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Phenology and Migration of Tef Epilachna, *Chnootriba similis* Thunberg; (Coleoptera: Coccinellidae) in Ethiopia

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Abstract: Studies were conducted on the phenology of tef Epilachna, *Chnootriba similis* Thunburg, formerly known as *Epilachna similis*, from 2003 to 2005 along two selected rivers and from 2004 to 2005 in two agricultural fields. Abundance of the insect was observed in barley fields every week and fortnightly along the rivers using 0.25 m^2 quadrates and insect sweep nets, respectively. It survives along rivers during the dry period as adult in diapause, which terminates around mid-January, with increased feeding and initiation of mating. The adults then migrate to agricultural fields between March and April. This may be delayed because of the reduced cumulative rainfall in January and February. Termination of diapause and adult migration is influenced by rainfall. It is a bivoltine insect. The adults from the second generation migrate to rivers between September and October as they require moisture to overwinter during the dry period of the year, while the majority of the first generation adults remain in the agricultural fields. The ovipositional, larval and pupal periods of both generations was investigated and the duration of the developmental stages of the first generation were longer than in the second. This insect is mainly a pest of seedlings.

Key words: *Chnootriba similis*, imagines diapause, bivoltine, overwintering

INTRODUCTION

Tef Epilachna (*Chnootriba similis*, Thunberg, formerly known as *Epilachna similis*, subfamily Epilachninae) is a phytophagous ladybird beetle widely distributed in Africa with reports of pest damage in Nigeria (Alam, 1992), Ghana (Scheibelreiter and Inyang, 1974), Burkina Faso (Lafleur, 1994) and Ethiopia (Raimundo, 1992; personal observation). *Chnootriba similis* is not only restricted to Africa and also found in Yemen (Moharram *et al*., 1996).

Both the larvae and adults produce similar damages. Many reports have shown that it has wide range of hosts, especially, from the grass family Poaceae. In Ethiopia, it was reported as a pest of tef (*Eragrostis* tef) and other small cereals in different parts of the country (Crowe and Shitaye, 1977; Haile and Ali, 1985) and particularly on wheat in the Rift Valley (Wale, 1998). It was reported as a pest of maize, rice, sugarcane and other graminaceous plants in the West, East and Southern African countries (Schmutterer, 1969, 1971) and cereal crops in Yemen (Moharram *et al*., 1996).

Chnootriba similis causes a typical leaf scarification on the foliage of its hosts. The damage was observed usually at seedling stage but can continue up to heading stage. Other than destruction of leaf tissue, it also transmits one of the most economically damaging diseases of rice in sub-Saharan Africa, the Rice Yellow Mottle Virus (RYMV) (Nwilene, 1999; Abo *et al*., 2001).

Although, damage on cereals has been well known, little information is available on the ecology and management of *C. similis* in Ethiopia. As basic information, ecological study of the insect is necessary to design a sound pest management programme. The objective of this research was to

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investigate the phenology and migration behavior of *C. similis* in Ethiopia. Such information would help to establish effective timing of scouting for sound management of the pest.

MATERIALS AND METHODS

Phenology of *C. similis* was studied over four seasons (two short and two main growing seasons) in Southern Ethiopia, Wolaita Zone in 2004 and 2005. During the four seasons of the study, two agricultural fields Damot Gale (37^0 49' 56.5'' East and North 6^0 55' 36.2'') and Boloso Sore (37^0 41' 17.8'' East and North 7^0 04' 24.0'') were selected. The distance between these sites is about 40 km. At two rivers close to the selected study sites, monitoring for the survival of the insect throughout the year was conducted for three successive years, 2003 to 2005. The two selected rivers, Wajakerero and Woybo, were situated around 10 and 5 km from the study sites, Damot Gale and Boloso Sore, respectively.

In both selected fields, barley (*Hordeum vulgare* L.) was sown during the main planting period in April for the short rainy season and in July for the main growing season in 2004 and 2005. Data on oviposition, larval and pupal periods and adult emergence was collected from 0.5×0.5 m (0.25 m^2) quadrates, every week from four plots in each of the agricultural fields. Five quadrates per barley field were sampled during the short rainy season (April to June/July) and the main rainy season (July/August to October). The number of insects was recorded as the number of egg batches, early larvae (1st and 2nd instars), late larvae (3rd and 4th instars), pupae and adults. The mean numbers of the developmental stages (egg batches, early and late larval instars, pupae or adults) per plot (1.25 m^2) of the weekly samplings were used to construct the graphs in Fig. 3.

Adult *C. similis* were monitored at the two selected rivers. One hundred sweeps were taken fortnightly for three years from the periphery of the water streams (within one meter distance from the water) and between 1 and 10 m from the water streams depending on the availability of wild grasses to assess its spread within the survival sites in relation to moisture or rainfall. Data was analyzed based on monthly counts of the adults per one hundred sweeps.

During the study, the population density of larvae per 100 sweep nets was also recorded from the two rivers to ascertain whether the ladybird beetle is able to reproduce in the survival sites. Regular observations were also made on feeding and mating activities of the adult insects throughout the year.

RESULTS

The regular survey conducted for three successive years along the two selected rivers showed that the adult tef Epilachna beetles were found throughout the dry period along rivers (Fig. 1a-c). The survey further indicated that more than 70% of the adult population along the rivers was recorded very close, within a meter distance, to the water streams predominantly during the dry period (October to beginning of January) (Table 1) and this may suggest that the adult insects favour to inhabit moist places during the overwintering period. Moreover, the data collected from the rivers indicated that when the surrounding of the rivers was relatively moist due to rains or floods, the adults spread relatively far from the water streams. For example, in most occasions in September, the adult population was higher and subsequently decreases during the following three months when rainfall was insufficient. In January, when the rainfall was relatively better (Fig. 1), the adults began to appear far from the adjacent area of the water streams (Table 1). This phenomenon may elucidate the significance of moisture for the survival and spread of the adults.

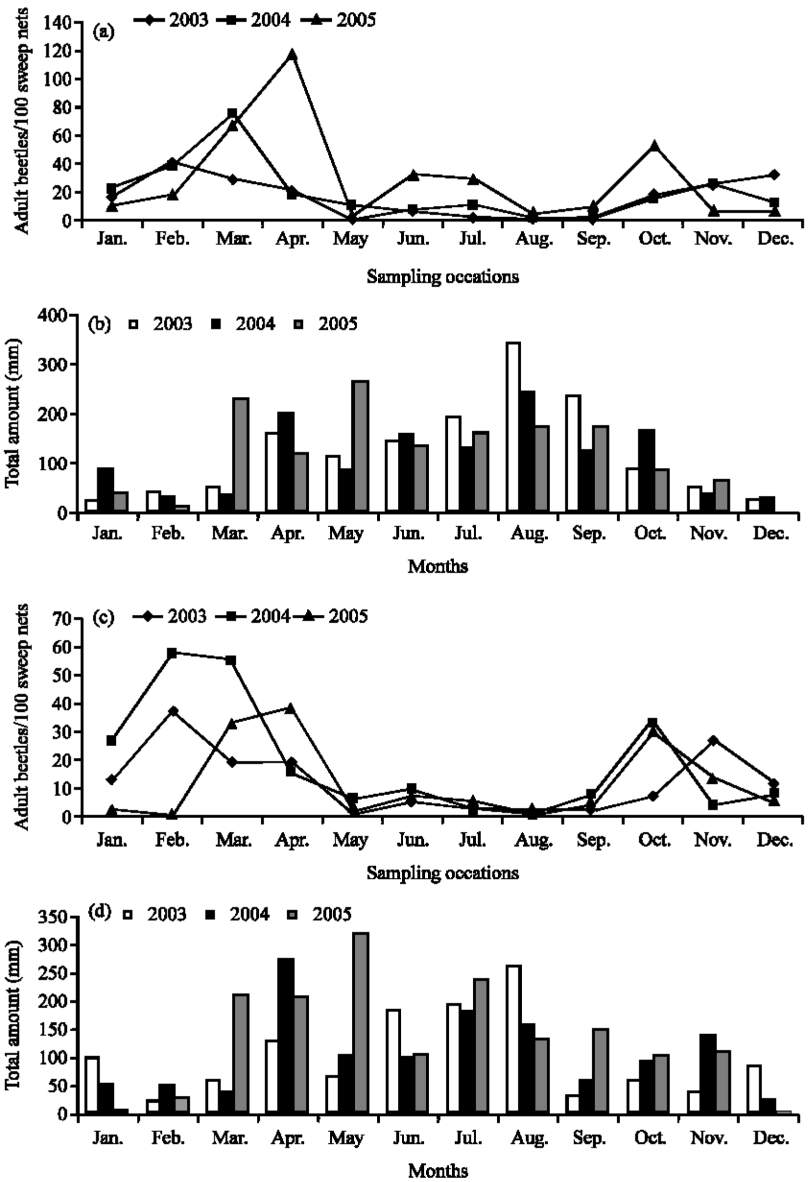

Fig. 1: Survivorship of adult *Chnootriba similis* in its survival sites (along the two selected rivers) in Southern Ethiopia (a) River Woybo (c) and River Wajakerero and rainfall condition around the rivers, in (b) Areka and (d) Sodo

Leaf scarification on wild grasses was observed very infrequently during the dry period along the rivers as compared to the rainy seasons at both the agricultural fields and the rivers on cereal crops and wild grasses, respectively. Though leaf scarification was observed on wild grasses along the rivers during the dry period, its extent was very insignificant. The length of the scarification was also very short and looked like a spot. This phenomenon may substantiate that the adults were inactive.

Table 1: Spread of adult *Chnootriba similis* along the two selected rivers, Woybo and Wajakerero, in Southern Ethiopia

Sampling occasions	2003 Woybo	2003 Wajakerero	2004 Woybo	2004 Wajakerero	2005 Woybo	2005 Wajakerero
September	60.0	91.1	20.0	37.9	44.8	47.1
October	28.6	21.1	3.1	24.8	1.9	19.4
November	18.8	20.6	0.0	0.0	7.7	6.8
December	15.6	13.8	0.0	0.0	0.0	16.7
January	*	*	27.4	39.3	0.0	0.0
February	*	*	3.8	9.4	0.0	77.8
March	6.5	15.6	3.8	16.4	23.0	8.3
April	0.0	0.0	5.3	3.1	0.0	49.3

The data are summarized as percent of adults overwintered far (within 1 to 10 m) from the water streams as compared to percent adult population density overwintered close (within 1 m from the water stream); *Data were not collected

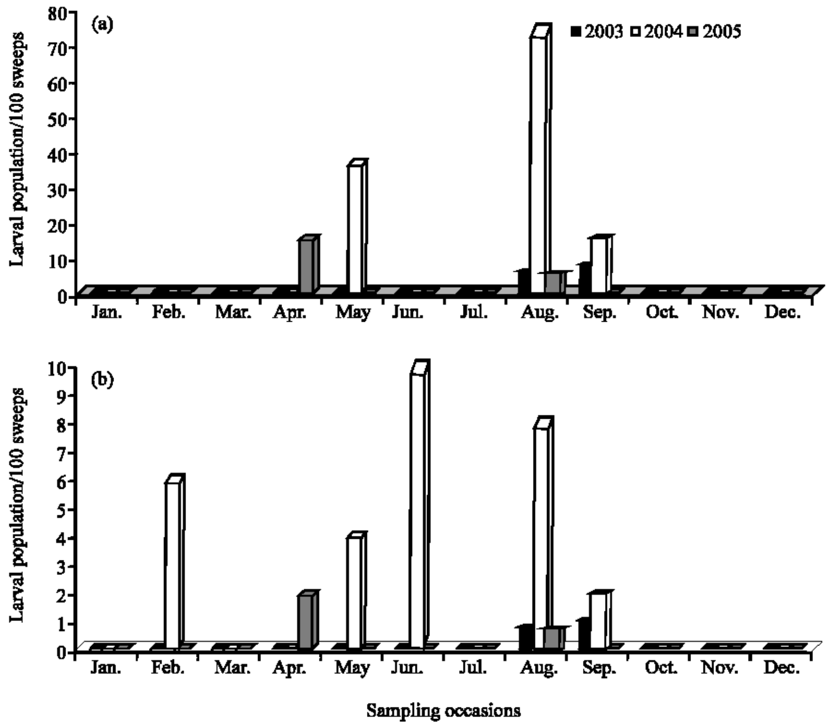

Fig. 2: Reproduction as it is marked by the presence of *Chnootriba similis* larvae along the two selected (a) Rivers Woybo and (b) Wajakerero

At the two selected rivers, observations made on the biological activities of the insect showed that no single pair of adults was found mating from October to around mid-January. Few incidents of mating were observed afterwards and one and six larvae at the rivers Woybo and Wajakerero, respectively, were recorded in February 2004 (Fig. 2). Conceivably, the adult insect survives during the dry period especially from October to around the second week of January at its dormant stage or it diapauses at its reproductive stage. The non-reproductive period and the limited feeding condition of the adults during the dry period, may suggest that a dormancy period is obligatory during their lifecycle. The mating, feeding and oviposition activities observed starting from the beginning of the third week of January indicated the termination of the dormancy period.

Table 2: Cumulative amount of monthly total rainfall (in mm) and monthly average population density per 100 sweep nets of adult *Chnootriba similis* along the two selected rivers (Wajakerero and Woybo) before they migrate to the agricultural fields

	2003		2004		2005	
Month	Rainfall	Population density	Rainfall	Population density	Rainfall	Population density
River Woybo at Boloso Sore						
January	19.9	17.0	89.5	22.5	38.5	10.0
February	62.7	41.0	120.0	38.5	49.3	19.0
March	113.5	29.0	154.6	76.0	276.3	67.0
April	273.1	21.0	355.1	18.0	393.4	118.5
May	386.4	0.0	437.8	10.7	611.5	3.5
River Wajakerero at Sodo Zuria						
January	99.5	13.0	55.4	25.5	8.2	3.0
February	122.9	37.0	107.9	58.0	38.9	1.0
March	184.9	19.0	148.9	56.0	251.9	33.0
April	316.2	20.5	426.7	15.5	460.3	38.5
May	382.8	1.5	532.7	7.0	783.5	2.0

Adults migrated to agricultural fields mainly in March to April prior to which an increased number of adults per 100 sweeps were noted in the overwintering sites (Table 2) before dispersal. Rainfall in January and February might have influenced the timing of adult migration. More rain was recorded in January and February 2003 and 2004 compared to 2005 when migration was delayed. Following these high levels of rain, the population density of the insect had increased between February and March. It was also observed that the population density of the adults has increased in 2005, it was as insignificant as the amount of rainfall increment in both rivers during the same period of the year. Subsequently, the adult beetles were migrated between March and April in 2003 and 2004 while they were delayed in 2005 (Table 2).

Most first generation adults survive in agricultural fields (Fig. 3), with few migrating back to the rivers (Fig. 1a, c). Mating was after mid July with eggs recorded at the end of July and beginning of August, indicating a preovipositional period of about a week. The second generation adult beetles required overwintering sites and migrated from the agricultural fields to the rivers when the weather was drier from September through October and continued to survive until the next short rainy season in the same place (Fig. 3, 1a, c). This was the stage which covered the longest period in the phenology of tef Epilachna as it encompasses the diapausing stage. The second-generation adults were not observed mating and laying eggs in the crop fields immediately.

The peaks in *C. similis* larvae population observed during the short rainy and main seasons in 2004 and 2005 at both sites signified that the insect is bivoltine. The first generation of the insect observed during the short rainy season from April to June/July and the second generation began around the end of July or beginning of August (Fig. 3) and extended until the diapausing stage.

In the agricultural fields in 2004, the oviposition period of the diapausing adults was found to be from the beginning of the second week of April until the end of the third week of May in both sites, Boloso Sore and Damot Gale. There was no significant difference in the oviposition period in 2005. On the other hand, during the main season, it was started within the first 10 days of August and continued until around the end of the third week of the next month in both experimental areas and study years (Fig. 3). Thus, the oviposition period began within a week of the barley germination and most eggs were recorded for only three to four weeks in both study areas and years.

The larval period of the first generation was from around the end of the third week of April to around the beginning of the second week of June in 2004 in both sites. Nevertheless, in 2005, it was commenced around a week and two weeks earlier in Boloso Sore and Damot Gale, respectively while it ended almost corresponding to the previous year. The larval period of the second generation, on the

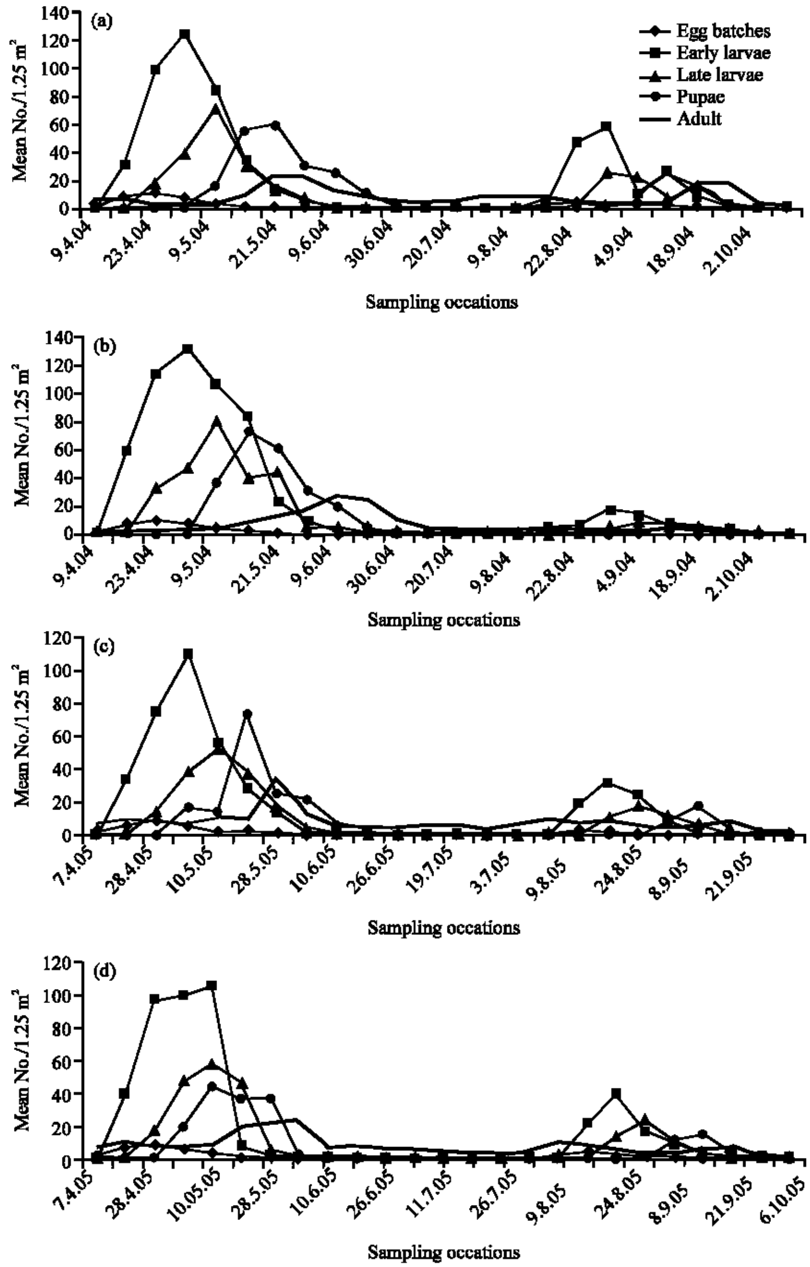

Fig. 3: Seasonal occurrence of different developmental stages of *Chnootriba similis* in barley fields at two selected sites in Southern Ethiopia, Boloso Sore in (a) 2004 and © 2005 and Damot Gale in (b) 2004 and (d) 2005

other hand, began during the third week of August in both sites in 2004 and continued until the beginning of the first week of September. In the next year, it started within the second week of August and continued until the beginning of the third week of September in Boloso Sore while it was delayed to begin by more than a week in Damot Gale and lasted at the end of the fourth week of September

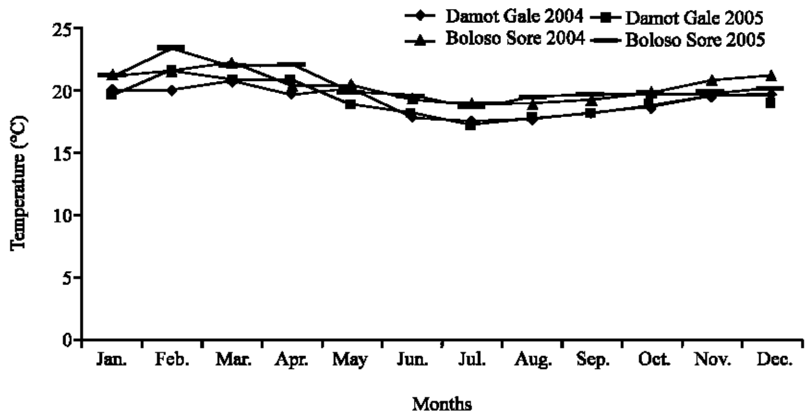

Fig. 4: Monthly average temperature in the two selected study areas (Southern Ethiopia, Damot Gale and Boloso Sore) in 2004 and 2005

(Fig. 3). However, the duration of the larval period of the first generation was almost the same (around 50 days) in all sites during both study years with a slight, around a week, extension in Boloso Sore in 2005. The duration of the larval period of the second generation was wider in 2004 as compared to 2005 in both study sites.

The larval period occurs at the seedling stage, around two weeks after germination of barley, with a peak of larval count extending for about 3 to 5 weeks with the longest period in Boloso Sore in 2005 short rainy season and the shortest period in Damot Gale during the main season of the same year.

In 2004, the pupal period of the first generation was from around the beginning of the second week of May to the end of June in both sites while the second generation it was started in the first week of September in both sites and lasted during the first and second week of October in Boloso Sore and Damot Gale, respectively. The pupal period of the first generation in 2005 was commenced around the first week of May and continued until the fourth week of June in both sites while the second generation was commenced at the beginning of September and it was ended within the first week of October in both sites (Fig. 3). The duration of the pupal period of the first generation was almost the same in both sites and during the study years. The duration of the second generation, however, was significantly shorter than the first generation with no significant differences among sites and study years. Nevertheless, the phenomenon was not attributed to temperature that the average temperature during the main season was even slightly lower than during the short rainy season (Fig. 4).

Larvae began to cause leaf damage on seedlings and continued until mainly the booting stage of barley with most damage due the late larval instars which caused long and larger leaf scarification. Damage caused by the adults was minimal compared to the larval population (Fig. 3), except on the newly emerged seedlings of barley prior to oviposition.

DISCUSSION

Insects move into, through and out of diapause in a series of interdependent steps. Prediapause is initiated when a life stages(s) perceives environmental cues (token stimuli) that warn of impending adverse conditions. The cues associated most commonly with diapause induction in insects are temperature and photoperiod (McNeil and Rabb, 1973; Brodeur and McNeil, 1989; Danks, 1987; Hodek and Hodkova, 1993; Van Driesche and Bellows, 1996; Berthiaume *et al*., 2003;

Asano *et al*., 2004; Nahrung and Allen, 2004) and in some cases the quality and quantity of food available (Wallace, 1968; Hunter and McNeil, 1997). However, the research results showed that the environmental cue that regulates the reproductive diapause in *C. similis* seams mainly moisture or rainfall as its migration to the diapausing sites begins around the end of the rainy season in September. Van Driesche and Bellows (1996) have also mentioned dryness as one of the factors that induce diapause in some insects. Diapause termination of the tef Epilachna was also associated with rainfall and it was happened around the mid of January when the patchy rain begins and some studies also confirmed that moisture or humidity terminates diapause in tropical insects (Canzano *et al*., 2003; Seymour and Jones, 2000).

Ladybird beetles seek overwintering sites to escape from hostile environmental conditions (Hodek *et al*., 1993; LaMana and Miller, 1996; Dixon, 2000) although most of the predatory ladybird beetles don't migrate to specific sites (Dixon, 2000). According to Hodek *et al*. (1993), migration behavior is also species-specific. In this study, it was revealed that the phytophagous ladybird beetle, *C. similis*, migrates to specific sites, as the adult prefers to overwinter along rivers close to water streams especially, when the surrounding area is dry. Though it was not mentioned how the tef Epilachna survives. Scheibelreiter and Inyang (1974) reported that in Ghana great numbers of adults were found in wet and swampy areas near rivers from December to February, the peak of the dry season and no adults were found in the Savannah Zone.

Migration of the adults during the rainy season from the rivers to the agricultural fields corresponds with sowing period of some cereal crops such as maize. Sowing period of small cereal crops normally is few weeks later as compared to the beginning of adults' migration.

The phenological study showed that *C. similis* has two generations annually and occurrence of the generations was synchronized with the growing seasons of its hosts, cereal crops. In the study area, cereals are grown twice a year and the two abundance peaks of the insect were observed during both growing seasons in 2004 and 2005. The first generation of the tef Epilachna occurs during the short rainy season from April to June/July and the second generation begins around the end of July or beginning of August and the adult from the later generation migrates to the overwintering sites. Adults of the first generation were commonly observed in the agricultural fields until they infest the cereal crops sown during the main season, around the end of July or beginning of August. Although the annual number of generations was not mentioned, in Ghana the insect reproduces during the rainy season from June to November and the dry season (Scheibelreiter and Inyang, 1974).

The present study shows that the adult insects from the first generation were inactive right after emergence in June to around the beginning of July with marked reduced feeding and not mating or laying eggs. In pot experiments on barley seedlings, the adults showed similar feeding behavior and mating was not observed until around the mid of July (Beyene *et al*., unpublished). Perhaps, they went through aestivation for short period of time, while the weather condition was still wet or rainy. In Ghana similar results were found as the adults were reduced their activity, stopped laying eggs and crowded together in the corners of the rearing cages possibly for aestivation (Scheibelreiter and Inyang, 1974).

In this study at field condition and in pot experiments (Beyene *et al*., unpublished), it was found out that the preovipositional period was around a week, but reports from Ghana showed that it depends on the seasons, three and one weeks during the rainy and dry seasons, respectively (Scheibelreiter and Inyang, 1974).

The present research results further indicated that, the duration of the first generation (egg to adult emergence) lasted longer than the second during the study years. Similarly, Scheibelreiter and Inyang (1974) reported that the duration from egg to adult was significantly extended during the rainy season (June to November) as compared to the dry season in Ghana. Research reports indicate that temperature is one of the most important factors that influence growth and development in insects

(Mazzei *et al*., 1999; Greenberg *et al*., 2000; Umble and Fisher, 2000; Howell and Neven, 2000; Cymborowski, 2000). According to the reports, the marked differences in the durations was attributed to the lower temperature during the rainy season in Ghana (Scheibelreiter and Inyang, 1974) while the same factor not seems to be the cause for the phenomenon in this study as the lower temperatures were recorded during the main season (Fig. 4) when the duration was relatively shorter.

During both seasons, adult *C. similis* infestation occurs on barley early at its seedling stage within the first week of germination. Similarly, Heinrichs (1991) reported that the adult population density was highest at seedling stage, the first two weeks after transplanting of lowland rice. Oviposition was commenced right after infestation and the larvae began to cause damage on leaves within two weeks of the barley germination and continue until mainly the booting stage. The field observations indicated that the older (third and fourth larval instars) larvae caused the main leaf scarification. According to the feeding studies conducted in Ghana, the fourth instar larvae inflict the major damage on leaves of maize (Scheibelreiter and Inyang, 1974).

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