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Status and Importance of Major Coffee Insect Pests in Major Coffee Growing Areas of Southern Ethiopia

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Abstract: In Ethiopia, coffee is known as the backbone of economy although the productivity was very low due to different factors. Among these, insect pests are one of the major affecting coffee productions in Ethiopia. The present study was conducted to assess the status of major coffee insect pests in major coffee growing areas of Southern Ethiopia. The survey result revealed that the infestation and damage level of insect pests varies among coffee fields, peasant associations and districts. The maximum percent of damaged coffee bean and number of antestia bug per tree was recorded at Wonago, 4.0% and 0.75 respectively. The mean number of bugs and bean damage levels were higher at higher elevations range (1931-2025 m.a.s.l) of Wonago district whereas the lower level was recorded at lower elevations range of (1449-1695 m.a.s.l) of Dilla Zuria district. The percent of infested farms of coffee blotch leaf miner (100%) was recorded in all assessed districts whereas the highest infestation of skeletonizer (90.90%) and serpentine coffee leaf miner (81.81%) at Dilla Zuria district. From the survey result the highest coffee blotch leaf miner infestation level was recorded at Aleta Wondo district (15.13%) while the lowest was at Dilla Zuria (5.32%); the highest infestation of skeletonizer (1.02%) and serpentine (0.60%) at Wonago while the lowest was (0.22%) and (0.10%) at Shebedino district, respectively. Lack of consulting professionals and practicing coffee agronomic recommendations were the knowledge gaps identified among the farmers and hence, adequate training for farmers and extension workers as well as districts' experts is needed. As future line, further studies should be conducted on the seasonal dynamics and developing integrated insect pest management strategies for major insect pests of coffee.

Keywords: Antestia Bug, Bean Darkening, Coffee Leaf Miners, Infestation Level, Insect Pests

1. Introduction

Amongst the top three agricultural exports in Ethiopia, coffee stands first followed by oil seeds and pulses. In the Ethiopian economy coffee has been enormous significance which accounts for 29% of the total export earnings of the nation, 4.7 million small-holders directly involved in producing coffee and about 25 million people directly or indirectly depends on coffee sector for their livelihoods [7, 28]. It is by far the most important export crop and contributes effectively to the country's foreign currency income [32].

Coffee production is limited by abundant factors, both biotic and abiotic. These factors losses are due to damage by pests, poor management practices, soil infertility, and poor pricing. Poor price of coffee is associated with the damage caused by pests, particularly insects that are proliferated by the climate change [15]. Insect pests are among these factors that considered limiting coffee production [22]. Over 47 species of insect pests are recorded on coffee [22, 6]. As reported by Esayas et al. [10] some insect pest species such as antestia bugs and coffee leaf miner are considered as major insect pests of coffee particularly in larger farms while coffee berry borer is a potentially important insect pest of coffee in Ethiopia.

Losses due to coffee pests are estimated to be 13% worldwide [25]. The yield loss due to some insect pests such as antestia bug was reported to be 9% in Ethiopia [10]. Nymphs and adults of antestia bugs feed on all vegetative and fruiting parts of the coffee tree leading to yield

reduction and poor quality of coffee beans [1]. Coffee blotch leaf minor was found to cause severe defoliation of coffee plant. However, CSA [7] reported that it never causes considerably yield loss. Million and Bayissa [22] reported coffee leaf skeletonizer as potentially occurring insect pests of coffee in plantation and other production system; however the intensity was lower than coffee leaf miner. The authors also reported that the coffee serpentine was very common in most coffee growing areas of Ethiopia though their populations was highly suppressed by the natural enemies.

Over the past 3 to 4 decades, changing climate, particularly global warming has already produced numerous shifts in the distribution and abundance of many species. Climate change and invasive species are considered as two of the most important ecological issues facing the world today [32]. The changes in climatic conditions are predicted to profoundly influence the population dynamics and the status of agricultural insect pests and as temperature has a strong and direct influence on insect development, reproduction and survival [31]. The impact of insect pest problem is pronounced more in intensive coffee production system than coffee in traditional home gardens and semi forest coffee since such systems could have long traditional and culturally associated protection practices [20]. However, there is a lack of sufficient current information about the distribution and status of major coffee insect pests in southern parts of the country. Survey on the current status of coffee insect pests is important to develop effective management strategies. Therefore, the objective of this study was to understand the status of major coffee insect pests infesting and assess the damaging levels in major coffee growing areas of Sidama and Gedeo zones of Southern Ethiopia.

2. Materials and Methods

2.1. Description of Surveyed Sites

The survey was conducted in six major coffee growing districts of Sidama and Gedeo zones, Southern Ethiopia during the 2016/17 cropping season. Sidama zone has-geographic coordinates of latitude/North: 5°45" and 6'45" and longitude/East, 38° and 39'. It has a variety of climatic conditions with total area coverage of temperate (54%), hot (30%) and cool (16%). The elevation ranges from 500 to 1500, 1500-2500 and 2500-3000 m. a. s. l for hot, temperate and cool climatic conditions respectively. The mean annual rainfall forhot, temperate and cool climatic zones are 400 to 799 mm, 1200 to 1599mm and 1600 to 1999mm and the mean annual temperature ranges from 20°C to 24.9°C, 15°C to 19.9°C and 15°C to 19.9°C, respectively [26]. Gedeozone with a total area of 1,347 km^2 is Located in 369 km from Addis Ababa to southern Addis Ababa Moyaletown road and 85 km from Hawassa (capital city of the region) in Southern Nation Nationality and People's Regional State [14]. Geographically, the zone is located North of Equator from 50 53'N to 60 27'N Latitude and from 380 8' to 380 30' East, Longitude. The altitude ranges from 1350 to 3000m [14]. The zone has sub-humid tropical climate and receives mean annual rainfall 1500 with range of 1200 and 1800 mm. The mean monthly temperature is 21.5°C with mean monthly maximum and minimum temperature of 25°C and 18°C, respectively.

2.2. Sample Unit and Assessment of Insect Pests

Based on the coffee potential producing areas three districts sampled from each zone, from each district three peasant associations and three up to five farmers from each peasant association were sampled. In each farm one hundred ripe cherries were randomly collected during harvesting then after, sampled cherries pulped by hand and identified into damaged and undamaged categories to compute the percent of bean darkening due to antestia bug Mugo [24] using hand lens. Thirty coffee trees per farm were randomly selected to count the number of antestia bugs (nymphs and adults) per tree in the morning from 6 to 10 a.m. and afternoon from 4 to 6 p.m. [4]. The entire sampled coffee tree was carefully examined and both nymphs and adult antestia bugs were counted by hand [16]. To determine the percent of infested farms of leaf miners (blotch, skeletonizer and serpentine) was calculated as number of infested farms divided by total number of surveyed coffee farms in each district and multiplied by hundred. Additionally, the infestation of these three coffee leaf miners assessed as twelve coffee trees per farm were selected. Sampled trees were selected systematically in employing the zigzag pattern sampling method and sample trees were stratified in to three-canopy layer and the total number of leaves on each sampled branches with damaged leaf was recorded. Infestation levels were computed from the cumulative number of damaged against the total number of leaves for each canopy layer multiplied by hundred. The first two pairs of leaves at the tip of the branches were not sampled for leaf miners damage assessment.

3. Results and Discussions

The survey result showed that the status of antestia bug and coffee blotch leaf miner observed and becoming the most important insect pests in the studied areas. Additionally, coffee leaf skeletonizer and serpentine leaf miner insect pests also recorded in different areas of surveyed districts. The distribution of these insect pests in surveyed areas of coffee growing areas varied widely. The variation in distribution of these pests in different coffee growing areas could be due to the age and history of coffee farms, type of cultivars, the natural topographical barriers, rainfall and temperature patterns, coffee farming systems and conserved bio-control agents. However, according to Camargo [2] report some climatic changes (temperature, solar radiation and relative humidity) have influence on physiological processes of coffee tree thereby playing an important role in defining its potential yield or ecological limitations.

3.1. Assessment of Antestia Bug

The damage level of coffee bean (bean darkening) and mean number of coffee antestia bug per tree were recorded variously among the assessed coffee fields, peasant associations and districts (Table 1 and Figure 1). The percent of damaged coffee bean and number of bugs per tree ranged from 2.0 – 4.0% and 0.19 – 0.75, respectively (Table 1). The maximum percent of coffee bean damage and number of bugsper tree was recorded at Wonago (4.0%) and (0.75) respectively (Table 1). Esayas et al. [10] reported that some insect pest species such as antestia bug and coffee leaf miner are considered as major insect pests of coffee particularly in larger farms in Ethiopia. Similarly, Fikadu et al. [12] also reported antestia bug, coffee blotch miner and white coffee borer were found as major coffee insect pests at Gedeo zone of Southern Ethiopia.

Among the surveyed peasant associations the maximum mean number of antestia bug was recorded at Worabe (0.80) peasant association from Yergachaffe followed by Odoya (0.76) and Dokicha (0.76) peasant association from Wonago whereas the minimum was recorded at Beratedachew (0.10) peasant association from Daledistrict (Figure 1). Even though the levels of infestations and damages to coffee bean varied among assessed areas the results obtained waslow which was below economic threshold levels (1-2 bugs/tree) [5]. This is in line with the report of Fikadu et al. [12] who reported the *Antestiopsis*spp are major coffee pests with density of 1-2 bugs per tree considered as the economic threshold level that requires insecticide spraying so as to avoid economical crop loss. Another finding reported by Tamiru et al. [27] also inline with this findings which indicated that 0.92, 0.85 and 0.76bugs per tree in Metu (IluAbabora), Hurumu (Ilu Ababora) and Ayira (Wollega) respectively. Mekasha [19] reported that branches of coffee trees infested with four pairs of the bugs caused the highest number of damaged coffee flower bud (1.2), 54.1% of berry fall, 90.2% of bean damage, and the lowest yield (0.41kg/tree) of red cherry [10]. The crop loss of 15-27% in total bean weight has been associated with infestation of 2-4 antestia bugs per tree [30]. Another finding showed that the presence of 2-3 antestia bugs per tree in the field can cause about 45% crop loss [13].

The lower extent of infestation and damage levels of antestia bugs in the southern Ethiopia could be associated with the presence of diverse natural enemies, which might keep the population at low level and genetic diversity of Arabica coffee. In Ethiopia, most of the coffee insect pests are categorized under minor importance while in most of coffee growing countries in the world considered most of insect pests as major importance [6, 22, 21]. Another study indicated that the genetic diversity of Arabica coffee coupled with cultural practices with minimum or no input used by subsistence farmers contributed to the low level of insect pests as described by Tsegaye et al. [29]. However, as Esayas et al. [9] reported, the disturbance of natural biological balance between pest and their natural enemies due to adverse changes of agronomic practices could get minor pests to major status and had a serious problem in coffee production.

Table 1. *Percent of damaged coffee bean and mean number of Antestia bug per district.*

Serial number	District	Coffee bean darkening (%)	Number of bugs/tree	Altitude
1	Dale	2.00	0.25	1729-1845
2	Shebedino	2.00	0.35	1812-1867
3	AletaWondo	3.00	0.37	1859-1977
4	Wonago	4.00	0.75	1931-2025
5	Yergachaffe	3.00	0.62	1833-1998
6	DillaZuria	2.00	0.19	1449-1695
Mean		2.00	0.42	

The present study also indicated that altitude is probably related with coffee bean damage and number of antestia bugs per tree (Table 1). The infestations and damage to beans levels were higher at higher elevations range (1931-2025 m.a.s.l) of Wonago whereas the lower infestations and damage to beans levels was recorded at lower elevations range of (1449-1695 m.a.s.l) of Dilla Zuria district (Table 1). This implies that the mean number and bean damage level of antestia bug was increased as altitude increase. The present study is in agreement with the observation by Ahmed et al. [1] who reported that the population's density of antestia bug linearly increased in elevations. The authors recorded the highest density of antestia bugs at 1600 m.a.s.l, were1.03 bugs per tree while the lowest population density at 1100 and 1500 m.a.s.l., with mean of 0.37 and 0.36 bugs per tree, respectively. Ahmed et al. [1] confirmed that the population density of antestia bug was highly influenced by elevation and which may reach economic injury level of one bug per tree at higher altitude. This might be due to the increase of antestia bug population in higher elevation as low temperature was found. The present finding is in line with Ahmed et al. [1] reported based on intrinsic rate of increase obtained from laboratory study showed the pest prefers low temperature.

3.2. The Relationship of Management Practices with the Distribution of Antestia Bugs

The survey results showed that the current status of management practices in the study areas was visually observed. The present study identified the areas of poor cultural practices (shade regulations, pruning, weeding, mulching, cropping systems, types of cultivars, soil fertility) used have contributions for the abundances of this insect pest. The abundance and damage level of antestia bug

variation might be due to the climate changes (rainfall, temperature, relative humidity). Similarly, Crowe and Tadesse [6] reported that cultural practices such as pruning of coffee trees and shade tree management can reduce the antestia bug populations by making unfavorable conditions, since they prefer dense coffee foliage. Mugo et al. [23] reported that coffee under shade and un-pruned coffee experience comparable micro-climate and habitat which promote rapid antestia bugs reproduction and low level of parasitism by natural enemies. Pruning coffee can reduce antestia bugs infestations by half compared to the bug population in dark bushy canopy [11]. The previous study reported by Mugo et al. [23] indicated that in open canopy of pruned coffee makes the habitat unsuitable for rapid reproduction of the pest but favorable for parasitoids. Additional, pruning increases the vigor of the plant by removing away unproductive vegetation and opening up the leaf canopy to allow more light to penetrate and air to circulate, thus reduce the humidity and temperature regimes [17, 18].

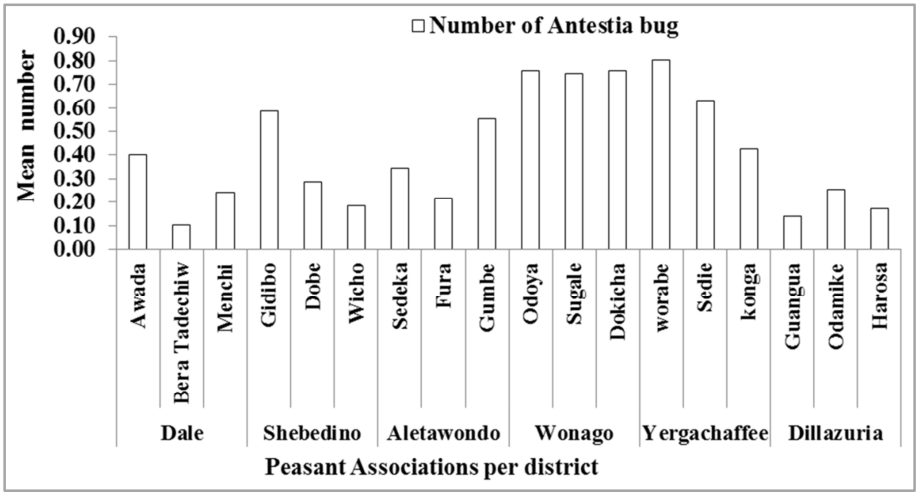

Figure 1. *The mean average number of Antestia bug per tree among peasant associations.*

3.3. Assessment of Coffee Leaf Miners (Blotch Miner, Skeletonizer and Serpentine)

The survey result revealed that coffee blotch leaf miner; skeletonizer and serpentine were present in assessed districts ranging from 22.22-100% (Table 2). The percent of infested farms by coffee blotch leaf miner (100%), recorded in all assessed farms in each district whereas the skeletonizer (90.90%) and serpentine (81.81%) at Dilla Zuria district respectively and lowest (22.22%) at Shebedino (Table 2). This implies that the highest number of coffee farms was infested by coffee blotch miner as compare to skeletonizer and serpentine. Chemeda et al. [3] reported significance differences in insect pest occurrence between and within forest coffee populations with regard to coffee leaf damaging insects. According to Fikadu et al. [12] coffee skeletonizer and serpentine leaf miner were found as minor coffee insect pestsat Gedeo zone of Southern Ethiopia.

Table 2. *The percent of infested farms by coffee Blotch, Skeletonizer and Serpentineleaf miners per districts.*

Serial number	District	Number of assessed farms per district	% of BLM	% of SK	% of SP
1	Dale	12	100.00	75.00	25.00
2	Shebedino	9	100.00	22.22	22.22
3	AletaWondo	9	100.00	66.67	55.56
4	DillaZuria	11	100.00	90.90	81.81
5	Wonago	9	100.00	88.88	77.77
6	Yergachaffee	8	100.00	75.00	37.50
	Total	58	100.00	69.78	49.98

%BLM=Blotch Leaf Miner %SK=Skeletonizer %SP=Serpentine.

From the survey results the highest coffee blotch leaf miner infestation level was recorded at Aleta Wondo (15.13%) while the lowest was at Dilla Zuria (5.32%); skeletonizer (1.02%) and serpentine (0.60%) while the lowest was (0.22%) and (0.10%) at Shebedino district, respectively (Figure 2). The infestation of coffee blotch miner at Dalle, Shebedino, Aleta Wondo, Dilla Zuria, Wonago and Yirgachafe districts were 7.99, 6.59, 15.13, 5.32, 10.15 and 8.60%, respectively (Figure 2). For skeletonizer and serpentine insect pests the infestation level at Dale, Shebedino, Aleta Wondo, Dilla Zuria, Wonago and Yirgachafe districts were 0.53, 0.22, 0.83, 0.90, 1.02, 0.40, and 0.11, 0.10, 0.26, 0.25, 0.60, 0.51%, respectively (Figure 2). The survey results showed that coffee blotch leaf miner was found in all assessed coffee farms of districts with highly infested coffee farms to cause severe defoliation of coffee

plants. However, Esayas and Chemeda [8] reported that it may not causes considerably significant yield loss. Currently the occurrence and distribution of coffee blotch miner has been increased and which becoming the most important insect pest in the study areas. This might be due to current environmental changes. Thus, present study indicated that the critical problems identified in the study areas might be due to altitudinal range and management practices (mulching, pruning, shade level, age and density of coffee trees, local landraces, weeding) with poor knowledge of farmers.

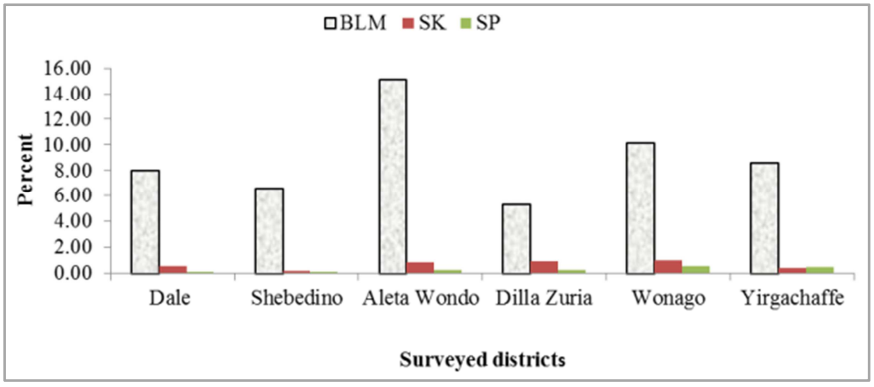

Figure 2. *The mean infestation level (%) of Blotch leaf miner (BLM), Skeletonizer (SP) and Serpentine (SP) among districts.*

Skeletonizer and serpentine leaf miners were very common affecting young leaf which outbreaks every year after the onset of short rain in study areas. However, the infestation of these insect pests was very low. Similarly, Million and Bayissa [22] reported coffee leaf skeletonizer as potentially occurring insect pests of coffee in plantation and other production system; however the intensity was lower than coffee leaf miner. The authors also reported that the coffee serpentine was very common in most coffee growing areas of Ethiopia though their populations was highly suppressed by the natural enemies.

4. Conclusions

In all surveyed areas of Southern Ethiopia, the major coffee insect pests, antestia bug and coffee blotch leaf miner were widely distributed varying in extent of infestation and damage levels. The infestation level variation might be based on the management practices and altitude in the study areas. The study showed that the number of antestia bugs per tree was low which below the economic threshold level might be due to the presence of diverse natural enemies and genetic diversity of Arabica coffee. Coffee blotch leaf miner infested coffee farms across districts is different level and becoming increased in the study areas. In addition, the status of minor coffee insect pests, skeletonizer and serpentine leaf miner also become increasing in the study areas. For future, further studies should be conducted on the seasonal variation and abundance of major insect pests, survey on the newly emerging and potentially important insect pests and the ecological influence on the distribution of pest, the economic threshold level and management practices. Practicing coffee agronomic recommendation, consulting professionals and implementation were the knowledge gaps identified among the surveyed farmers in the study area. Hence, adequate training for farmers, extension workers and district's experts on how to manage insect pests ought to be given and effective Integrated Pest Management strategies should be developed.

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