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Distribution and Damage of African Citrus Psyllids (*Trioza erytreae*) in *Casimiroa edulis* Producing Areas of the Eastern Zone of Ethiopia.

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Abstract*— *The common white sapote, Casimiroa edulis occurs both wild and cultivated in central Mexico and produced in a different part of Ethiopia as home garden fruit crop for consumption as food. People also consider the fruits as one of the stimulant fruit crop. Currently, African citrus psyllids (Trioza erytreae) became one of the important pests of C. edulis in Ethiopia. The distribution and severity of this pest were recorded with an irregular pattern in the eastern part of Ethiopia. From all surveyed area (except some districts of Dire Dawa), very high infestation with high population density were recorded. The pest is currently in Ethiopia. This is first record of Trioza erytreae as devastating pest of casimir trees in Ethiopia. It is worth reporting to promote coordinated efforts amongst stakeholders, research specialists and extension officers to create awareness for proper management of the pest.

Keywords*— *African citrus psyllids, White sapote, Casimir, distribution, severity.

I. INTRODUCTION

White sapote *(Casimiroa edulis* L1ave & Lex), is native to Mexico and Central America. It can be found in central and southern Mexico as a cultivated and wild species and is also grown in Guatemala, EI Salvador, and Costa Rica. Commercially, it is grown in New Zealand, Australia, and Israel. The fruit has recently been introduced in Japan (Yamamoto *et al*., 2007) and on a small scale in South Africa, Egypt and different part of Ethiopia (Mathewos *et al*., 2013; Reta, 2013; Emelda, 2012; Haileab *et al*., 2011; Mesele *et al*., 2012).

Few pests affect white sapote crop, however, the fruit is highly infested by *Anastrepha ludens* (Aluja *et al*., 1987). Some volatile compounds in white sapote have been found to attract *A. ludens* to baited traps (Gonzalez *et al*., 2006). Although not a target, white sapote has been attacked by the African citrus psylla *(Trioza erytrea)* as one of its a host (Fernandes and Franquinho A., 2001).

African citrus psyllid is native to Africa. It has spread to islands off the coast of Africa and to Saudi Arabia and Yemen (Van den Berg, 1990). Del Guercio, originally described the species in 1918 from samples collected from Citrus limon (L.) Burm (Rutaceae) in Eritrea. The species currently is present mostly throughout the Afrotropic ecozone, including Sub- Saharan Africa and the islands of St. Helena, Mauritius, Reunion and Madagascar, and in Saudi Arabia and Yemen (EPPO 2005; CABI 2015). The species recently has invaded Macaronesia (West Palaearctic), where it was found in Madeira in 1994 (Carvalho and Aguiar, 1997) and the Canary Islands in 2002 (Gonza´lez-Herna´ndez, 2003). *T. erytreae* apparently remained confined to these non-continental areas of Europe, until it was initially recovered, in August 2014, in northwestern Spain (Pe´rez-Otero *et al*., 2015). The psyllid was found in subsequent months at two other locations in the province, at six locations in the province of Pontevedra (Galicia) and in the district of Oporto in Portugal (Pe´rez-Otero *et al*. , 2015), where it has been detected at eight locations (Anonymus, 2015). This psyllid lives from about 100 to 1300 m a.s.l. in the various geographical areas where it has been recorded (Gonza´lez-Herna´ndez 2003; Ekesi, 2015). The distribution of the psyllid in Africa, Saudi Arabia, and Yemen show that it has been able to adapt and settle under a variety of environmental conditions such as in equatorial, arid, and warm temperate climates with different temperatures and rainfall.

The invasion of *T. erytreae* into northern Spain is very similar to that of *T. citricidus*, which, despite its tropical origin, was found first in 2002 on the coast of Asturias and later became adapted to the climatic conditions of northwestern Iberian Peninsula (Ilharco *et al*., 2005). The adaptability of *T. erytreae* and its optimal development

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according to the climatic factors of the country indicates that, if it finds suitable host plants, it might disperse within Portugal, northern Spain, and into the interior of the peninsula, although, with greater difficulty because of the more extreme climatic conditions. Whatever the path, *T. erytreae* could reach the Mediterranean coast of Spain, the major citrus-producing area of the country, and possibly other citrus growing areas of Europe and North Africa.

T. erytreae was considered a pest of secondary importance for citrus in native regions for many years because of the negligible direct damage caused to adult trees (Catling, 1973; van den Berg & Deacon, 1988). The damage consists of the evident open gall-like structures on leaves, which are diagnostic for the presence of the insect. Leaves can become chlorotic and slightly curled, especially when heavily infested. Van der Mewre (1923) reported that infested leaves normally could perform their vital functions without dropping. Tamesse and Messi (2002), however, reported that *T. erytreae* could be an important pest for nurseries, causing strong deformations on leaves, which can cause 90 % of young plants to die in the absence of insecticidal control. An additional direct damage may also be due to the abundant honeydew excreted by nymphs as soft, white, sticky granules that, in severe infestations, give a dusty appearance to the plants (van den Berg *et al*. 1991), facilitate the development of fungi such as Capnodium sp. and attractants that collect it and disrupt the protective action of natural enemies.

Van den Berg *et al*. (1987) monitored indigenous plants near a citrus orchard and found citrus Psylla, *Trioza erytreae*, on fifty *C. anisata*,; twenty *Z. capense* and ten *V. lanceolata* plants. Adult citrus psyllas were also found, in a feeding position, on *Casimiroa edulis*, however, it was uncertain as to whether the psylla could feed on the plant (van den Berg & Deacon, 1989*T. erytreae* was observed to be feeding on the prevalent *C. anisata* trees in the highlands of Cameroon and Ethiopia (Aubert *et al*., 1988).

Currently, in the different parts of Ethiopia such as East Harerge, *T. erytreae* severely distorted leaves of White sapote (*Casimiroa edulis*), which stunted and galled, and appeared dusted with faecal pellets. Young leaves turned yellow when severely damaged. The presence of small pit galls on young leaves can indicate *T. erytreae* damage. *T. erytreae* is one of the major problems of White sapote producing farmers in Eastern Ethiopia. The infestations were so severe and sometimes caused complete devastation of the white sapote plants. However, there is no detail data concerning *T. erytreae* in Ethiopia. Therefore, this survey was aimed at studying the distribution and severity of *T. erytreae* to create awareness among stakeholders in Eastern Ethiopia and beyond.

II. METHODS AND MATERIALS

The survey was conducted in 2018 cropping season (3/05/2018 - 12/05/2018) to determine African citrus psyllid (AfCP) distribution and severity in *C. edulis* growing area of West Harege, East Harereghe, Harari regional state, and Dire Dawa as shown in Table-4. The survey was carried out in four (4) Zones, twenty one (21) districts/kebeles and one hundred forty three sites. From each zone, survey fields were selected after categorizing the producers based on the size of the plantation. From each surveyed area five to ten small-scale farmers were selected. Accordingly the following number of small scale farmers were selected, namely: Gumbi Bordode (5), Miheso (4), Chiro (6), Tulo (6), Doba (2), Goro Gutu (8), Meta (5), Kurfa Chele (4), Gurawa (4), Kombolcha (6), Haramaya district including Haramaya University (56), Kersa or Adele (5), Dire Dawa town (8), Erere Woldiya (3), Sofi (7) and Harari regional state town (7). Five plants were taken from each small scale farmer's site to assess distribution and severity of damage due to AfCP. Twenty leaves sample was collected near to middle canopy of each Casimir tree purposely from four cardinal directions (North, South, West, and East).

Data collection included field visit at Haramaya University and its surrounding for physical observation on *C. edulis* farms, discussion with men, women, children (boys and girls), and key informant interview with relevant government officials and staff and other knowledge rich individuals. Accordingly, a total of 40 participants (12 males and 10 females), 10 children (5 boys and 5 girls) and eight agricultural officers participated in key informant interview in the area.

The identification was done based on macro and micro growth and morphological characters of the insect using identification guideline for an insect. Relative frequencies were computed as follows:

Relative frequencies of AfCP **occurrence = Number of** Af CP **recorded per Casimir site/Total number of** AfCP **recorded from the survey site**.

Table 1 Severity status scale developed by Kataria and Kumar, 2012

Relative frequency of AfCP occurrence	Severity	Grades of severity status
0	0	No infestation

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1-5	1	low infestation
6-10	2	High infestation
> 11	3	Very high infestation

Source: Kataria and Kumar. 2012.

Geographic data (Longitude, Latitude, and Altitude) of each sampling site were recorded by the use of GPS. Sampled leaves were transported to Haramaya University plant protection laboratory for further quantification of the insect life stage and each leaf was examined under a stereomicroscope for counting the immature (egg, larvae/nymphs, and adult). ArcGIS 10.3 was used for spatial data management and Mapping of AfCP distribution. Relative frequencies of African citrus psyllids occurrence at each site were calculated by the use of formula adopted from Kataria and Kumar (2012). The value obtained was used to define severity index from which severity status at each site was determined, as follows. Microsoft office excel were used for the data organization. SAS 9.0 software package was used for population variation between surveyed districts.

Identification

After laboratory diagnosis and using internet resource it was confirmed that the observed pest is the African citrus psyllids, Trioza erytreae, which is currently devastating Casimir trees in Ethiopia (Figure 5&6).

III. RESULT AND DISCUSSION

5.1. Distribution and Severity of AfCP in south western part of Ethiopia

The present survey revealed that there was an irregular pattern of African citrus psyllids distribution and severity in the eastern part of Ethiopia. A total of 3 regions (Oromiya, Harari and Dire Dawa) were surveyed and a total of 143 plantations of Casimir were assessed for the presence or absence of African citrus psyllids during the survey. This pest was recorded causing various degree of severity in all surveyed area (Table 2, 4 and Fig-1). Except for Dire Dawa, all surveyed areas showed low to very high AfCP infestation (Table 1 and 4). During the survey AfCP free casimir trees were also recorded at Dire Dawa (Table 3). There is significant difference in AfCP population density among the surveyed areas. The high population density of AfCP in these Zones resulted in high to very high damage severity on Casimir trees in these particular areas (Table. 3). Microscopic observation of leaves collected from surveyed area showed significant difference in egg, nymph, and adult of African citrus psyllids (Fig 2, 3 and 4).

The severely damaged Casimir by psyllid adults and nymphs feeding caused the newly forming leaves to twist and curl which was similar to the feeding damage by green aphid (Fig. 2). Psyllid feeding also results in the reduction of shoot length giving a witches' broom effect (Fig. 3). Population density variation recorded in these areas were probably caused by varietal difference, ecological variation, farmer cultural practice, elevation, Casimir trees population scattered over surveyed area and time of arrival of AfCP to the area (Fig.2, 3 & 4). During the survey, it was also observed that citrus and Ficus spp. (*Yeshola Zaf*) infested with AfCP at Harari regional state and Haramaya district.

These findings are in line with that of Halbert & Manjunath., (2004); Flores *et al*. (2009) who indicated that Asian citrus psyllid, *Diaphorina citri* and is an important pest of citrus because it transmits phloem-limited bacteria (citrus greening disease), currently considered the world's most serious disease of citrus were found at Florida citrus plantation fields.

2.2. Agricultural experts, Farmers' and youngster perceptions about the pest

As far as the current distribution of the insect is concerned, all the Casimir growing kebeles in the surveyed areas were already infested, according to the discussants participated in the assessment. The discussants in Haramaya disclosed that they observed the infestation of their Casimir trees for the first time in 2015 and 2016. They also said that they had never ever seen such kind of problem in their Casimir farm and considered it as a new phenomenon for the people in the area. But they did not know whether the problem was caused by insect pest or disease. They commonly called it "*Besheta*" because of its fast expansion and deadly effect on Casimir trees. As per the discussant farmers, the insect was less in number during the rainy period. It limited itself to some part of the tree like leaves and lower part of the stem. However, the pest started to increase in population and found on every leaf of Casimir trees at the end of the rainy period. Following the vegetative/leaves regenerated the insect gradually distributed to the top of the trees during the flowering stage and present in almost every part of the tree. This helped the insect to easily infest and attack the fruit crop at maturity.

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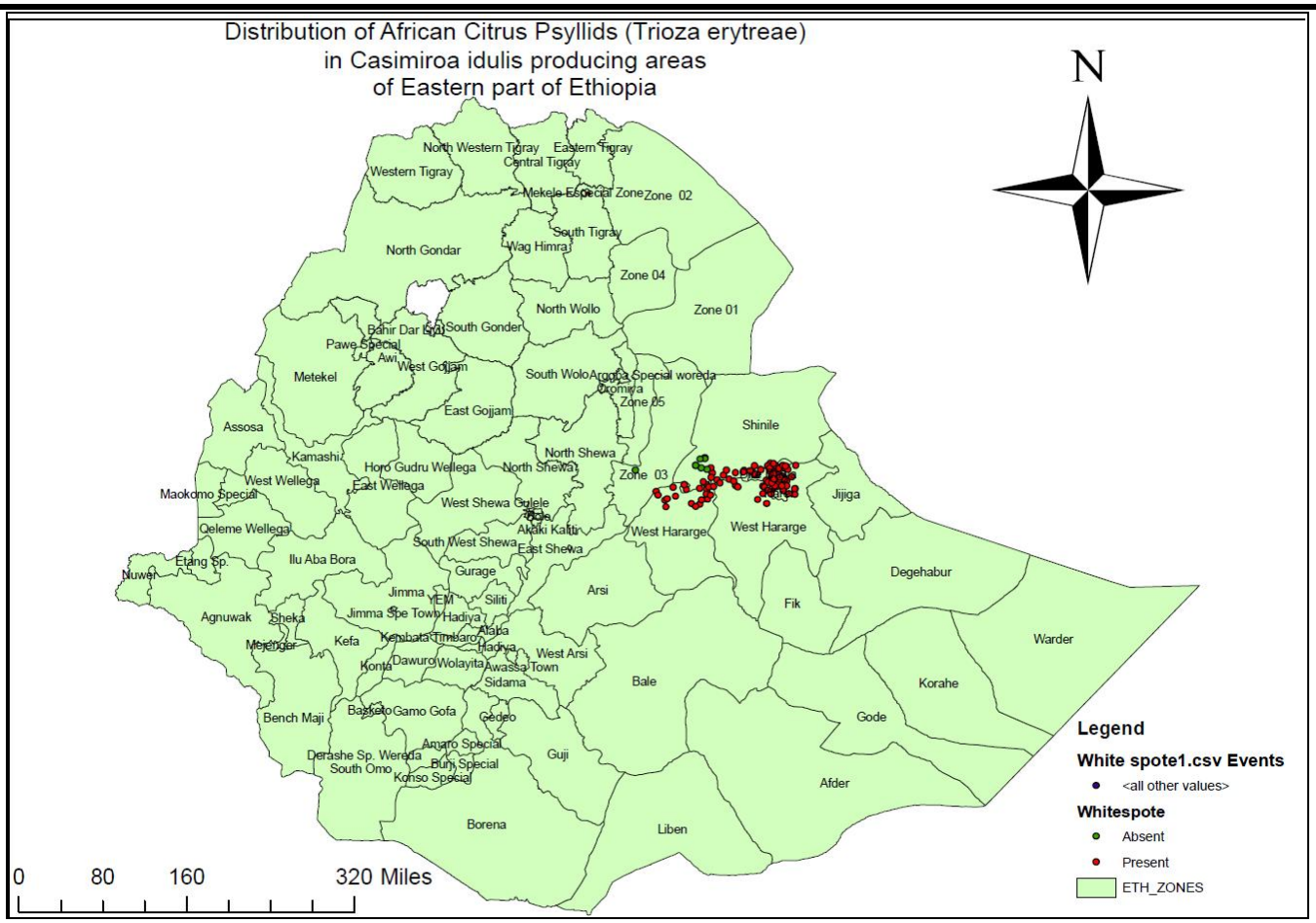

Fig.1: Map shows distribution of African citrus psyllids on Casimir producing areas in Eastern part of Ethiopia during 2018 cropping season

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Region	Zones	District	Eggs	Nymphs	Adult Females & Males
Oromia	Eastern Hararghe	Haramaya University	276.8CD	599.8BAC	7.523DBC
„	Eastern Hararghe	Gend Boyi	424.3CB	968.8 A	11.195 B
„	Eastern Hararghe	Finkile	138.3FED	265.3BC	0.612 E
„	Eastern Hararghe	Tinike	236.8CED	492.0BAC	0.612 E
„	Eastern Hararghe	Bate	531.0 B	1051.3 A	10.590 B
„	Eastern Hararghe	Haramaya Town	343.0CBD	805.3BA	8.825CB
„	Eastern Hararghe	Keresa/Adele	414.0CB	1002.0 A	8.613CB
Dire Dawa	Dire Dawa	Dire Dawa	0.0 F	0.0 C	0.030 E
Harari	Harari reginal state	Yerer Weldiya	62.5FE	52.8 C	4.765CED
Harari	Harari reginal state	Sofi	402.8CB	464.5BAC	8.363CBD
Harari	Harari reginal state	Harar Town	1047.5 A	1053.3 A	16.508 A
		CV (%)	40.92023	71.96	46.16
		LSD (0.05)	28.27	38.21	4.887
		F Value	12.33	2.47	6.48
		P Value	<.0001	0.0201	<.0001

Means followed by the same letters within columns are not significantly different at P<.0.05 level of probability

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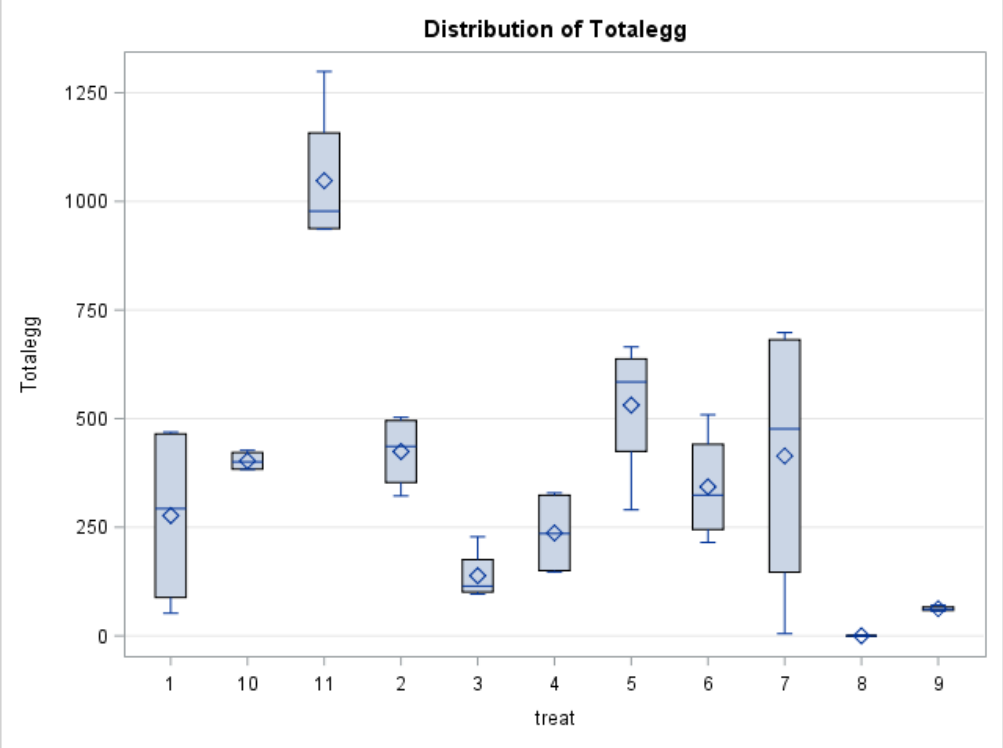

Fig.2: Distribution of total egg of African citrus psyllids, Trioza erytreae over surveyed areas.

NB: Treat represents districts or place of the survey and 1- refer Haramaya University, 2 - Gend Boyi, 3 - Finkile, 4 - Tinike, 5- Bate, 6- Haramaya Town, 7- Keresa, 8- Dire Dawa, 9- Yerer Weldiya, 10 - Sofi, 11- Harar Town

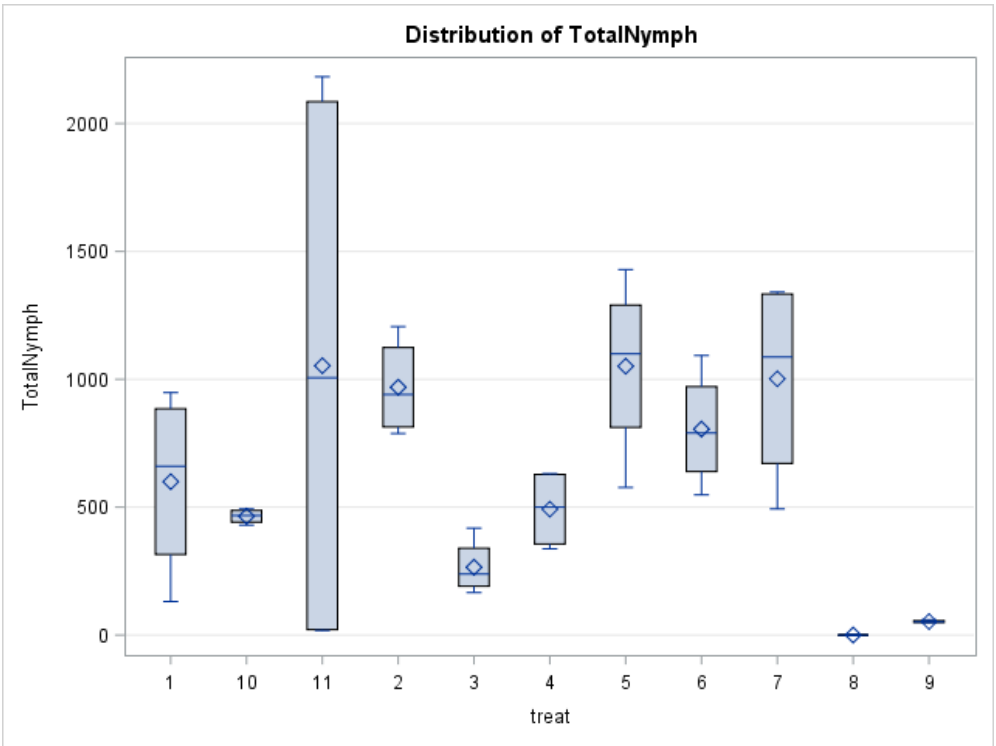

Fig.3: Distribution of total Nymph of African citrus psyllids, Trioza erytreae over surveyed areas.

NB: Treat represents districts or place of the survey and 1 refer Haramaya University, 2 Gend Boyi, 3 Finkile, 4 Tinike, 5 Bate, 6 Haramaya Town, 7 Keresa, 8 Dire Dawa, 9 Yerer Weldiya, 10 Sofi, 11 Harar Town

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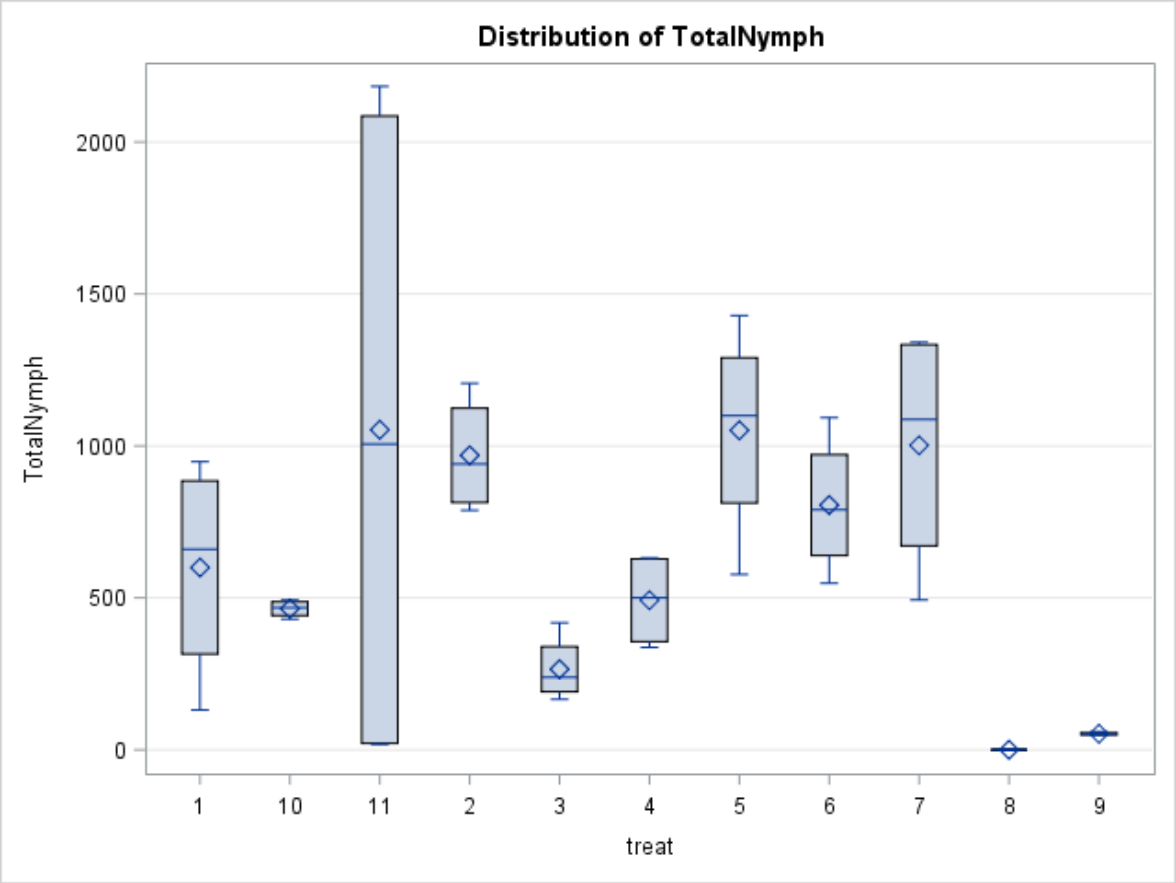

Fig.4: Distribution of total Adult of African citrus psyllids, Trioza erytreae over surveyed areas.

NB: Treat represents districts or place of the survey and 1 - refer Haramaya University, 2- Gend Boyi, 3- Finkile, 4 - Tinike, 5- Bate, 6- Haramaya Town, 7- Keresa, 8- Dire Dawa, 9- Yerer Weldiya, 10- Sofi, 11- Harar Town

Table 2 Severity status of African citrus psyllids in eastern part of Ethiopia during 2018 cropping seasons

Region	Zone	District or Kebele	Severity index	Severity status	Number of field observed
Oromia	East Harerege	Gumbi Bordede	3	Very high infestation	5
,,	East Harerege	Miheso	3	Very high infestation	4
,,	East Harerege	Chiro	3	Very high infestation	6
,,	East Harerege	Tulo	2	High infestation	6
,,	East Harerege	Doba	2	High infestation	2
,,	East Harerege	Goro Gutu	2	High infestation	8
,,	East Harerege	Meta	3	Very high infestation	5
,,	East Harerege	Kurfa Chele	1	Low infestation	4
,,	East Harerege	Gurawa	1	Low infestation	4
,,	East Harerege	Kombolcha	3	Very high infestation	6
,,	East Harerege	Haramaya University	3	Very high infestation	15
,,	East Harerege	Gand Boyi	3	Very high infestation	10
,,	East Harerege	Finkle	3	Very high infestation	5
,,	East Harerege	Tinike	3	Very high infestation	4
,,	East Harerege	Bate	3	Very high infestation	5
,,	East Harerege	Haramaya	3	Very high infestation	15

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„	East Harerege	Kersa	3	Very high infestation	9
Dire Dawa	Dire Dawa	Dire Dawa Town	0	No infestation	8
Harari	Harari reginal state	Erere Weldiya	1	Low infestation	3
„	Harari reginal state	Sofi	1	Low infestation	7
„	Harari reginal state	Harari reginal state Town	2	High infestation	7

Fig.5: African citrus psyllids infesting casimir leaves in Eastern part of Ethiopia

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Fig.6: The microscopic features of T. erytreae on casimir tree leaves: A and B lower face of an infested leaf, with nymphs settled at each gall, C, fourth and fifth instars nymph, D, eggs, E and D, adult male and female.

IV. SUMMARY AND CONCLUSION

The current survey showed the distribution of AfCP in eastern part of Ethiopia and considerably threatened casimir tree production and productivity. No AfCP was observed on Casimir at 8 different areas of Dire Dawa zone. On other areas West Hararghe (Gumbi Bordede, Miheso, Chiro, Tulo and Doba), *Eastern Hararghe (Haramaya University, Gand Boyi, Finkile, Tinike, Bate, Haramaya Town, and Keresa,*

Meta, Kurfa Chele, Gurawa and Kombolcha) and Harari regional state zone (Erere Wolediya, Sofi, Harar town), mild to very high infestation of AfCP was observed.

Studies conducted in different countries on this insect showed that in addition to direct damage, the insect is the vector for citrus greening pathogen but was not given attention in Ethiopia. Research centers, Agricultural experts and plant health clinics, require awareness on this newly attaining pest status in Ethiopia. There is no adequate information regarding this important pest in Ethiopia and requires studies on further distribution, pest status, and management options. Awareness creation and provision of training for Casimir growers and development agents is critical to overcome the negative effects of the pest. Different techniques including natural enemies of the pest require research for the effective management of *T. erytreae*.

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