ADDIS ABABA UNIVERSITY

College of Natural and Computational Sciences

STUDY ONCOCHINEAL AND ITS EFFECT ON CACTUS PRODUCTION HINTALO WEJERAT WEREDA, TIGRAY REGIONAL STATE, ETHIOPIA

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN BIOLOGY

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Department of Zoological Sciences

This is to certify that the thesis prepared by Teklab Negash entitled "study on cochineal and its effect on cactus production in some selected areas of Hintalo Wejerat Wereda, Tigray regional state, Ethiopia" and submitted to the partial fulfillment of the requirement for the degree of Masters of Science in Zoological Science complies with the regulation of the university and meets the accepted standard with respect to originality and quality**.**

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Declaration

I, the undersigned, declare that this thesis is my original work and has not been presented For a degree in any other universities and that all sources of materials used for the thesis Have been correctly acknowledged

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List of Acronyms

TBOARD	Tigray Bureau of Agriculture and Rural Development
BOARD	Tigray Bureau of Agriculture and Rural Development
FAO	Food and Agriculture Organization
CCC	Cochineal control Committee
TCP	Tigray cactus pear project

ABSTRACT

Now days, cochineal infestation problem is the burning issue in cactus growing areas as it has most devastating effect on fruit and forage production of the crop. The purpose of the study was To Share experience about practice of reducing infested area in the implementation with other none infested area. Second the study will serve as an input for other interested researchers who want to conduct further study on the issue. Secondly, the study would be helpful for the community to suggest possible options. Data gathered were analyzed through descriptive percentage and frequency. Wereda was selected through non-probability (purposely) namely Hiwane, Adikeyh, Tsehafti and Fikrealem and selected in terms of the cochineal infected area.The study involved total of 161 respondents out of these (six) were either hesitant to complete the questionnaires or unhappy to fill out questionnaires finally 155 have been filled the questioner. Respondents representative were selected namely, cactus pear project coordinators kebelle households (local communities.)Maheber Wejerat association and youth.. According the majority of respondents that Cochineal insect has already become a serious pest spreading at a fastest rate and is highly damaging the cactus plants in the region with no effective solutions discovered yet. The results showed that the interest of the communities in the introduction of cochineal insect believed as an introduction of disease to the cactus pear production Most of the respondents cochineal infested area, were not satisfied with action plans and were pessimistic about the effectiveness of the control Options and the opinion that cochineal cannot be eradicated through mechanical and chemical means.

Based on the finding of the study, the researcher, drawn the following conclusions the immediate solution to bring food security especially in drought prone areas is working with cactus.

Based on the results of the study, the recommendations are forwarded: Awareness or Consulted before the expansion of the insect to the locality area. Mechanical and chemical control with human labor might work for a small farm. Establishing intra-regional quarantine (enforcement), to limit the movement of cactus planting materials, fruits to new areas, Establishing/ strengthening regional plant and animal quarantine offices no more effective

Key words: ***cactus, cochineal introduction, abundance of cactus***.

1. INTRODUCTION

1.1 Background of the study

Cactus pear is the corner stone of economic and social development for the overall development of southern and eastern zone of Tigray. And it enables individuals and society to make all rounded effective on economically and the life style community .Today the expansion of cochineal introduction and the effect on cactus production in different areas rapidly increases in Tigrayand the regional government unable to control the cochineal effects on cactus production. The introduction of cochineal to Tigray has been effect on economically and the life style of the community.

According to legend, cactus pear locally known by the vernacular name "Beles" was introduced between 1848 and 1870 by Catholic Missionaries to eastern zone of Tigray. An interview with key-informants in Erob identified a priest called "Abune-Yakob" who visited Erob and realized that the area was not suitable for cropping and other agricultural activities due to recurrent drought, erratic rainfall, rocky and mountainous topography. As a result the priest brought three spineless cladodes from Mexico, its country of origin (Griffith 2004) and planted one cladode in Alitena (Erob), the second cladode planted in Golea (Ganta-afeshum) and the third cladode planted in Lehe (Eritrea). Then after, the plant was distributed throughout the region and beyond. Over the last few decades, interest in cactus pear as food and feed has increased due to its drought resistance, in the last few years; most cultivated cactus in Tigray is usually consumed in its raw form. However, the cactus plant is now being at a higher risk of damage due to the exotic insect, Cochineal (*Dactylopiuscoccus*Costa).

Following the workshop recommendations, Mekelle University implemented a project on cactus pear production and utilization in Ethiopia during 2002-2004 (Chipeta, 2010) financed by the Food and Agriculture Organization of the United Nations (FAO). In fact FAO was requested for support by the Ethiopian Federal Government and Tigray Regional Government. One component of the FAO project was the introduction of a carmine cochineal (Dactylopiuscoccus) that would be based primarily on the abundant cactus pear resources in southern Tigray. All requirements starting from pest risk analysis, quarantine, import permit, permit for experimental and final

Releases for commercial use were pursued from the competent authorities (Tesfay, 2010). The performance of the carmine cochineal in the field was very encouraging and the insect was host specific (Tesfay, 2006).

1.2 Statement of the problem

In northern Ethiopia, the prickly pear cactus (opuntiaficusindica,) is important plant as food, feed and source of income. However, currently the plant is suffering from the attack of a cochineal (*Dactylopiuscoccusc*.) insect pest. Today the expansion of cochineal introduction and the effect on cactus production in different areas rapidly increases in Tigray and the regional government unable to control the cochineal effects on cactus production. The introduction of cochineal to Tigray has been effect on economically and the life style of the community.

The cochineal insect was therefore introduced from South Africa to Tigray in April 2003 after a pest risk analysis indicated that its introduction was safe. The need to search for companies that can produce and market cochineal insect was obvious and a Chilean company food-safe showed strong interest to be involved in cochineal production in the southern zones of Tigray. Subsequently the company was granted cactus infested land in january2007. The company started its colonies with the insects introduced from South Africa and maintained here in Tigray. The company has so far developed around122 ha of the land and has for the first time exported dried cochineals to the world market. As cactus pear grows in communal lands, conflict of interest arose and it polarized the community. The company was forcibly closed and it was a tragedy that a onetime commercial insect became a full-fledged invasive insect pest. Attempts to contain the insect with mechanical and chemical control were not successful.

The wide spread of the insect is assumed through biotic (human and livestock) and abiotic (wind) factors.

The main objective of this study is to assess the introduction of cochineal and the effect on cactus production in Tigray and Cochineal infestation problem on the community in cactus growing areas devastating effect on fruit and forage production of the crop.

1.3 Basic research questions

Based on the above statement, the study attempts to answer the following basic research questions.

1. What are the Causes of cochineal introduction to the study area?

2. What are the community interests to introduce carmine cochineal in the study area?

3. What are the ways of reducing of the infested area?

1.4 Objectives

1.4.1 General objective

- To understand the cause of introduction of cochineal and conduct its effects on cactus production in some selected kebelle of Hintalowegerat Wereda, Tigray Regional State.

1.4.2 Specific objectives

- To gather, indigenous knowledge on the cause of cochineal introduction in the study area;
- To assess the community interests in introduction of carmine cochineal in the study area.
- To assess the ways of control and reduction of infested area.

2. Literature review

2.1 Cochineal species

In many literatures different authorities come up with different definitions of on the life history and fecundity of the cochineal insect, (*Dactylopiida*e) outrinus De Lotto (sited 2014) defined Cochineal (*Dactylopiuscoccus*) also called true cochineal is a scale-like insect that lives on cactus pads. The females are flat, oval-shaped and less than quarter of an inch long. The males are much less than females and they have wings and they are mobile. The females, they attach to the cactus through their mouth and suck the juices. They also secrete white cotton-like balls or coatings on the cactus. Out of the 200 species of Opuntia cacti from which cochineal can be cultivated, the most common is *Opuntiaficus-indica.* Cochineal insects are sap-suckling insects that feed only on cactus species (plants with in the family Cactaceae) there are nine species of cochineal, and each species feeds on only one or a few related species of cactus .it was recently discovered that there are host-specific races or biotypes with in some of the species of cochineal insects and that each biotype can only develop on one cactus species, although the different biotypes look exactly identical .cochineal insects are all of south American or north American origin.

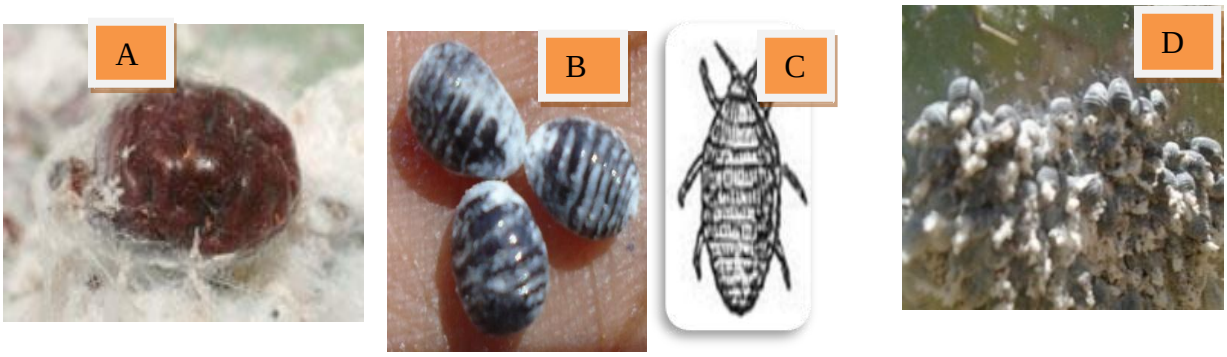

Figure 1. Female cochineal in (A) Larva (crawler) (B) pupa (cocoon)(C) sessile (crawler)

(D)colony (crawler)

2.2 Life cycle of cochineal insect

There are many definitions and various interpretations of defined Cochineal insects usually live in colonies or clusters of individuals grouped together on the surface of the cactus plants. Adult

females resemble small puffy sacs, but are normally not seen because they are covered with a coat of white, woolly wax. The body fluids are typically dark red due to a high content of carminic acid, which remain is the source of red cochineal dye. The waxen coat protects the insect from heat, cold and predation by ladybirds and the carminic acid seems to deter parasites.
The adult males are seldom seen bear no resemblance to the females; they are tiny, pink, mobile insects with two semitransparent wings and long "tail" filaments. Female cochineal insects lay up to o thousand eggs , which hatch almost immediately and give rise to minute pink nymphs less than 1mm in length ,known as "crawlers" because they have functional legs which enable them to move and female crawlers differ from each other in behavior and development .

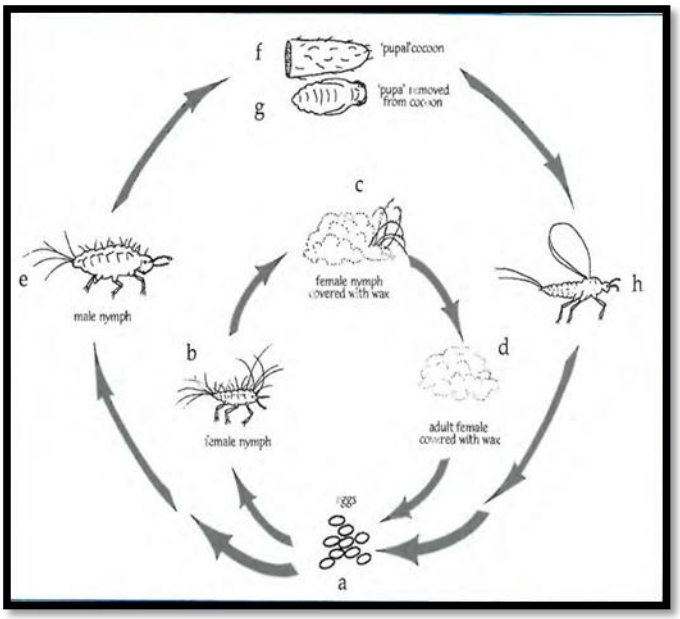

Figure 2. The life cycle of cochineal (A) Egg; (b) Male nymph; (c) Female nymph (covered With wax); (d) Adult female (colored with wax); (e) Male nymph; (f) 'Pupa' cocoons; (g) 'Pupa' removed from cocoon; (h) Mature male cochineal

2.2.1 Female crawlers:

As elaborated by Moran, etal1982), wind dispersal and settling of the first-instars crawlers of the cochineal insect. the central definition of the crawlers are covered with elongate, stiff bristles that act as a parachute or sail and enable the insects to disperse on the wind when overcrowded .on warm days, the crawlers move upwards and aggregate on the highest points of the cactus plants or surrounding vegetation .from there they are blown off by the wind and carried up to several

meters in only this form of dispersal relies on chance and results in only a few of the crawlers landing on another host plant. Unsuccessful crawlers climb upwards again and can repeat the dispersal process several times over a few days before they die from starvation. The crawlers that land on or near a suitable host plant insect their suckling mouthparts and start to Feed , usually in shady spots or close to the base of a spine. in un crowded conditions, many of the crawlers settle around the parent females and do not disperse alone settled, the female never moves again and feeds in the same place for the rest of her life .if removed from the plant a nymph or young female will be unable to insert its long, delicate mouth parts in to the plant again and will die from starvation.

The female nymphs now start to secret the characteristics wooly, waxy filaments that cover and protect their bodies. As they grow, the insects molts (shed their skin) twice, but their legs remain small and become non-functional .after the second molt, the females are mature and ready to mate. They start laying eggs about three weeks later and continue to do so for approximately50days.

Figure 3.Female Crawler

2.2.2 Male crawlers:

Are not as well adapted for wind dispersal as the young females and male cochineal insect dispersal mostly during the adult stage

The males have fewer and short bristles than female crawlers, but can also be wind dispersed most remain beneath the protective wax covering of their mother, or settle in groups near her .shortly after starting to feed, they secrete a waxen coating .at the first molt, the waxy covering is

shed with the old skin and the crawlers have very little protective wax .they spend a few more days feeding and crawling. about on the plant before secreting more wax to form an open- ended ,hallow “papal” cocoon .inside the cocoon the males undergo three further molts including a “pupa “and finally become winged adults ,which leave the cocoons and fly way to find a female to mate with .the males live for about three days and do not feed .

2.3 Importance and Side Effect of carmine cochineal

2.3.1 Importance of cochineal

According to Miller (1976), the biological controls of natural enemies over carmine cochineal in Mexico are very strong and frequently hold cochineal populations in check. Cochineal for Ethiopia became one of the items that the country earns hard currency. The carminic acid content of the cochineals produced in the Tigray region ranged from 21-23% (Tesfay and Bustamante, 2010) and was much higher than what was reported in the literature (Anonymous, 2014).

Since long time mainly it is used as source of coloring agent. As elaborated by tesfay., (cited in Jimma , 2011),the Commercialization of carmine cochineal in northern Ethiopia Carmine dye known by its commercial name as cochineal extract”, “carmine”, “natural red ”, or “natural coloring” is a natural, red coloring agent derived from the cochineal insect. Due to global restrictions on artificial colorants in food and other consumer items the carmine dye is used in foods, drugs, and cosmetics, beverages and for medical applications. Also it is not carcinogenic but it is more light and heat-stable with time than many synthetic dyes. Cochineal die is still better as a dye for wool than most synthetics produced at much cheaper. Peru is the major supplier then Chile, then Canaries and at fourth Bolivia. Peru enjoys a considerable advantage in the world market, supplying 80% of the world's cochineal, about 40% as a dye and 60% in insect form. Cochineal is still produced and exported from Peru (200 tons/year). In 2005 when synthetic food dyes were selling for $10-20 per kilogram, cochineal was selling for $ 50-80 per kilogram

2.3.2 Side effect of cochineal on cactus pear

There are many definitions and various interpretations of the side effect of carmine cochineal, According Borges, (in2013). Defined that Selection of cactus pear clones regarding resistance to carmine cochineal and cochineal control committee(CCC) ,(sited in Mekelle in 2011) has been

created an action plan for cochineal controlling in the Tigray region of northern Ethiopia , Due to the immense important of it has, cochineal insect was introduced to Tigray Regional State of Ethiopia. However, due to wild use of this insect, the cactus pear which is the integral part of economy of the people is being destroyed. Let alone to get additional benefit which was assumed during the introduction of this insect, the enormous benefits of this fruit which have been for many years is being lost. Currently, the people of Tigray, especially, the northern part lost their whole cactus pear. What makes it more sever is that, the insect is rapidly expanding to the rest of the area where cactus pear and the people are highly interconnected. Cactus is widely distributed and used in the region than any other places in Ethiopia. Specifically, in Adigrat town and surrounding areas as it is owned by individual farmers. The use of the cladode as fodder for cattle has similar beginning to the arrival of cactus by missionaries. The fruits themselves dated long since the recognized as favorite fruits. Recently cactus Salads and juices are familiar to the area. With the current global environmental change cactus is promising due to its drought tolerant properties. Food security is one of the major plans of the country in its twenty years transformation plan and the continents major goal. However, cactus is been gradually destroyed. With its potential recognized the loss is severe, because the farmers are still preparing fodder even from the infected ones. Most pests produce toxic substances against their hosts while the white powder produced by cochineal insect is acid (carmine acid). May be this is the only chance they have than to see their cattle's dying from starvation.

The infected ones may lead them to death in cumulative effect. To lose the cattle's is one problem; to lose the fodder is another major long lasting problem need to be addressed immediately the use of cactus cladodes to the farmers as fodder for their cattle, sheep, camel and goats for one Solid year and as their seasonal favorite fruit for 3-4 months is far more useful than to the die industry which uses carmic acid produced from the insects (even though there is no such industry in over all the country). Life of their cattle's can never be an option over use of the insect in giving die. The source of income by selling the fruits has covered house expenses of many poor farmers and educational expenses of many poor students especially girls. No report appear on the literature with remedy to the infected plants. Some chemical pests are suggested however, much time is needed to study the side effect and cost analysis.

Concerned action has not done even as immediate solution for the problem. The destruction of the cladodes is one thing but the effect of the carmic over the animals who probably consumed

the infected cladodes is another thing that should be considered seriously. There is no time to stay before even the infection become unmanageable and widespread in over all the country In the eve of the day to recognize the potential use of cactus, this is severe economic lose that needs the attention of any stakeholder in the field and the region in general.

2.6. **Benefits of the carmine cochineal business**

The carmine cochineal, *Dactylopiuscoccus* Costa, belongs to family *Dactylopiidae* Cochineal (Dactylopius, coccus) also called true cochineal is a scale-like insect that lives on cactus pads. The females are flat, oval-shaped and less than a quarter of an inch long. The males are much less than females and they have wings and they are mobile. The females, they attach to the cactus through their mouth and suck the juices. They also secrete white cotton-like balls or coatings on the cactus. Out of the 200 species of Opuntia cacti from which cochineal can be cultivated, the most common is *Opuntiaficus-indica*.

The company started its first export of dried cochineal insects to Mexico in April 2009 (Bustamante, 2010). Mexico, the land of Aztecs and home of cactus pear and the carmine cochineal, has become an importer of cochineal. According to Miller (1976), the biological control of natural enemies over carmine cochineal in Mexico is very strong and frequently holds cochineal populations in check. Cochineal for Ethiopia became one of the items that the country earns hard currency. The carminic acid content of the cochineals produced in the Tigray region ranged from 21-23% (Tesfay and Bustamante, 2010) and was much higher than what was reported in the literature (Anonymous, 2014). The environmental conditions should have contributed to the higher carminic acid content of the cochineals produced in the Tigray region of northern Ethiopia, and according to Artesaga (1990), higher carminic acid is associated with higher phosphorus content of soils in the cactus pear growing areas. Habtuet al. (2005) found highest phosphorus (8 fold) on dense cactus lands compared to arable lands in northern Ethiopia. The higher carminic acid content should have fetched. The company introduced and demonstrated a skill on the rearing and production of carmine cochineal to the area, much known for rain failures. Farmers were involved in cochineal production through an out grower scheme and were selling their produce back to Food safe Extent of the conflict The conflict concerns to the right of use on a communal resource that is cactus pear. Farmers from this community that collaborated with Food safe were prohibited from participation in community affairs. However

the increased income of farmers who worked for Food safe became an incentive for others to be involved in cochineal Harvesting and sale.

The young and women started harvesting and selling cochineal to Food safe at a nearby town of Mehoni. The elderly and church came up with a new idea that those involved in cochineal harvesting and sale will not get church services and are no more members of the Coptic Church. This information was conveyed to the community members during the Sunday church services. The cochineal issue divided members of the same family; while the young were involved in cochineal harvesting, the elderly were bound by the church decisions and were against the cochineal harvesting. Yet the family heads cannot influence their children probably because of the income. Another possible reason could be because there were middlemen formed in the village that buy fresh cochineal, the young might be selling the fresh cochineal immediately after harvest without the knowledge of their families. Young men were also attracted from afar communities to collect and sell cochineal because the cactus is on communal land. So with increased intensity of the conflict, the young men who came from faraway places took the cochineal and introduced it to their cactus backyards. This way the cochineal spread became very fast in a space of few years. As the church initiative is about to fail, the community came up with a new bylaw, to guard cactus communal lands and fining those involved in harvesting cochineal. They set up a Schedule where every member of the community is assigned a date when they will be engaged in guarding the cochineal infested cactus lands. This was the worst part as they are about to reach the turning point. Because those assigned to guard were chasing the children and the young were running to escape capture and fining, some failed onto rocks and Sustained wounds. Retribution as a tradition is deep rooted in the community and they were worried because they knew where they are heading as someone could die while escaping arrest by those guarding the cactus plantation. According to Brinkerhoff *et al*. (1988) within Group conflict has adverse effects on social cohesion. So the new idea supported by bylaws was also destined to failure. Cochineal really became a challenge to the community and community church leaders. The interest of the youth and also the spread of the cochineal became beyond control of the community. Members of the same community that were against cochineal harvesting and sale became themselves involved in the business after they observed an increase in the price of cochineal and also income of those involved in cochineal business. The community elders and church leaders, backed by the *Maheber-Wejerat* association, finally demanded that the market

link be disconnected *i.e.* the company be closed. The *Maheber Wejerat* association complained about false claims; livestock bleed to death after eating cochineal infested *Tesfay, 2015* JPACD (2015) 17:61-80 71cladodes and the cochineal insect spread to indigenous vegetation while it is known that humans eat food and take drinks colored with cochineal and is host specific to the genu *Opuntia*.

2.4 Opportunity for cochineal introduction and production in Tigray

In 1997, a workshop was jointly organized by University of Mekelle and the University of Wiesbaden-Polytechnic Germany, to encourage alternative uses (for food, feed, as a raw material for small scale industries etc.) of this abundant resource, cactus pear. This was followed by an FAO-TCP project implemented by Mekelle University in 2002 -2004 that put into action some of the suggestions that emerged from earlier initiative. One of them was the introduction of a cochineal industry that would be based primarily on the abundant cactus pear resources in the Southern and Eastern parts of Tigray. The cochineal insect was introduced from South Africa to Tigray and the introduction was possible in April 2003. The introduction of the carmine cochineal insect was supported by the FAO-TCP project hosted by Mekelle University. A pest risk analysis was performed and results indicated that its introduction would be safe (give reference). The risk was considered low because the insect has to be cultivated to survive over the long term. Once introduced (cochineal introduction permit no 1020), the cochineal insect was kept in partly conditioned glasshouse and was reared to five generations on detached cladodes. Freedom from unwanted organisms was also conformed. The permission for a field release was obtained from the Federal Ministry of Agriculture and Rural development (ref. no. 21/126/1.1 dated 4/01/97). Accordingly the insect was released at three locations on the 12th of September 2004: *Tsehafti*area of *Wejerat*, *Embachara*area in *Mehoni*and *Endayesus*campus of Mekelle University. The performance of the carmine cochineal insect in the field was very encouraging and was also found to be very host specific (Tesfay, 2006). Satisfied with the performance in the field, we requested permission from the Ministry of Agriculture and Rural Development on 01 March 2007 for wider release of the insect for commercial use. Permission was then granted on the 12th March 2007 in the Tigray region. The insect was then allowed to multiply at the inoculation sites of Endayesus campus, Tsehafti and Mehoni areas where the insect was originally introduced for experimental release. Side by side we should have searched for market

opportunities outside Ethiopia as there is no knowledge about the insect in country. With the help of Dr Helmut Zimmerman of the Plant Protection Research Institute of South Africa Food safe Ethiopia started developing nurseries on April 2007 for the multiplication of cochineal insects at *Fachagamma* area of the *Raya Valley* in Southern Tigray. The company was using insects that were multiplied at the inoculation sites of *Tsehafti, Embachara and Endayesus* areas of Tigray. Food safe has so far developed 135 hectares of land into an ideal cochineal farm and is expecting to expand to 300 hectares. The company has the first export of dried cochineal insects in April 2009 and is believed to have continued since then. The carminic acid content of the cochineals produced in the Tigray region ranged from 21-23% and was much higher than what was reported in the literature. The favorable environmental conditions should have contributed to the increased carminic acid content of the cochineals produced in the Tigray region of Northern Ethiopia. It has also created a job opportunity for more than 120 Ethiopians in the Raya valley in the last three years and is expected to continue in the years ahead. The company has also demonstrated a skill on the rearing and production of carmine cochineal to the area much known for rain failures

2.5 Interest of carmine cochineal in Tigray

The conflict concerns to the right of use on a communal resource that is cactus pear. The Conflict first involved taking hostage of Food safe company manager while on a cochineal Tesfay, 2015JPACD (2015) 17:61-80 70Collecting mission at Wejerat area and was later on freed with the involvement of the Regional Government. Farmers from this community that collaborated with Food safe were prohibited from participation in community affairs. However, the increased income of farmers who worked for Food safe became an incentive for others to be involved in cochineal Harvesting and sale. The young and women started harvesting and selling cochineal to Food safe at a nearby town of Mehoni. The elderly and church came up with a new idea that those involved in cochineal harvesting and sale will not get church services and are no more members of the Coptic Church. This information was conveyed to the community members during the Sunday church services. The cochineal issue divided members of the same family; while the young were involved in cochineal harvesting, the elderly were bound by the church decisions and were against the cochineal harvesting. Yet the family heads cannot influence their children probably because of the income. Another possible reason could be because there were

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2.6 Cactus production and utilization of in Tigray

Over the last few decades, interest in cactus pear as food and feed has increased due to its drought resistance, high biomass yield, high palatability and tolerance to salinity (Barbra 1995, Ben Salem et al 1996). Stint zing and Carle (2005) described cactus pear as a miracle plant,

dromedary of the vegetation world and the bank of life as it can contribute to livelihoods of rural populations in dry areas. Therefore, cultivation of the plant may assume greater agricultural importance in dry areas since a larger part of the land is destined to become arid or semi-arid due to climate change (Snyman 2006). Because of ever increasing human and livestock pressures on the land, a decline in soil productivity, and recurrent drought and famine, there is an increasing reliance on cactus pear to minimize risk and ensure crop and food security. In Tigray, the immediate solution to bring food security especially in drought prone areas is working with cactus (Nefzaoui et al 2010).

Currently, cactus pear is widely spread through the region and is believed to cover more than 379,338 hectares of land, i.e., 7.4% of the total land of the Tigray region (SAERT 1994, Nefzaoui et al 2010), of which about 56% is found in southern Tigray. Across the study areas, cactus pear is utilized to serve a range of functions. Some of the functions reported were as human food, feed for livestock, cash income, environmental protection (soil and water conservation, fence, fire wood, cochineal production, honey bee forage and as a means of additional income, thereby increasing the efficiency and economic viability of small and low-income farmers (Haile et al 2002). In several countries, a number of products are produced from cacti, which include: edible oil from cactus seeds, Sauce, Jams, Marmalade, Candy from cladodes and fruits, Shampoo, Soaps, thickeners from mucilage, etc (Barbera, 1995). Even if efforts have been made to process cactus at household level in the last few years, most cultivated cactus in Tigray is usually consumed in its raw form. However, the cactus plant is now being at a higher risk of damage due to the exotic insect, Cochineal (*Dactylopiuscoccus* Costa). The insect is exotic scale insect which lives feeding on cactus plant moisture and nutrients. It is primarily sessile parasite native to tropical and subtropical South America and Mexico. It belongs to the family Dactylopiidae in the order Hemiptera reared for the purpose of carminic acid production (Rodriguez and Niemeyer 1999, Roderuez et al 2001). The insect being host specific feeds only on Opuntia species and is known as a commercial insect for its production of a natural dye (carminic acid) that can be used for cosmetic, pharmaceutical, textile and food industries for coloring (Baranyovits 1978, Einser and Nowicki 1980).

Despite being a commercial insect and its many advantages, its introduction since 2003 to the Tigray region had a very negative impact on the multi-purpose cactus plant by sucking ruthlessly

with no effective management to date. Nowadays, cochineal infestation problem is the burning issue in cactus growing areas as it has most devastating effect on fruit and forage production of the crop. Cochineal infestation to date reaches 31,184 ha (Board 2014). Number of infested districts and tabia (lower administrative unit) are nine and eighty seven respectively. As compared to the previous years, particularly in 2013, the infestation level of this year increased alarmingly by 263% in area coverage, 80% and 47% district and tabia wise respectively (Board 2015 unpublished field report). Therefore, the demand for its eradication by the many rural communities was high and the complain remains still as a hot issue.

The wide spread of the insect is assumed through biotic (human and livestock) and abiotic (wind) factors. Hence, to maintain the cactus plant and its socio-economic high values, it needs a concerted action inter alia, looking for an effective cheap and available means of control options.

Pest control by small-scale farmers is still heavily dependent on chemical insecticides even though their use is associated with many undesirable and sometimes lethal consequences. Improper and wide - spread use of chemical insecticides can cause underground and surface water pollution (Dalvie et al 2003). Excessive use of insecticides also induces resistance development in target pests as well as killing beneficial organisms such as pollinators and natural enemies (Pedigo and Rice 2006). The greatest concern with use of chemical insecticides in crop production is their potential poisonous effects on human health through dietary exposure (Lu et al 2008, 2010; Łozowicka et al 2012).

3. Materials and methods

3.1 Description of the study area

The study was carried out in Tigray region, Northern Ethiopia, southern Zone in Hintalowegerat Wereda four kebelle and were purposive selected. Southern zone has a bimodal rainfall distribution that ranges from 400 – 912 mm annually, with an average annual rainfall of 656 mm. The short and long rainy seasons fall in February to April and June to early September, respectively. The annual temperature ranges from 9 – 32 ^{O}C. Southern zone of Tigray Regional State is located between 12° 17’ – 12° 56’ N latitude and 39° 32’ – 39° 36’ E longitude and lies at an altitude range of 1000 – 3500 meters above sea level (masl) with an average altitude of 2250 masl (SZARDO 2010).

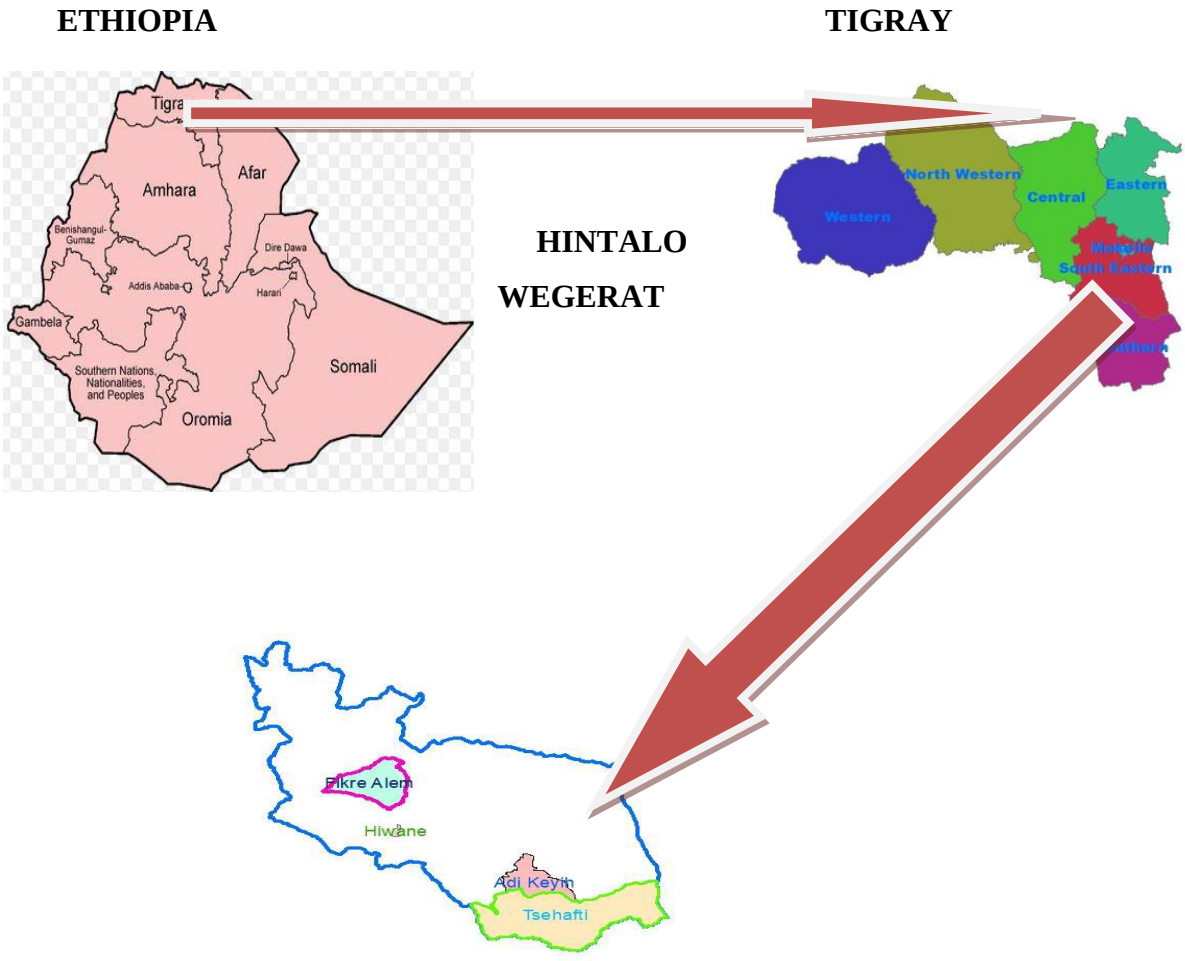

Figure 4.Shows map the study area

3.1.1 Primary Data

The primary data were collected from cactus pear coordinators householders' wegerat association members and landless youths. These respondents for the source of data were based on the expectation that they would have better information and knowledge about the subject matter of the study.

3.1.2 Secondary Data source

Secondary data were collected from carmine cochineal related documents such as, cactus pear guidelines, different reports of Tigray region.

3.2 Sample size and Sampling Techniques

Both probability and Non-probability (purposive sampling) techniques were used to collect relevant data from the classified population of the study. According to Victor Juppe (2006) purposive sampling is a form of non-probability sampling in which an experienced individual selects the sample based on his judgments about some appropriate characteristics required of the sample numbers. The selected one Wereda consist of 23kebelle. From these, four (4) kebelle were selected namely tsehafti, Adikeyh, Hiwane and Fikre Alemusing purposive sampling technique. The household respondents were selected by random sampling technique via lottery method but the rest respondents were also selected purposely. The reason to select four Kebelle was so as to manage the data in relation to the cactus production and cochineal infested area, time limitation, workload, researcher's experience, resource and transport access. In the selection of sample size of the community participated in the study area from each study area were determined by the formulas set by Yamane's (1967) as cited in Anwar (2015) as follows.

$$n = \frac{N}{1 + N(e)^2} \rightarrow \qquad n = \frac{\mathbf{270}}{1 + \mathbf{270(0.05)^2}} \rightarrow \qquad = 161$$

Where **N**= 270 the target population community

e = Error percentage 0.05%

n= Sample size = 161

Not all community members are willing to get involved in the study. Some have negative attitude others do not feel comfortable talking to and getting involved in any kind of. What cochineal does not seem relevant to its needs, the community shows reluctance or resistance. Some respondents were either hesitant to complete the questionnaires or unhappy to fill out questionnaires.

3.3 Data collecting instruments

The common data collecting methods used in this study were questionnaires, documents, records, observation. Questionnaires were used as a major data collecting tool in this study. Document analysis and. observation also employed to enrichment the triangulation of the data obtained from questionnaires and to provide in-depth information on the issue under investigation. The use of more than one data collection method enables the researcher to combine strengths and correct some of the deficiencies of one technique and it helps to increases the validity and reliability of data collected.

3.3.1 Questionnaire

Questionnaires are useful for the collection of appropriate data and to secure data from many respondents at a time and questionnaire is the fastest data collecting tool and gives freedom to express their opinion without fear and anxiety and it also more confidential than other data collection tools. Both close ended and open ended questionnaires were used in this research study for householders, cactus pear coordinators, Wejerat association members and landless youths. The questionnaires were prepared in English language and translated in to local language (Tigrigna) for easy communication purposes for respondents.

3.3.2 Document analysis

Document analysis was purposively used to assess the introduction of cochineal and the effect on cactus pear. The secondary sources of data related cactus pear improvement documents such as, different records of carmine cochineal, challenges, Journals, other legal documents and books were assessed. Finally the document analysis was used to validate and check the consistency of the primary source.

3.5.3. Observation

The involvement of the community with respects to carmine cochineal and cactus pear improvement was observed through direct observation the overall condition of the cactus pear and carmine cochineal. As to Best and Kahan (2003), the information obtained through observation is more accurate, more valid, and more reliable than information gathered through other means. According to Kothari (2004), observation is important tool that can be employed in descriptive research and other qualitative research types for gathering genuine and pertinent data to see the overall activities of the community.

3.4 Data collecting procedure

Data collecting procedures are important for collecting the data effectively. Before collecting and implementing the data, the respondents of the community representatives were informed to be participated in the study voluntarily and assured that any information offered to the researcher was only for the purpose of the study. Similarly before the questionnaires were also distributed all the necessary information's were given to the four data collectors proposed in each of the selected. The participants were encouraged to actively participate in responding to the Questionnaires. All of the distributed questionnaires to the selected respondents were answered and returned back to the research.

3.5 Data analysis

The quantitative were analyzed through descriptive (percentage, and frequency). The background information of the respondents were analyzed through percentage (%) while the data obtained through close ended questionnaire from young landless , households elder community representation, cactus pear project coordinators and Mahber Wejerat association were analyzed through percent and frequency. During the data analysis similar items were clustered together for the sake of simplicity of presentation.

4. RESULTS AND DISCUSSIONS

4.1 Responding rate

The study targeted a total of 161 respondents who live in the study area for questionnaire method. However, 155 questionnaires were successfully administered yielding a response rate of 96.27%.the remaining questionnaires could not be administered due to different reasons. in some cases, three respondents were not happy to fill the questionnaires three respondents have forgotten it Nonetheless ,Mugeneda (2003) cited that a response of 72 % and over is considered as a very good and adequate for analysis and reporting. In light of this assertion, 96.27% of response rate is therefore sufficient to make conclusions for this study.

Table 1.Socio demographic characteristics of respondents

Respondents									
Respondents characteristics	Socio demographic Characteristics	Cactus pear project Coordinators		Kebelle house holders		Mahber Wejerat Association		Young youth	
		N	%	N	%	N	%	N	%
Sex	Male	9	5.806	32	20.645	9	5.806	18	11.61
	Female	12	7.74	40	25.8	28	18.06	7	4.516
	Total	21	13.5	72	46.5	37	23.9	25	16.1
Age Group	20-30	1	1.55	1	1.55	15	9.67	24	15.48
	31-40	19	12.25	12	7.74	11	7.09	1	1.55
	41-50	1	1.55	28	18.06	11	7.09	-	-
	Above 50	21	-	31	20	-	-	-	-
Educational level	Illiterate	-	-	29	18.7	-		4	2.58
	<10	5	3.22	24	15.48	2	1.29	12	7.74
	Certificate	8	5.16	19	12.25	5	3.22	2	1.29
	Diploma		-	-	-	14	9.03	7	4.516
	1st		-	-	-	7	4.516	-	-
	2nd	4	2.58	-	-	7	4.516	-	-
	PHD	4	2.58	-	-	2	1.29	-	-

Table 2 shows that from the total respondents 87 (56.1) female respondents where as the rest 68(43.9%) were males. Most of the respondents 43(35.05%) were at the age of 31-40 years old. and also actively they have been participated in the study area. the educational level of the respondents varied from less than 10 years to PhD(cactus pear project coordinators.

4.2 Expansion of cochineal increasing

Table 2. Cochineal infestation through Percentage and frequency

Does cochineal raised in your locality?	Total number of respondents	Frequency	Percent
Yes	155	135	87.5
No	155	20	12.9
Total	155	155	100.0

As shown in Table.3 the respondents response 135 (87.5%) concerning cochineal infestation on their local area clarified yes. This indicates the expansion of cochineal is increasing different areas. Similar ideas obtained from document analysis Cochineal Control Committee (2011) Action plan for cochineal control in the Tigray confirmed that those areas exposed by cochineal.

4.3 Causes of the cochineal introduction

Table3.Response of the knowledge about the introduction & causes of cochineal

Items related to respondents on the Causes of the cochineal introduction	**Rating scales**										
	N^{o} of respondents	Not causing		Somewhat causing		Causing		Strolling causing		Very strolling causing	
		frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	percent	frequency	Percent
To Value add on existing cactus pear	155	12	7.7	19	12.3	21	13.5	45	29	57	36.8
To eradicate the invasive plant.	155	48	31.0	42	27.1	22	14.2	26	16.8	17	11.0
Perception of the community on the cactus pear as pest	155	47	30.3	43	27.7	36	23.2	14	9.0	15	9.7
Perception of the community on the cochineal as a commercial type.	155	37	23.9	51	32.9	34	21.9	15	9.7	18	11.9
Perception of the regional government as beneficial insect,	155	21	13.5	18	11.6	32	20.6	41	26.5	43	27.7

The result of the study revealed that in Table.4 the respondents' response57 (36.8%) shows that Carmine cochineal, Dactylopius coccus Costa was introduced to northern Ethiopia to add considerable value to existing cactus pear at the level of strolling causing.

According Mekelle University implemented a project on cactus pear production and utilization in Ethiopia during 2002-2004 (Chipeta, 2010) financed by the Food and Agriculture Organization of the United Nations (FAO). The vast areas of cactus pear in South Tigray could also a potential for cochineal production for there were various opportunities: absence of significant insect pests and diseases in Tigray that could hamper cochineal production, production costs will also be low because cochineal production will depend on the naturally growing cactus pear plantations and the many farmers have cactus backyards indicating that the culture is already rooted.

For this reason, the respondents clarified that the cause of the carmine cochineal introduced to northern Ethiopia to add considerable value to existing cactus pear vegetation that in places like the southern Tigray was becoming abundance of wild cactus outside of the arable lands. Results obtained from document analysis and key informants records one of them was the introduction of a cochineal industry that would be based primarily on the abundant cactus pear resources. There was abundance of wild cactus outside of the arable lands and this resource was least utilized.

As shown in Table 4.The respondents response48 (30.1%)that the invasive plant was not causing to introduction of cochineal. For this reason the respondents' clarified Cactus pear was not a neglected plant and in some as shown in Table 4. 42 (27.1%) were at somewhat causing. Some respondents believed that the cause of cochineal introduction was as a very serious aggressor where thousands of hectares are invaded both on steep Mountain slopes and also in the fertile lowlands. Fruits are damaged during harvesting because of traditional equipment's used similar idea obtained according (Habtu, 2005). In 1997, however, an international workshop on "Opuntiain Ethiopia: State of Knowledge in Opuntia Research" was organized for the first time by University of Mekelle and University of Wiesbaden-Polytechnic Germany to encourage alternative uses and control measures according (Mintesenot and Firew, 1997).

The workshop recognized Opuntia ficus indica as a very serious aggressor where thousands of hectares are invaded both on steep Mountain slopes and also in the fertile lowlands (Zimmermann, 1997) One of the workshop recommendations was introduction of the carmine cochineal (Dactylopius coccus) for the production of red dye as this may add considerable value to existing stands and also lessen the expansion of cactus pear to grazing lands and enclosures in southern Tigray. Other incentives for the promotion of cochineal production were the healthy

conditions of the plants, a favorable climate and availability of cactus pear in most small farming communities (Haile et al. 2000).

As shown in Table4 the respondent response47 (33.0%) believed that the Perception of the community on the cactus pear as pest was not causing to introduce the cochineal. For this reason the respondents clarified, that In Tigray, the immediate solution to bring food security especially in drought prone areas is working with cactus comparing to the cochineal harvesting.

As shown in Table4of the respondents response 51 (32.9%) that the perception of the community on the cochineal as a commercial type were somewhat causing. according documents analysis and observation indicated that there were showing self-assessment of stakeholders done after cochineal introduction most of them do not feel comfortable getting involved in any kind of carmine cochineal business, what do not seem relevant to its needs. Some of literature documented showed that Cochineal not acceptable by the most of community of study area, could not accept the cochineal insect as a beneficial insect despite existing market Opportunities. This could be due to the fact that the community was not consulted before the introduction of the insect to the locality and were reluctant to embrace cochineal. Respondents In the southern zone of Tigray believed that the introduction of cochineal insect as an introduction of disease to the cactus pear Production. The young, landless believed the insect as beneficial insect strongly agreed that trust and mutual respect for cochineal harvesting.

Figure 5. Cut and chopped cochineal infested cactus pear in Hintalo wegerat (Tsehafti)

As shown in Table4perception of the regional government41(26.5%) as beneficial insect were strongly causing .From my practical observation and of stake holders, that most Perception of the regional government believed that insect as beneficial insect that trust and mutual respect for cochineal harvesting.

4.4 Interest in cochineal production

Table 4. List of items related to interest of the community on carmine cochineal production and the corresponding response of respondents

Interest of cochineal in the study area-related to respondents	Rating scales										
	Number of responders	Very low		High		Medium		Low		very low	
		frequency	percent	Frequency	Percent	Frequency	Percent	frequency	Percent	Frequency	Percent
Insect as an introduction of disease to the cactus pear production.	155	25	16.1	55	35.5	35	22.6	21	13.5	19	12..3
Believe the cochineal business.	155	15	9.7	26	16.8	47	30.3	40	25.8	27	17.4
The cochineal business is outside of your traditional and culture.	155	49	31.6	44	28.4	17	11.0	21	13.5	24	15.5
The cover of cactus for arresting erosion and degradation,	155	70	45.2	76	49.0	9	5.8	-	-	-	-
indigenous biodiversity is at risk	155	38	24.5	58	37.4	13	8.4	29	18.7	17	11.0
For food, livestock feed,	15	38	24.5	48	31.0	23	14.0	21	13.5	25	16.1

The results showed in Table.5that the interest of the communities55 (35.5%) in the introduction of cochineal insect as an introduction of disease to the cactus pear production were high. Furthermore, the results showed in Table.5that the interest of the communities55 (35.5%)in the introduction of cochineal insect as an introduction of disease to the cactus pear production were high. Stintzing and Carle (2005) described cactus pear as a miracle plant; therefore, cultivation of the plant may assume greater agricultural importance in dry areas since a larger part of the land is destined to become arid or semi-arid due to climate change (Snyman 2006). Because of ever increasing human and livestock pressures on the land, a decline in soil productivity, and recurrent drought and famine, there is an increasing reliance on cactus pear to minimize risk and ensure crop and food security. In Tigray, the immediate solution to bring food security especially in drought prone areas is working with cactus (Nefzaoui et al 2010).

As shown inTable.5shows that interest of the community 47 (30.3%) in cochineal business medium. Similar from my practical observation and documents obtained from the key informants. According (Tesfay and Bustamante, 2010), Stated that the youth and the women showed strong interest in cochineal harvesting. This group was privileged in that they were not discouraged by the low price but were happy to get quick cash soon after they have harvested and their produce from the communal lands.

As shown in Table.5they believe49 (31%) the cochineal business is outside of their tradition or culture was very high. For this reason, that the elderly and church came up with a new idea that those involved in cochineal harvesting and sale will not get church services and are no more members of the Coptic Church. This information was conveyed to the community members during the Sunday church services. The cochineal issue divided members of the same family; while the young were involved in cochineal harvesting, the elderly were bound by the church decisions and were against the cochineal harvesting. Yet the family heads cannot influence their children probably because of the incomes.

Similar with the idea of Cochineal Control Committee (CCC 2011) Action plan for cochineal control in the Tigray region of northern Ethiopia The conflict of interest among community members arose as the benefit from the cochineal business increased in young, landless men and

women. Generation thought religious, spiritual and cultural related practices has played a significant role against the carmine cochineal expansion

As shown in Table.5of the respondents76 (49%) indicated that the interest of the community the cover of cactus for arresting erosion degradation at high level. According (Le Houérou, 1992; Nefzaoui and El Mourid, 2009) stated that Cacti and in particular can prevent or reverses desertification through different ways. this indicated cacti are drought tolerant species, they are used in watershed management and in water harvesting and its efficient use, in wind and water erosion control, in rangeland and marginal land rehabilitation, in cropland management and crop diversification to contribute alleviating poverty and to reach better livelihood of the rural poor in dry land, According (Githure*et al*. 1999; Volchansky*et al*. 1999).

As shown in table 5.The respondents 58 (34.7%) believed that the cactus suppresses and in growth. According borges (sited in Brazil, *D.* 2009; Borges *et al*. 2013) Farmers are also well aware of the fact that cactus suppresses and inhibits growth, occupies space and suffocates other plant species including grasses and field crops (Habtu, 2005) In Australia and South Africa *D. opuntiae* was introduced for the control of invasive cactus species like *Opuntia stricta* and *O. Ficus* indica.

As shown in Table4.The respondents 48(31.0%) believed that cactus is grown in the area to serve as a source of household income; livestock feed, household food, and for its functional benefits in soil and water conservation were at high level. Similar documents analysis obtained the reasons listed include need for increasing income, livestock feed, household food, and for gully stabilization. The rest had various reasons for expansion including increased demand for food, feed, and income and also for gully stabilization

4.5 Reducing of cochineal expansion

Table 5. List of items related to reducing of cochineal expansion and the corresponding response of respondents through percentage and frequency

The way of reducing of the infested area.	Rating scales										
	Number of respondents	Very high		High		Medium		Low		Very low	
		Frequency	percent	frequency	Percent	Frequency	Percent	Frequency	percent	Frequency	Percent
Regional quarantine to limit of movement.	155	13	8.4	38	24.5	29	18.7	37	23.9	38	24.5
mechanical control	155	21	13.5	16	10.3	34	21.9	40	25.8	44	28.4
Chemical control.	155	20	12.9	35	22.6	27	17.4	36	23.2	37	23.9
Modernizing cactus production	155	44	28.4	39	25.2	25	16.1	27	17.4	20	12.9
Creating awareness	155	14	9.0	58	37.4	17	11.0	28	18.1	38	24.5
Biological control	155	2	1.3	1	o.6	5	3.2	84	54.2	63	40.6

The current finding on the way of reducing of the infested and non-infested area using Regional quarantine to limit of movement shows in Table 5 the respondents38 (24.5%)believed that at high level and at the same time 38(24.5%) shows at low level. The result showed that the

responsibilities and duties of the representatives creating conducive environment and in working collaboration with other stack holders were no more. Some respondents believed the planned activities were perhaps either not fully implemented or were not efficient as a result of which cochineal kept on expanding to new areas and cactus fruit and feed production was significantly affected.

According some respondents indicated that Cochineal insect has already become a serious pest spreading at a fastest rate and is highly damaging the cactus plants in the region with no effective solutions discovered yet.

According In 2011 the Regional Government organized a team that worked on an action plan for cochineal control (CCC 2011) Establishing intra-regional quarantine (enforcement), to limit the movement of cactus planting materials, fruits to new areas. Farmers were trained so that they do not take cochineal infested cladodes from one place to another and report the first sighting of the insect in their localities to the local authorities for immediate action.

(A)Infected cladodes (B) Infected material

Figure 6.Shows infected material transfer to non-invested area

As shown in Table5.the respondents 44 (28.4%) that revealed that mechanical control were at very low level. This indicated Response from key informant community members from Wejerat area, severely cochineal infested area were not satisfied with action plans and were pessimistic

about the effectiveness of the control options and were of the opinion that cochineal cannot be eradicated through mechanical and chemical means.

As shown in Table 6the respondents37(23.9%) that the effectiveness of chemical controlling in the study area at very low. this indicated the respondents clarified that Pest control by small-scale farmers is still heavily dependent on chemical insecticides even though their use is associated with many undesirable and sometimes lethal consequences. Improper and wide - spread use of chemical insecticides can cause underground and surface water pollution (Dalvie et al 2003). Excessive use of insecticides also induces resistance development in target pests as well as killing beneficial organisms such as pollinators and natural enemies (Pedigo and Rice 2006). The greatest concern with use of chemical insecticides in crop production is their potential poisonous effects on human health through dietary exposure (Lu et al 2008, 2010; Łozowicka et al 2012).

This indicated, that community members from severely cochineal infested area, were not satisfied with action plans and were pessimistic about the effectiveness of the control options and were of the opinion that cochineal cannot be eradicated through mechanical and chemical control.

As shown inTable6the respondents44 (28.4%) that believed the effective using moderating cactus pearat very high level. this indicated communities believed that the effective using Moderating cactus pear more preferable and Cactus population density; Passive crawler dispersal is most effective in dense infestation of cactus. The result indicated Dispersal becomes inefficient and wasteful in sparse cactus infestations, because most crawlers miss their host

As shown in Table.6 the respondents 58 (37.4%) that creating awareness were raising workshops to the community, trainings on cochineal biology and identification to extension agents and possible control options were at high level. Cochineal insect has already become a serious pest spreading at a fastest rate and is highly damaging the cactus plants in the region with no effective solutions discovered yet. Similar ideas obtained from observation documents analysis according (CCC, 2011) the action plan included awareness raising workshops to the community, Trainings on cochineal biology and identification to extension agents and possible control Options. However community members from Wejerat area, severely cochineal infested area, were not satisfied with action plans and were pessimistic about the effectiveness of the control options.

Observation has proved that the potential for well establishment, its wider area coverage and damage of cochineal in Tigray as here are no records of predators feeding on the insect.

As shown in Table6the respondents effectiveness application of the extent of minimization of the cochineal infested using biological control were at low level. As shows from practical observation and data analysis that Cochineal is an introduced insect and there are no natural enemies that can infest and infect cochineal in our country. This is a very good opportunity for the expansion of the cochineal in different areas. Results obtained from documents also indicated that there were no specified documents showing the way of controlling of stakeholders done before cochineal introduction in to Tigray but there are Factors affecting to reduce of cochineal expansion that evident in different literature.

5. Conclusions and Recommendations

5.1 Conclusions

Based on the finding of the study, the researcher, drawn the following conclusions:

The current finding which revealed, that over the last few decades, interest in cactus pear as food and feed has increased due to its drought resistance, high biomass yield, high palatability and tolerance to salinity. This indicated In Tigray, the immediate solution to bring food security especially in drought prone areas is working with cactus. According the majority of respondents that Cochineal insect has already become a serious pest spreading at a fastest rate and is highly damaging the cactus plants in the region with no effective solutions discovered yet. Concerning the current status of cochineal infestation in the local area community revealed increased.

The result of the study revealed that indicated that the involvement majority of the respondents, Carmine cochineal, Dactylopius coccus Costa, were introduced to northern Ethiopia to add considerable value to existing cactus pear vegetation those in places like the southern Tigray were more believed causes to introduction of cochineal than the cause becoming an invasive plant. The introduction of a cochineal industry that would be based primarily on the abundant cactus pear

Perception of Generation thought religious, spiritual and cultural related practices has greater played a significant role against the carmine cochineal expansion. The results showed that the interest of the communities in the introduction of cochineal insect believed as an introduction of disease to the cactus pear production, and most of the respondents indicated that the interest of the community concerning on the cover of cactus for arresting erosion degradation believed at high level of value .According to the majority of respondents cactus is grown in the area to serve as a source of household income, livestock feed, household food, and for its functional benefits in soil and water conservation

The current result finding shows on the way of minimization of the infested area using Regional quarantine to limit of movement better than Mechanical and chemical control Believed. The results indicated that the study area respondents involving in the minimization of cochineal

infested area using biological control less effective than creating awareness in the study area.. most of the respondents from Wejerat area, severely cochineal infested area, were not satisfied with action plans and were pessimistic about the effectiveness of the control options and were of the opinion that cochineal cannot be eradicated through mechanical and chemical means.

5.2 Recommendations

Based on the results of the study, the following recommendations are forwarded:

- Awareness or consulted before the expansion of the insect to the locality area.
- Mechanical and chemical control with human labor must be encouraged for a small farm
- Establishing intra-regional quarantine system to limit the movement of infected cactus planting materials, fruits to new areas.
- Eradicated the infected cactus pear and exposing cactus to the sun proved good in controlling cochineal

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7. Appendices

Appendices 1. Improved utilization of cactus pear for food, feed, soil and water conservation and other products in Hiwane kebelle, Hintalowegerat Wereda & Cactus pear infested mountain chains

Appendices 2. Cactus pear infested in Hintalowegerat in southern Tigray, Northern Ethiopia

Appendices 3. Beles (Fruit) selection and needed for better marketing in Hiwane tabia

Appendices 4. Cladode and fruit of Opuntia ficus-indica from Adikeyhtabia in Hintalowegerat northern Ethiopia

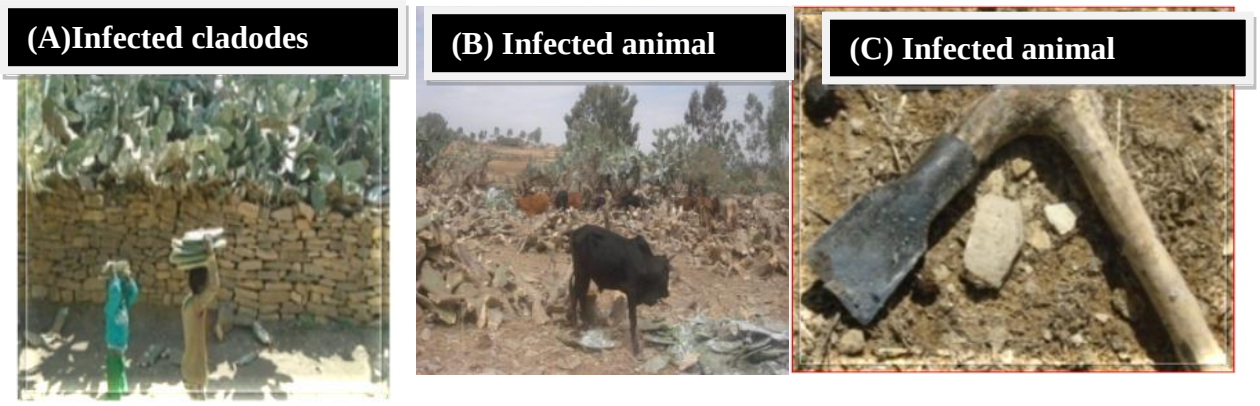
(A)FRUIT

(B) Infected Cladodes

Appendices 5. Cut and chopped cochineal infested cactus pear in Hintalowegerat (Tsehafti)

Appendices 6. (A) no more infected (B) and severely infected cladodes

Appendices 7. Factors affecting to expand carmine cochineal



Appendices 8. Cladodes with carmine cochineal

Appendices 9. Cactus pear grown in Hiwane kebelle ready for market

Appendices 10. Questionnaires

Questionnaire to be filled by Key-informants consisting of *kebelle* representatives (cactus pear project coordinators, *kebelle* households elder, young youth men & women, Mahberwgerat members association,

General Directions

Dear Respondents; the ultimate purpose of this questionnaire is to assess , gather, knowledge on the cause of cochineal introduction ,community interests in introduction of carmine cochineal and the ways of Minimization infested area and none infested area and To provide recommendations that would contribute to minimizations Cochineal infested area and for conservation and sustainable cactus pear in the study area. Hence, the success of this study directly depends upon your honest and genuine response to each item. Therefore, I sincerely request you to fill this questionnaire openly. Each data you supply will be used only for the purpose of target goal and also treated with utmost confidentiality. Since your answers will be treated with the strictest care, feel free to answer all the questions frankly **Thank you in advance for your cooperation**

Note: no need of writing your name and if you need extra support, ask the data collector

This questionnaire consists of three basic questions

A: What are the causes of cochineal introduction to the district area?

B: What is the community interest to introduce carmine cochineal in the study area?

C: What are the ways of minimization of the infected area?

Objective of the Study:

1. To gather, assess document indigenous knowledge on the cause of cochineal introduction in the study area;
2. To assess the community interests in introduction of carmine cochineal in the study area.
3. To assess what are the ways of Minimization infested area from none infested area.
4. To provide recommendations that would contribute to minimizations Cochineal infested area and for conservation and sustainable cactus pear in the study area.

Thank you in advance for your willingness to fill the questionnaires and returning them back on time.

SECTION A: Respondents Profiles

1. Sex

1. Female ☐ 2. Male ☐

2. Age ☐

1.20-30 ☐ 2.31-40 ☐ 3.41-50 ☐ 4.51 &above ☐

3. Educational level ☐

1. Illiterate 2. < 10 ☐ 3.Certificate ☐ 4.Diploma ☐ 5.1st degree ☐

6. 2nd degree ☐ 7. PHD ☐

.

4. Respondent responsibility

1. Young youth Landless ☐
2. Hintalowegerat association ☐
3. *Kebelle* household elders ☐
4. Cactus pear project coordinators ☐

5. Name of Wereda (*kebelle*)

1. *Kebelle*Hewane ☐
2. *Kebelle*Adikeyh ☐
3. *Kebelle*tsehafti ☐
4. *Kebelle*FikreAlem ☐

6. Does cochineal raised on your local area

1. Yes ☐ No ☐

Please, thick one box and table

Section B-causes of cochineal introduction

Causes of introduction of cochineal	Rating scale				
	1	*2*	*3*	*4*	*5*
Value add on existing cactus					
To eradicate the invasive plant					
Perception of the farmers on the cactus pear as pest					
Perception of the farmers on the cochineal as a commercial type.					
Perception of the regional government as beneficial insect					

Each scale represents the following rating:

1. Not causing
2. Somewhat causing
3. Causing
4. Strongly causing
5. Very strongly causing

Section C-Interest of the community

Interest of the community	Very high effective	High effective	Medium effective	Low effective	Very low effective
Insect as an introduction of disease to the cactus pear production					
believe the cochineal business					
The cochineal business is outside of your traditional and culture					
The cover of cactus for arresting erosion and degradation					
indigenous biodiversity is at risk					
For food, livestock feed, cash income, environmental protection, Fence, fire wood, and bee forage.					

Section D -The way of minimization of the infested area

The way of reducing of the infested area	Very high effective	High effective	Medium effective	Very low effective	Low effective
Regional quarantine to limit of movement.					
mechanical control					
Chemical control					
Cutting and exposing cactus to the sun					
Modernizing cactus production					
Creating awareness					
Biological control					

1. Very high effective
2. High effective
3. Medium effective
4. Low effective
5. Very low effective.

Other Please specify_____

Please, state out your comment for any recommendations: