483	.040	.1074	4.4326
		September	.4000	1.08483	.713	-1.7626	2.5626
	March	April	-8.0200 <sup>*</sup>	1.08483	.000	-10.1826	-5.8574
		Decmeber	14.4900 <sup>*</sup>	1.08483	.000	12.3274	16.6526
February		6.4200 <sup>*</sup>	1.08483	.000	4.2574	8.5826	
		January	9.9800 <sup>*</sup>	1.08483	.000	7.8174	12.1426

T2	November	November	13.2900 <sup>*</sup>	1.08483	.000	11.1274	15.4526
		October	12.2500 <sup>*</sup>	1.08483	.000	10.0874	14.4126
		September	10.3800 <sup>*</sup>	1.08483	.000	8.2174	12.5426
		April	-21.3100 <sup>*</sup>	1.08483	.000	-23.4726	-19.1474
		Decmeber	1.2000	1.08483	.272	-.9626	3.3626
		February	-6.8700 <sup>*</sup>	1.08483	.000	-9.0326	-4.7074
		January	-3.3100 <sup>*</sup>	1.08483	.003	-5.4726	-1.1474
		March	-13.2900 <sup>*</sup>	1.08483	.000	-15.4526	-11.1274
		October	-1.0400	1.08483	.341	-3.2026	1.1226
		September	-2.9100 <sup>*</sup>	1.08483	.009	-5.0726	-.7474
	October	April	-20.2700 <sup>*</sup>	1.08483	.000	-22.4326	-18.1074
		Decmeber	2.2400 <sup>*</sup>	1.08483	.043	.0774	4.4026
		February	-5.8300 <sup>*</sup>	1.08483	.000	-7.9926	-3.6674
		January	-2.2700 <sup>*</sup>	1.08483	.040	-4.4326	-.1074
		March	-12.2500 <sup>*</sup>	1.08483	.000	-14.4126	-10.0874
		November	1.0400	1.08483	.341	-1.1226	3.2026
		September	-1.8700	1.08483	.089	-4.0326	.2926
		April	-18.4000 <sup>*</sup>	1.08483	.000	-20.5626	-16.2374
		Decmeber	4.1100 <sup>*</sup>	1.08483	.000	1.9474	6.2726
		February	-3.9600 <sup>*</sup>	1.08483	.000	-6.1226	-1.7974
September	January	-.4000	1.08483	.713	-2.5626	1.7626	
	March	-10.3800 <sup>*</sup>	1.08483	.000	-12.5426	-8.2174	
	November	2.9100 <sup>*</sup>	1.08483	.009	.7474	5.0726	
	October	1.8700	1.08483	.089	-.2926	4.0326	
	Decmeber	23.280 <sup>*</sup>	1.2445	.000	20.799	25.761	
	February	14.940 <sup>*</sup>	1.2445	.000	12.459	17.421	
	January	18.800 <sup>*</sup>	1.2445	.000	16.319	21.281	
	April	9.780 <sup>*</sup>	1.2445	.000	7.299	12.261	
	November	22.040 <sup>*</sup>	1.2445	.000	19.559	24.521	
	October	20.860 <sup>*</sup>	1.2445	.000	18.379	23.341	
April	September	18.920 <sup>*</sup>	1.2445	.000	16.439	21.401	
	April	-23.280 <sup>*</sup>	1.2445	.000	-25.761	-20.799	
	February	-8.340 <sup>*</sup>	1.2445	.000	-10.821	-5.859	
	January	-4.480 <sup>*</sup>	1.2445	.001	-6.961	-1.999	
	March	-13.500 <sup>*</sup>	1.2445	.000	-15.981	-11.019	
	November	-1.240	1.2445	.322	-3.721	1.241	
	October	-2.420	1.2445	.056	-4.901	.061	
	September	-4.360 <sup>*</sup>	1.2445	.001	-6.841	-1.879	
	February	-14.940 <sup>*</sup>	1.2445	.000	-17.421	-12.459	
	Decmeber	8.340 <sup>*</sup>	1.2445	.000	5.859	10.821	

		January	3.860 <sup>*</sup>	1.2445	.003	1.379	6.341
		March	-5.160 <sup>*</sup>	1.2445	.000	-7.641	-2.679
		November	7.100 <sup>*</sup>	1.2445	.000	4.619	9.581
		October	5.920 <sup>*</sup>	1.2445	.000	3.439	8.401
		September	3.980 <sup>*</sup>	1.2445	.002	1.499	6.461
		April	-18.800 <sup>*</sup>	1.2445	.000	-21.281	-16.319
		Decmeber	4.480 <sup>*</sup>	1.2445	.001	1.999	6.961
		February	-3.860 <sup>*</sup>	1.2445	.003	-6.341	-1.379
	January	March	-9.020 <sup>*</sup>	1.2445	.000	-11.501	-6.539
		November	3.240 <sup>*</sup>	1.2445	.011	.759	5.721
		October	2.060	1.2445	.102	-.421	4.541
		September	.120	1.2445	.923	-2.361	2.601
		April	-9.780 <sup>*</sup>	1.2445	.000	-12.261	-7.299
		Decmeber	13.500 <sup>*</sup>	1.2445	.000	11.019	15.981
		February	5.160 <sup>*</sup>	1.2445	.000	2.679	7.641
	March	January	9.020 <sup>*</sup>	1.2445	.000	6.539	11.501
		November	12.260 <sup>*</sup>	1.2445	.000	9.779	14.741
		October	11.080 <sup>*</sup>	1.2445	.000	8.599	13.561
		September	9.140 <sup>*</sup>	1.2445	.000	6.659	11.621
		April	-22.040 <sup>*</sup>	1.2445	.000	-24.521	-19.559
		Decmeber	1.240	1.2445	.322	-1.241	3.721
		February	-7.100 <sup>*</sup>	1.2445	.000	-9.581	-4.619
	Novembe	January	-3.240 <sup>*</sup>	1.2445	.011	-5.721	-.759
	r	March	-12.260 <sup>*</sup>	1.2445	.000	-14.741	-9.779
		October	-1.180	1.2445	.346	-3.661	1.301
		September	-3.120 <sup>*</sup>	1.2445	.014	-5.601	-.639
		April	-20.860 <sup>*</sup>	1.2445	.000	-23.341	-18.379
		Decmeber	2.420	1.2445	.056	-.061	4.901
		February	-5.920 <sup>*</sup>	1.2445	.000	-8.401	-3.439
	October	January	-2.060	1.2445	.102	-4.541	.421
		March	-11.080 <sup>*</sup>	1.2445	.000	-13.561	-8.599
		November	1.180	1.2445	.346	-1.301	3.661
		September	-1.940	1.2445	.123	-4.421	.541
		April	-18.920 <sup>*</sup>	1.2445	.000	-21.401	-16.439
		Decmeber	4.360 <sup>*</sup>	1.2445	.001	1.879	6.841
		February	-3.980 <sup>*</sup>	1.2445	.002	-6.461	-1.499
	Septembe	January	-.120	1.2445	.923	-2.601	2.361
	r	March	-9.140 <sup>*</sup>	1.2445	.000	-11.621	-6.659
		November	3.120 <sup>*</sup>	1.2445	.014	.639	5.601
		October	1.940	1.2445	.123	-.541	4.421
		Decmeber	22.560 <sup>*</sup>	1.0069	.000	20.553	24.567
T3	April	February	15.080 <sup>*</sup>	1.0069	.000	13.073	17.087
		January	17.900 <sup>*</sup>	1.0069	.000	15.893	19.907

	March	9.030 <sup>*</sup>	1.0069	.000	7.023	11.037
	November	21.520 <sup>*</sup>	1.0069	.000	19.513	23.527
	October	20.240 <sup>*</sup>	1.0069	.000	18.233	22.247
	September	18.320 <sup>*</sup>	1.0069	.000	16.313	20.327
	April	-22.560 <sup>*</sup>	1.0069	.000	-24.567	-20.553
	February	-7.480 <sup>*</sup>	1.0069	.000	-9.487	-5.473
	January	-4.660 <sup>*</sup>	1.0069	.000	-6.667	-2.653
Decembe r	March	-13.530 <sup>*</sup>	1.0069	.000	-15.537	-11.523
	November	-1.040	1.0069	.305	-3.047	.967
	October	-2.320 <sup>*</sup>	1.0069	.024	-4.327	-.313
	September	-4.240 <sup>*</sup>	1.0069	.000	-6.247	-2.233
	April	-15.080 <sup>*</sup>	1.0069	.000	-17.087	-13.073
	Decmeber	7.480 <sup>*</sup>	1.0069	.000	5.473	9.487
	January	2.820 <sup>*</sup>	1.0069	.007	.813	4.827
February	March	-6.050 <sup>*</sup>	1.0069	.000	-8.057	-4.043
	November	6.440 <sup>*</sup>	1.0069	.000	4.433	8.447
	October	5.160 <sup>*</sup>	1.0069	.000	3.153	7.167
	September	3.240 <sup>*</sup>	1.0069	.002	1.233	5.247
	April	-17.900 <sup>*</sup>	1.0069	.000	-19.907	-15.893
	Decmeber	4.660 <sup>*</sup>	1.0069	.000	2.653	6.667
	February	-2.820 <sup>*</sup>	1.0069	.007	-4.827	-.813
January	March	-8.870 <sup>*</sup>	1.0069	.000	-10.877	-6.863
	November	3.620 <sup>*</sup>	1.0069	.001	1.613	5.627
	October	2.340 <sup>*</sup>	1.0069	.023	.333	4.347
	September	.420	1.0069	.678	-1.587	2.427
	April	-9.030 <sup>*</sup>	1.0069	.000	-11.037	-7.023
	Decmeber	13.530 <sup>*</sup>	1.0069	.000	11.523	15.537
	February	6.050 <sup>*</sup>	1.0069	.000	4.043	8.057
March	January	8.870 <sup>*</sup>	1.0069	.000	6.863	10.877
	November	12.490 <sup>*</sup>	1.0069	.000	10.483	14.497
	October	11.210 <sup>*</sup>	1.0069	.000	9.203	13.217
	September	9.290 <sup>*</sup>	1.0069	.000	7.283	11.297
	April	-21.520 <sup>*</sup>	1.0069	.000	-23.527	-19.513
	Decmeber	1.040	1.0069	.305	-.967	3.047
	February	-6.440 <sup>*</sup>	1.0069	.000	-8.447	-4.433
Novembe r	January	-3.620 <sup>*</sup>	1.0069	.001	-5.627	-1.613
	March	-12.490 <sup>*</sup>	1.0069	.000	-14.497	-10.483
	October	-1.280	1.0069	.208	-3.287	.727
	September	-3.200 <sup>*</sup>	1.0069	.002	-5.207	-1.193
	April	-20.240 <sup>*</sup>	1.0069	.000	-22.247	-18.233
	Decmeber	2.320 <sup>*</sup>	1.0069	.024	.313	4.327
October	February	-5.160 <sup>*</sup>	1.0069	.000	-7.167	-3.153
	January	-2.340 <sup>*</sup>	1.0069	.023	-4.347	-.333

T4	September	March	-11.210 <sup>*</sup>	1.0069	.000	-13.217	-9.203	
		November	1.280	1.0069	.208	-.727	3.287	
		September	-1.920	1.0069	.061	-3.927	.087	
		April	-18.320 <sup>*</sup>	1.0069	.000	-20.327	-16.313	
		Decmeber	4.240 <sup>*</sup>	1.0069	.000	2.233	6.247	
		February	-3.240 <sup>*</sup>	1.0069	.002	-5.247	-1.233	
		January	-.420	1.0069	.678	-2.427	1.587	
		March	-9.290 <sup>*</sup>	1.0069	.000	-11.297	-7.283	
		November	3.200 <sup>*</sup>	1.0069	.002	1.193	5.207	
		October	1.920	1.0069	.061	-.087	3.927	
	April	Decmeber	22.820 <sup>*</sup>	1.1767	.000	20.474	25.166	
		February	14.370 <sup>*</sup>	1.1767	.000	12.024	16.716	
		January	18.210 <sup>*</sup>	1.1767	.000	15.864	20.556	
		March	8.140 <sup>*</sup>	1.1767	.000	5.794	10.486	
		November	21.690 <sup>*</sup>	1.1767	.000	19.344	24.036	
		October	20.260 <sup>*</sup>	1.1767	.000	17.914	22.606	
		September	18.360 <sup>*</sup>	1.1767	.000	16.014	20.706	
		April	-22.820 <sup>*</sup>	1.1767	.000	-25.166	-20.474	
		February	-8.450 <sup>*</sup>	1.1767	.000	-10.796	-6.104	
		January	-4.610 <sup>*</sup>	1.1767	.000	-6.956	-2.264	
	Decmeber	March	-14.680 <sup>*</sup>	1.1767	.000	-17.026	-12.334	
		November	-1.130	1.1767	.340	-3.476	1.216	
		October	-2.560 <sup>*</sup>	1.1767	.033	-4.906	-.214	
		September	-4.460 <sup>*</sup>	1.1767	.000	-6.806	-2.114	
		April	-14.370 <sup>*</sup>	1.1767	.000	-16.716	-12.024	
		Decmeber	8.450 <sup>*</sup>	1.1767	.000	6.104	10.796	
		January	3.840 <sup>*</sup>	1.1767	.002	1.494	6.186	
		February	March	-6.230 <sup>*</sup>	1.1767	.000	-8.576	-3.884
		November	7.320 <sup>*</sup>	1.1767	.000	4.974	9.666	
		October	5.890 <sup>*</sup>	1.1767	.000	3.544	8.236	
January	September	3.990 <sup>*</sup>	1.1767	.001	1.644	6.336		
	April	-18.210 <sup>*</sup>	1.1767	.000	-20.556	-15.864		
	Decmeber	4.610 <sup>*</sup>	1.1767	.000	2.264	6.956		
	February	-3.840 <sup>*</sup>	1.1767	.002	-6.186	-1.494		
	March	-10.070 <sup>*</sup>	1.1767	.000	-12.416	-7.724		
	November	3.480 <sup>*</sup>	1.1767	.004	1.134	5.826		
	October	2.050	1.1767	.086	-.296	4.396		
	September	.150	1.1767	.899	-2.196	2.496		
	April	-8.140 <sup>*</sup>	1.1767	.000	-10.486	-5.794		
	Decmeber	14.680 <sup>*</sup>	1.1767	.000	12.334	17.026		
March	February	6.230 <sup>*</sup>	1.1767	.000	3.884	8.576		
	January	10.070 <sup>*</sup>	1.1767	.000	7.724	12.416		
	November	13.550 <sup>*</sup>	1.1767	.000	11.204	15.896		

		October	12.120 <sup>*</sup>	1.1767	.000	9.774	14.466
		September	10.220 <sup>*</sup>	1.1767	.000	7.874	12.566
		April	-21.690 <sup>*</sup>	1.1767	.000	-24.036	-19.344
		Decmeber	1.130	1.1767	.340	-1.216	3.476
	Novembe	February	-7.320 <sup>*</sup>	1.1767	.000	-9.666	-4.974
	r	January	-3.480 <sup>*</sup>	1.1767	.004	-5.826	-1.134
		March	-13.550 <sup>*</sup>	1.1767	.000	-15.896	-11.204
		October	-1.430	1.1767	.228	-3.776	.916
		September	-3.330 <sup>*</sup>	1.1767	.006	-5.676	-.984
		April	-20.260 <sup>*</sup>	1.1767	.000	-22.606	-17.914
		Decmeber	2.560 <sup>*</sup>	1.1767	.033	.214	4.906
		February	-5.890 <sup>*</sup>	1.1767	.000	-8.236	-3.544
	October	January	-2.050	1.1767	.086	-4.396	.296
		March	-12.120 <sup>*</sup>	1.1767	.000	-14.466	-9.774
		November	1.430	1.1767	.228	-.916	3.776
		September	-1.900	1.1767	.111	-4.246	.446
		April	-18.360 <sup>*</sup>	1.1767	.000	-20.706	-16.014
		Decmeber	4.460 <sup>*</sup>	1.1767	.000	2.114	6.806
	Septembe	February	-3.990 <sup>*</sup>	1.1767	.001	-6.336	-1.644
	r	January	-.150	1.1767	.899	-2.496	2.196
		March	-10.220 <sup>*</sup>	1.1767	.000	-12.566	-7.874
		November	3.330 <sup>*</sup>	1.1767	.006	.984	5.676
		October	1.900	1.1767	.111	-.446	4.246
		Decmeber	22.770 <sup>*</sup>	.9108	.000	20.954	24.586
		February	14.350 <sup>*</sup>	.9108	.000	12.534	16.166
		January	18.390 <sup>*</sup>	.9108	.000	16.574	20.206
	April	March	8.180 <sup>*</sup>	.9108	.000	6.364	9.996
		November	21.600 <sup>*</sup>	.9108	.000	19.784	23.416
		October	20.600 <sup>*</sup>	.9108	.000	18.784	22.416
		September	18.540 <sup>*</sup>	.9108	.000	16.724	20.356
		April	-22.770 <sup>*</sup>	.9108	.000	-24.586	-20.954
		February	-8.420 <sup>*</sup>	.9108	.000	-10.236	-6.604
T5		January	-4.380 <sup>*</sup>	.9108	.000	-6.196	-2.564
	Decmebe	March	-14.590 <sup>*</sup>	.9108	.000	-16.406	-12.774
	r	November	-1.170	.9108	.203	-2.986	.646
		October	-2.170 <sup>*</sup>	.9108	.020	-3.986	-.354
		September	-4.230 <sup>*</sup>	.9108	.000	-6.046	-2.414
		April	-14.350 <sup>*</sup>	.9108	.000	-16.166	-12.534
		Decmeber	8.420 <sup>*</sup>	.9108	.000	6.604	10.236
	February	January	4.040 <sup>*</sup>	.9108	.000	2.224	5.856
		March	-6.170 <sup>*</sup>	.9108	.000	-7.986	-4.354
		November	7.250 <sup>*</sup>	.9108	.000	5.434	9.066

	October	6.250 <sup>*</sup>	.9108	.000	4.434	8.066
	September	4.190 <sup>*</sup>	.9108	.000	2.374	6.006
	April	-18.390 <sup>*</sup>	.9108	.000	-20.206	-16.574
	Decmeber	4.380 <sup>*</sup>	.9108	.000	2.564	6.196
	February	-4.040 <sup>*</sup>	.9108	.000	-5.856	-2.224
January	March	-10.210 <sup>*</sup>	.9108	.000	-12.026	-8.394
	November	3.210 <sup>*</sup>	.9108	.001	1.394	5.026
	October	2.210 <sup>*</sup>	.9108	.018	.394	4.026
	September	.150	.9108	.870	-1.666	1.966
	April	-8.180 <sup>*</sup>	.9108	.000	-9.996	-6.364
	Decmeber	14.590 <sup>*</sup>	.9108	.000	12.774	16.406
	February	6.170 <sup>*</sup>	.9108	.000	4.354	7.986
March	January	10.210 <sup>*</sup>	.9108	.000	8.394	12.026
	November	13.420 <sup>*</sup>	.9108	.000	11.604	15.236
	October	12.420 <sup>*</sup>	.9108	.000	10.604	14.236
	September	10.360 <sup>*</sup>	.9108	.000	8.544	12.176
	April	-21.600 <sup>*</sup>	.9108	.000	-23.416	-19.784
	Decmeber	1.170	.9108	.203	-.646	2.986
	February	-7.250 <sup>*</sup>	.9108	.000	-9.066	-5.434
Novembe r	January	-3.210 <sup>*</sup>	.9108	.001	-5.026	-1.394
	March	-13.420 <sup>*</sup>	.9108	.000	-15.236	-11.604
	October	-1.000	.9108	.276	-2.816	.816
	September	-3.060 <sup>*</sup>	.9108	.001	-4.876	-1.244
	April	-20.600 <sup>*</sup>	.9108	.000	-22.416	-18.784
	Decmeber	2.170 <sup>*</sup>	.9108	.020	.354	3.986
	February	-6.250 <sup>*</sup>	.9108	.000	-8.066	-4.434
October	January	-2.210 <sup>*</sup>	.9108	.018	-4.026	-.394
	March	-12.420 <sup>*</sup>	.9108	.000	-14.236	-10.604
	November	1.000	.9108	.276	-.816	2.816
	September	-2.060 <sup>*</sup>	.9108	.027	-3.876	-.244
	April	-18.540 <sup>*</sup>	.9108	.000	-20.356	-16.724
	Decmeber	4.230 <sup>*</sup>	.9108	.000	2.414	6.046
	February	-4.190 <sup>*</sup>	.9108	.000	-6.006	-2.374
Septembe r	January	-.150	.9108	.870	-1.966	1.666
	March	-10.360 <sup>*</sup>	.9108	.000	-12.176	-8.544
	November	3.060 <sup>*</sup>	.9108	.001	1.244	4.876
	October	2.060 <sup>*</sup>	.9108	.027	.244	3.876

Based on observed means.

The error term is Mean Square (Error) = 4.148.

\*. The mean difference is significant at the .05 level.