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POPULATION DYNAMICS AND DISTRIBUTION OF THE COFFEE BERRY BORER, *HYPOTHENEMUS HAMPEI* (FERRARI) (COLEOPTERA: SCOLYTIDAE) ON *COFFEA ARABICA* L. IN SOUTHWESTERN ETHIOPIA

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ABSTRACT: Population dynamics and distribution of coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Scolytidae) were studied on *Coffea arabica* L. in southwestern region of Ethiopia. Thirty coffee trees were sampled at weekly intervals from 2000 to 2001. Findings of this study showed that coffee berry borer population had a marked seasonal variation both on dry leftover and fallen coffee berries. Number of adult borers on dry leftover berries was significantly higher than on fallen berries (χ^2= 3.89, P < 0.05). All the developmental stages of the borer were more abundant during January to August. There were seasonal differences in the relative abundance of pre-brood, brood and post-brood female borers. Weather factors showed a marked influence on the population dynamics of the borer. Distribution of the borer covered a wide range of altitudes ranging from 1200–1770 m.a.s.l.

Key words/phrases: Coffee berry borer, *Coffea arabica*, Ethiopia, *Hypothenemus hampei*, population dynamics

INTRODUCTION

The coffee berry borer, *Hypothenemus hampei* is a major insect pest of coffee in many of the world's main coffee producing countries causing a considerable damage (Le Pelley, 1968; Reid, 1983; Mansingh, 1991; Baker, 1999; 2000). The borer has expanded its distribution along with the extension of coffee plantation (Baker, 1999). At present, it is found in almost all the major coffee producing countries of the world. It attacks all commercial species of coffee (*Coffea*), which are primary hosts of the berry borer (Mansingh, 1991; Baker, 1999). Among its natural hosts, preference of the borer varies according to species and variety of coffee (Mansingh, 1991). Crop losses caused by this pest can be severe, ranging from 50 - 100% if no control measures are applied (Le Pelley, 1968).

Davidson (1968) reported the first incidence of coffee berry borer in Ethiopia. Later on, its occurrence was reported from various parts of the country (Crowe *et al*., 1977; Crowe and Tadesse Gebremedhin, 1984; Million Abebe, 1987). Survey conducted in some coffee growing areas showed mean percentage infestation of 13.3% to 61% on dry leftover coffee berries (EARO, 2000). This suggested that a comprehensive assessment of coffee berry borer and loss posed by this pest in Ethiopia should be further investigated.

Information on the population dynamics enables: to anticipate the seasonal occurrence of the pest; the time when plant damage may take place; and design proper management of the pest. However in spite of its increasing importance in the country, there is no published information on the population dynamics of the pest. Therefore, this study was initiated to determine population dynamics and distribution of the coffee berry borer.

MATERIALS AND METHODS

The research was conducted in the field at Jimma Agricultural Research Centre (JARC), which is located at around 7° 46′ N latitude and 36° E longitude, and at an elevation of 1750 m.a.s.l. It receives an average of 1595 mm annual rainfall and

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the mean minimum and maximum temperatures are 11.3°C and 25.9°C, respectively.

To investigate population dynamics of the coffee berry borer, one hundred dry leftover berries were collected from 30 coffee trees at weekly intervals from September 2000 to August 2001 at Melko, Jimma following the method of Rémond and Cilas (1997) and Baker and Barrera (1993). Similarly, fallen berries were collected from around each sample tree and placed in a labeled paper bag separately. All the berries collected were examined for the presence of an entry hole (perforation) on the berry, which is a typical symptom of coffee berry borer attack (Le Pelley, 1968; Baker, 1999). Damaged berries were separately dissected with surgical blade and the number of each of the four developmental stages of the borer was recorded. Then mean number of each stage of borer was calculated for each sampling month. In addition, female borers in infested berries were classified into pre- brood, brood and post- brood and number of female borer in each category was determined following the method of Baker and Barrera (1993).

To assess the effect of weather on the population dynamics of the berry borer, rainfall (RF), relative humidity (RH), minimum (MIT) and maximum temperature (MAT) data of the experimental site were obtained from the meteorology section of JARC. Mean monthly count of the different stages of the borer was correlated with mean monthly weather data.

To study the distribution of the borer at different localities and to determine degree of damage, survey of the borer was conducted at 14 localities in the major coffee growing areas of southwestern Ethiopia from February to May 2001 (Fig. 1). At each site, thirty coffee trees were sampled and berries were collected from the top, middle and bottom canopy of the trees. All the berries collected were examined for the presence of an entry hole (perforation) on the berry, which is a typical symptom of the coffee berry borer damage (Le Pelley, 1968; Baker, 1999).

Degree of damage due to feeding and tunneling activities of the coffee berry borer was assessed based on visual score based on the method recommended by Reid and Mansingh (1985) so that:

Slight = less than 25% bean damage
Moderate = 25 – 50 % bean damage
Heavy = more than 50% damage

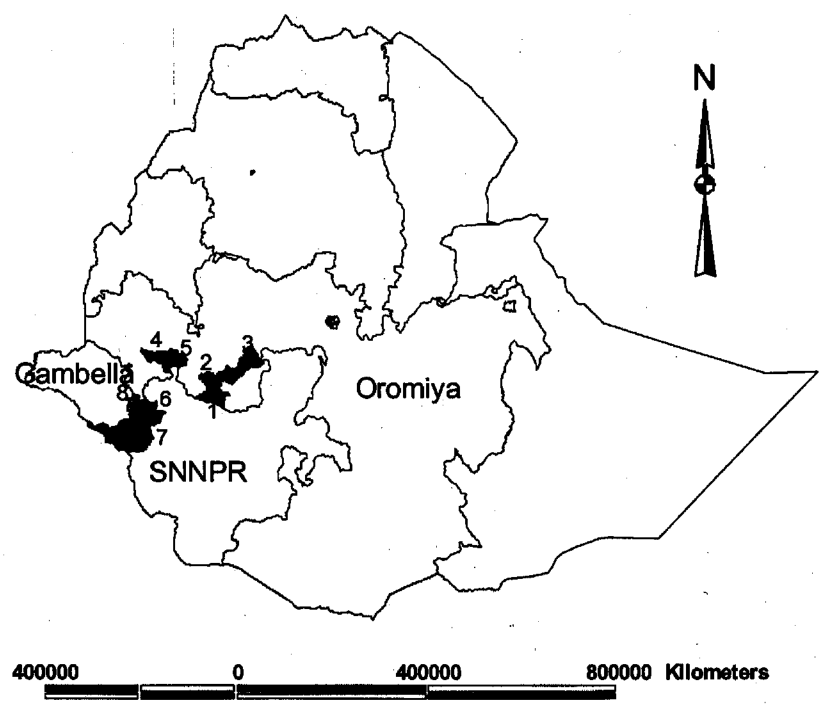

Fig.1. Sampled localities of coffee berry borer in southwestern Ethiopia [1= Melko (Seka), 2=Agaro (Goma), 3=Limu Suntu (Kosa), 4=Metu and Ihud Gebeya (Metu), 5=Yayo (Yayo), 6=Tepi, Baya and Shosha (Yeki), 7=Sheko, Selale and Gezmeret (Sheko), 8= Kabo and Meti (Godere)].

RESULTS

Population dynamics

Coffee berry borers were found to occur almost throughout the experimental periods with fluctuating numbers. Number of adult borers rose steadily from January onwards reaching peak in August and July on dry leftover and fallen berries, respectively (Figs 2 and 3). This is the period at which over ripe, dry leftover and fallen berries are available. As presented in Figs 2 and 3, neither eggs nor immature stages (larvae and pupae) were observed during November to December and November to January on dry leftover and fallen berries, respectively. However, after February, the number of eggs and immature stages showed a steady increase, but declining after September. It was also observed that the number of adult borers on dry leftover berries was significantly ($\chi^2 = 3.89$; $P < 0.05$) higher than on fallen berries.

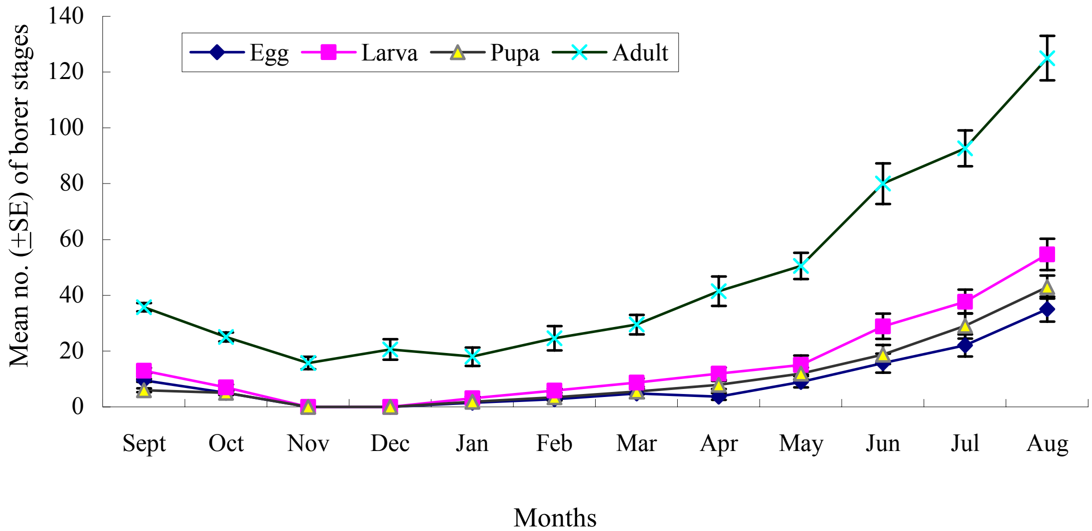

Fig. 2. Seasonal changes in coffee berry borer population on dry leftover berries at Melko, Jimma.

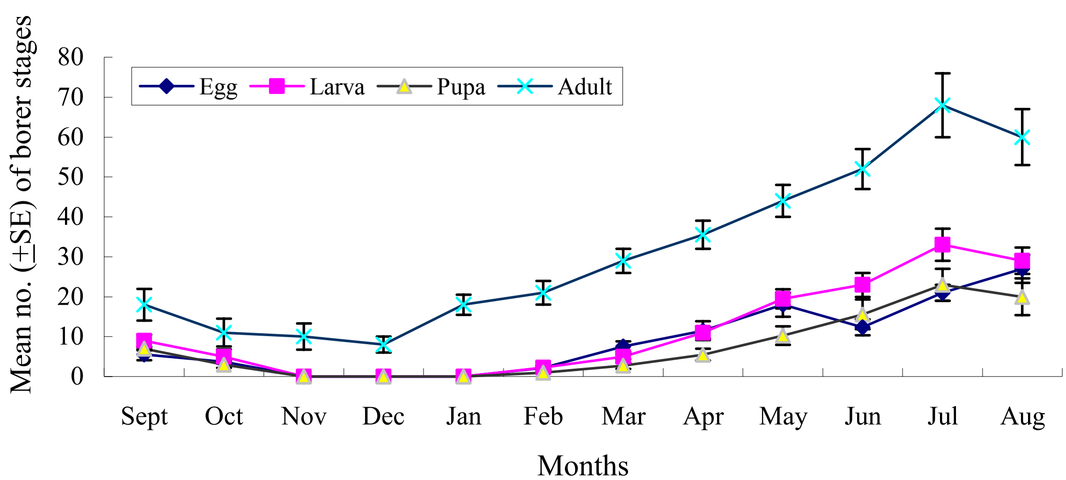

Fig. 3. Seasonal changes in coffee berry borer population on fallen berries at Melko, Jimma.

There were marked seasonal differences in the relative abundance of pre- brood, brood and post-brood females (Fig. 4). Infested berries containing pre- brood females were found to be at their peak in September and declined then after. On the other hand, brood females increased steadily just after February and reached peak in July, but they were not found during November to December and November to January on dry leftover and fallen infested berries, respectively. Whereas, post- brood berries were more abundant from September to February.

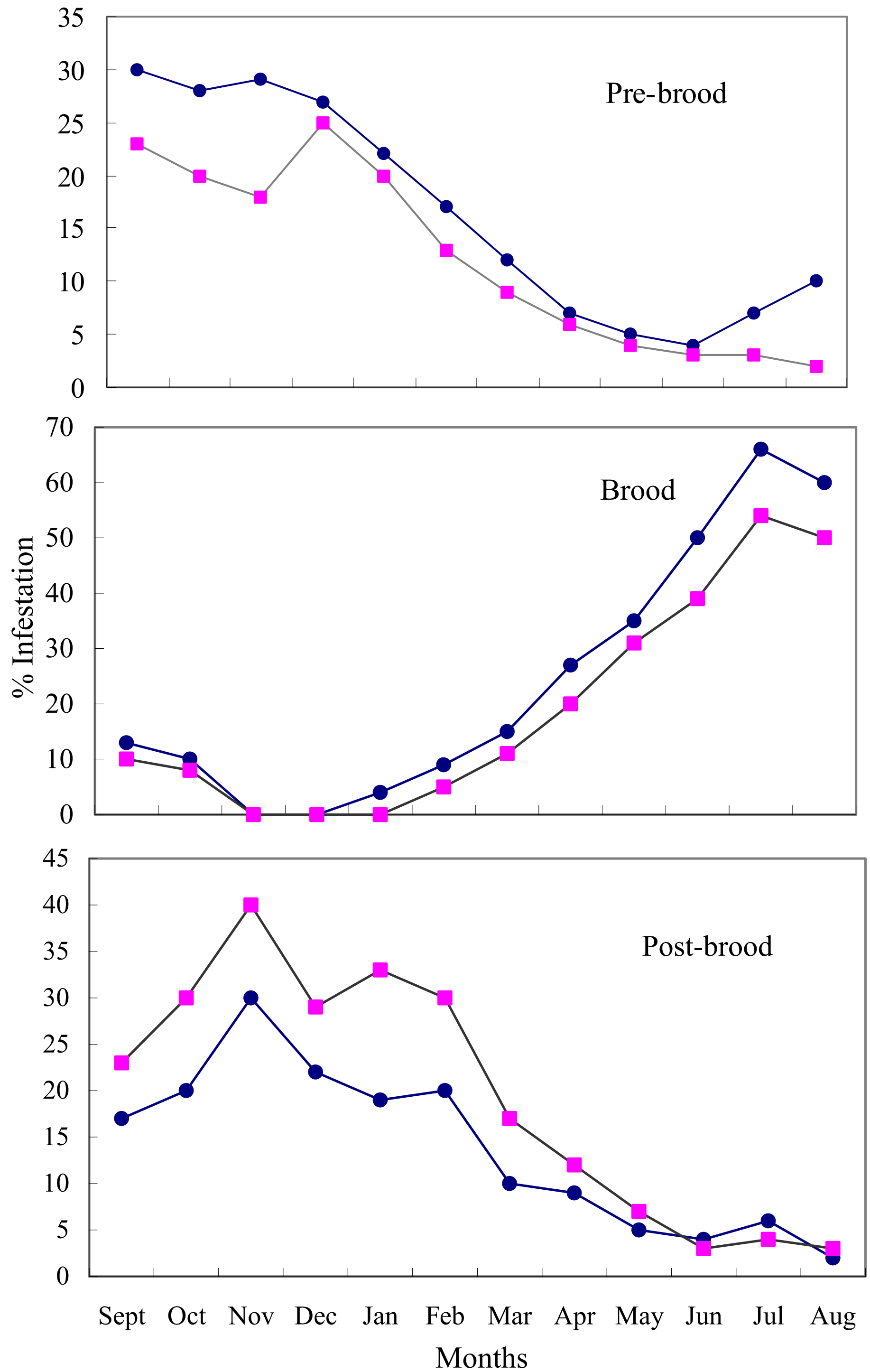

Fig. 4. Seasonal changes in pre-brood, brood and post-brood female borers on dry leftover ● and fallen berries ■ at Melko, Jimma.

As presented in Table 1, weather factors showed a marked influence on the population dynamics of the borer. Rainfall had significantly positive correlation ($r = 0.88$ and $r = 0.91$, $P < 0.01$) with egg and adult population of the borer, respectively. Moreover, relative humidity showed significantly positive correlation ($r = 0.88$, $P < 0.01$) with larval stages of the borer and maximum temperature showed significantly positive correlation ($r = 0.89$, $P < 0.01$) with pupal stage of the borer.

Population distribution and level of damage

As elucidated in Table 2, coffee berry borer covered a wide range of altitudes ranging from 1200 to 1770 m.a.s.l. It was recorded in large-scale coffee plantations, research centers and small- scale farmers' holdings at a considerable variation in the level of damage. The highest mean percent infestation was recorded at Tepi (60%). In general, at Yeki and Godere Districts (Wereda), where most of large-scale coffee plantations are found and at research centers like Melko, Metu and Tepi the level of infestation was considerably higher. On the other hand, in small-scale farmers' holdings like Ihud Gebya, Selale and Gezmeret, the infestation was very low (<5%). It was also noted that, in the survey areas there are localities with no coffee berry borer infestation. As shown in Table 2, level of damage due to feeding and tunneling activities of the borer among berries collected from most of the localities showed a slight (< 25% bean damage) and moderate (25–50%) damages. Nevertheless, most of the damaged berries obtained from Tepi showed high degree of damage (> 50% damage).

Table 1. Correlation analysis of coffee berry borer population and weather factors at Melko, Jimma.

Stage	Weather factors	Correlation	Probability
Egg	RF	0.876**	0.004
	MIT	0.335	0.517
	MAT	-0.329	0.525
	RH	0.500	0.313
Larva	RF	0.446	0.354
	MIT	-0.057	0.914
	MAT	-0.395	0.438
	RH	0.876*	0.010
Pupa	RF	0.518	0.292
	MIT	0.585	0.222
	MAT	0.894*	0.017
	RH	0.471	0.346
Adult	RF	0.912**	0.007
	MIT	-0.013	0.980
	MAT	-0.465	0.353
	RH	0.302	0.561

*Significant, **Highly significant

Table 2. Distribution of coffee berry borer and level of damage of coffee berries at different localities in southwestern Ethiopia.

District (Wereda)	Locality	Altitude	Total percent damaged berry	Degree of damage*		
				S	M	H
Seka	Melko	1750	43.0	8.0	18.0	17.0
Goma	Agaro	1560	13.5	5.0	5.0	3.5
Kosa	Limu Suntu	1700	3.0	2.0	1.0	0.0
Metu	Metu	1600	41.5	13.5	10.0	18.0
Metu	Ihud Gebeya	1770	4.5	3.0	1.5	0.0
Yayo	Yayo	1340	11.7	6.0	3.7	2.0
Yeki	Tepi	1200	60.0	20.0	18.0	22.0
Yeki	Baya	1250	27.7	15.0	5.7	7.0
Yeki	Shosha	1250	45.0	12.0	15.0	18.0
Godere	Kabo	1260	21.2	8.5	8.2	4.5
Godere	Meti	1440	19.6	15.0	2.6	2.0
Sheko	Sheko	1670	7.7	4.7	2.0	1.0
Sheko	Selale	1200	4.0	3.0	1.0	0.0
Sheko	Gezmeret	1210	4.6	3.0	1.6	0.0

*S= Slight (<25% bean damage); M= Moderate (25–50 % bean damage); H= Heavy (> 50% damage)

DISCUSSION

Although coffee berry borer populations were found to occur the whole year round, mean number of the developmental stages of the borer and level of damages they induce showed a marked seasonal variation both on the dry leftover and fallen berries. Number of adult borers on dry left over berries was significantly ($P < 0.05$, $\chi^2 = 3.89$) higher than on fallen berries. Similar to this finding, Baker and Barrera (1993) found significantly higher borer population on tree berries than fallen berries. This implies that the borer seems to prefer dry leftover berries to fallen berries. In addition, decaying and rotting of some of the fallen berries may also dwindle number of borers on fallen berries. Immature stages of the borer in the present study rose steadily after February and started declining from September and disappeared from November to January. This may be due to the occurrence of a large number of borers in the pre-brood stage. Furthermore, this period is associated with low rainfall and high daily temperature, which probably force the borer to cease breeding. Fallen berries were found to be an important site for breeding of the borer. It can support the population of the borer even in the absence of any crop on the tree and it can carry over the borer from one crop season to the next. This conforms with the report of Baker (1999) that fallen berries are a major source of re infestation.

There were seasonal differences in the relative abundance of pre-brood, brood and post-brood female borers as was the case with the findings of Baker and Barrera (1993). Availabilities of coffee berries, which are used either for feeding or oviposition or both and weather factors, appeared to influence the relative abundance of broods in infested berries. As stated by Baker and Barrera (1993), the classification of infested berries according to the reproduction stage of the borer is a useful approximate method of estimating the state of the population of the borer.

Weather factors markedly influenced population of the borer. In other studies, rainfall significantly affected level of infestation and evacuation of the borer from fallen berries (Baker, 1997) and a significant effect of temperature and relative humidity on emergence of the coffee berry borer from infested coffee berries was reported by Baker *et al*. (1992). A significant effect of rainfall on adult population of the borer determined the oviposition rate of female borer as confirmed by highly significant and negative correlation between rainfall and number of eggs laid. It was also reported that rainfall will stimulate emergence of adult borers from fallen berries (Baker and Barrera, 1993) as a result, removal of fallen berries from the ground was recommended as a means of controlling the borer. As opposed to findings of the present study, no relation was established between weather conditions and prevalence of the borer (Le Pelley, 1968) and level of infestation had no correlation with temperature and rainfall ($r = 0.35$) (Rhodes and Mansingh, 1986).

It was noted that, abundance of the borers coincided with the availability of over ripe, dry left over and fallen berries of the preferred hosts of the borer. In addition, the existence of such berries either on the tree or on ground at all time contributes to the occurrence of the borer almost throughout the year.

As reported by previous workers, coffee berry borer is a serious pest of low altitude coffee, and almost absent at higher altitudes (Evans, 1965; Le Pelley, 1968; Wrigley, 1988). In the present study, the borer has been found to occur from 1200–1770 m.a.s.l. In agreement to the present study, Rhodes and Mansingh (1986) and Ticheler (1961 cited in Rhodes and Mansingh, 1986) found this insect in areas of 1603 and 1700 m.a.s.l. Murphy and Rangi (1991) also reported its occurrence at 1600 m.a.s.l. Altitude is among other factors, which appeared to limit the distribution of the borer as indicated by a significant and negative correlation between altitude and infestation ($r= - 0.6$; $P<0.05$). On the other hand, Rhodes and Mansingh (1986) found no significant correlation ($r= -0.3$; $P<0.05$) between infestation of the borer and altitude. In the present study, coffee berry borer infestation is higher at large-scale coffee plantations and in research centers. This indicated that the borer has been well established in these areas. Weather conditions and availability of dry leftover coffee berries almost throughout the year may contribute for high infestation of the borer. Moreover, changes in cultural practices associated with the newly planted coffee cultivars may have created a conducive environment and thereby high level of infestation (Million Abebe, 1987). The level of damage on dry coffee berries varied among surveyed localities. Such variation may be due to coffee variety and age of coffee berry. Moreover, number of borer per infested berry and duration of infestation may also determine the level of damage. It is evident that, any level of damage on coffee berries significantly affects the quality of coffee.

Since the present survey was conducted only at some coffee growing localities of south-western region of the country, more thorough survey should be done including other coffee growing regions during different seasons. In addition, surveys are also necessary on the amounts and severity of bored berries in picked coffee berries at processing plants.

The current study has clearly shown the importance of dry leftover and fallen berries for population build up and incidence of coffee berry borer throughout the year. Therefore, coffee berries should be collected as they are ripen and all over ripe, dry leftover and fallen berries should be collected after harvest in order to deprive the borer the opportunity for breeding and leave little host for immigrating borer.

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