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Population Trends of *Hilda cameroonensis* Tamesse & Dongmo (Tettigometridae), a Pest of *Vernonia amygdalina* Delile in Yaoundé, Cameroon

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ABSTRACT

Vernonia amygdalina Delile in Yaoundé, Cameroon, known as a bitter leaf, is a perennial shrub from the Asteraceae family, widely distributed across tropical Africa. It is considered one of the most extensively used medicinal plants within the Vernonia genus. The leaves of this plant suffer significant damage due to insect pests. In Cameroon, a newly identified species from the Hilda genus (Tettigometridae), *Hilda cameroonensis* Tamesse & Dongmo, was recently documented for the first time on *V. amygdalina*. This pest causes the leaves to shrivel. The objective of this study was to analyze the population dynamics of H. cameroonensis about its host plant, V. amygdalina. Both abiotic and biotic factors influencing the natural fluctuations of pest populations were examined. A study on the population dynamics of this insect was carried out on a natural farm in the Yaoundé region between November 2014 and October 2016. Weekly surveys were conducted to monitor and count eggs, larvae, and adult insects. Throughout the research, seven generations of *H. cameroonensis* were observed in the first year, while six generations were recorded in the second. Climatic conditions, particularly temperature, relative humidity, rainfall, and wind speed, were found to influence pest population fluctuations. The key factors driving changes in pest numbers and the seasonal emergence of each developmental stage in the Yaoundé region will be considered for future integrated pest management strategies.

Keywords: Cameroon, Tettigometridae, Pest control, *Hilda cameroonensis*, Yaounde, *Vernonia amygdalina*

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Introduction

Planthoppers are sap-feeding homopteran insects that include several species recognized as significant agricultural pests worldwide. These insects belong to a diverse group, primarily feeding on the phloem tissues of woody and herbaceous plants, though some species also consume mosses, fungi, horsetails, or ferns [1]. Their feeding behavior varies, with some species exhibiting polyphagy, feeding on a wide range of unrelated plants, while others are monophagous, restricted to a single host plant species. Numerous studies have examined the effects of specific planthopper species on economically important crops such as rice, maize, sugarcane, wheat, oats, coconut palm, and barley, leading to their classification as agricultural pests [2].

Planthoppers are categorized into twenty families, all included within the superfamily Fulgoroidea [2]. Members of this superfamily inhabit a broad range of environments across the globe, from arid regions to the Arctic, including Alaska. However, their distribution is primarily concentrated in tropical areas, with variations among families influenced by historical and ecological factors. The Tettigometridae family, for instance, is absent from the Nearctic, Neotropical, and Australian regions. Although it is one of the smaller groups within Fulgoroidea, Tettigometridae is notable for its role as a vector of plant pathogens affecting members of several plant families, including Fabaceae, Rutaceae, Anacardiaceae, Solanaceae, Annonaceae, Poaceae, and Asteraceae [2]. Species from the genus *Hilda* within this family are particularly associated with Asteraceae plants as their preferred hosts [3, 4]. Despite this association, no research has been conducted on the influence of biotic and abiotic factors on the population dynamics of Tettigometridae species on *Vernonia amygdalina* Delile in Yaoundé, Cameroon (Asteraceae).

V. amygdalina is a fast-growing, multipurpose shrub that can reach heights between 2 and 10 meters, with petiolate leaves approximately six millimeters in diameter. Various ethnic communities worldwide have distinct names for this plant [5]. It belongs to the order Asterales, family Asteraceae, genus Vernonia, and species *V. amygdalina* [6]. The plant is widely distributed throughout tropical Africa, from Guinea in the west to Somalia in the east, extending southward to northeastern South Africa and Yemen. It is cultivated as a vegetable in several countries, including Benin, Nigeria, Gabon, the Democratic Republic of Congo, and Cameroon [7]. Under cultivation, *V. amygdalina* is typically maintained as a hedge or shrub, though it has the potential to grow into a tree. For commercial purposes, farmers generally prefer younger plants over mature ones.

The chemical profile of *V. amygdalina* makes it highly suitable for both nutritional and medicinal purposes [8]. Its leaves are commonly consumed by humans, though they undergo a washing process before cooking to reduce their bitterness [9]. The plant contains essential bioactive compounds and other beneficial substances that support overall health and maintain proper physiological functions without exhibiting toxic effects [10]. William *et al*. [11] reported that *V. amygdalina* possesses notable medicinal properties. It is likely the most widely used medicinal species within the *Vernonia* genus [12]. Research conducted by Thomas *et al*. [13] has demonstrated that this plant offers various therapeutic benefits, functioning as an antibacterial, antidiuretic, antimalarial, antifungal, and anticancer agent. Based on these properties, *V. amygdalina* can be classified as a health-promoting food. Additionally, dried leaves of *V. amygdalina* have been shown to exhibit insecticidal properties, effectively targeting the larvae of *Callosobruchus maculatus* and *Sitophilus zeamais*, pests responsible for significant losses in stored cowpea and maize, respectively [14]. These findings reinforce the potential role of *V. amygdalina* in traditional medicine, alongside its pesticidal applications.

A few years ago, a newly identified species within the Tettigometridae family, *Hilda cameroonensis* Tamesse & Dongmo, was documented in Cameroon for the first time [4]. This species was observed feeding on *V. amygdalina*, causing the plant's leaves to shrivel [4]. At present, no specific control methods have been established in Cameroon to manage this pest affecting *V. amygdalina*. Effective pest management relies on a comprehensive understanding of population dynamics [15]. Milaire [16] reported that studying population dynamics helps maintain pest numbers below economically damaging levels through the use of insecticides. Such research contributes to optimizing chemical applications within integrated pest management strategies [17] and offers valuable insights for implementing preventive measures against future infestations [18].

The objective of this study was to analyze the population dynamics of *H. cameroonensis* about its host plant, *V. amygdalina*. Both abiotic and biotic factors influencing the natural fluctuations of pest populations were examined.

Materials and Methods

Site and period of study

The research took place over a continuous two-year period, spanning from November 2014 to October 2016, within an experimental plantation located in Nkolfoulou, Yaoundé, Cameroon.

Sampling

Farmers cultivated the host plants, and a total of 30 plants were consistently monitored throughout the study. From this group, ten plants were randomly selected for surveying and collecting Tettigometridae specimens. No pesticides were applied to these plants before or during the research period. A visual inspection method was used for sampling, with weekly observations conducted over a span of 24 months, from November 2014 to October 2016. Each year, the leaves of *V. amygdalina*, which exhibited the highest infestation levels, were examined. Adult Tettigometridae and nymphs from the third to fifth developmental stages were counted directly. Additionally, 5-10 infested leaves were collected, and eggs along with earlier nymphal stages were examined using a handheld magnifying lens. Meteorological data for the study were sourced from the Meteorological Center of Yaoundé.

Data analysis

The SPSS statistical software was employed to compare means using the non-parametric Mann-Whitney test. It was also utilized to compute the Spearman correlation coefficients between the abiotic factors and the population dynamics of *H. cameroonensis*.

Results and Discussion

A total of 826 adult *H. cameroonensis* were counted on *V. amygdalina*, consisting of 260 males and 566 females, resulting in a female-biased sex ratio of 2.17. The egg count reached 13,186, while early-stage larvae (first and second stages) numbered 16,367, and advanced-stage larvae (third, fourth, and fifth stages) totaled 3,595.

Laying preference

H. cameroonensis adults laid their eggs on both the stems and leaves of the host plant, with a notable preference for the stems. An important difference ($P < 0.0001$) was found between the average number of eggs laid on leaves and those laid on stems, as revealed by the Mann-Whitney non-parametric U test.

Variation in egg numbers

The egg count on each plant fluctuated from week to week throughout the study period. During the first year, there were six distinct peaks in egg numbers, occurring in November 2014, January 2015, February 2015, April 2015, June 2015, August 2015, and October 2015. In the second year, five peaks were observed, with significant outbreaks in April 2016, June 2016, July 2016, September 2016, and October 2016 **(Figure 1)**.

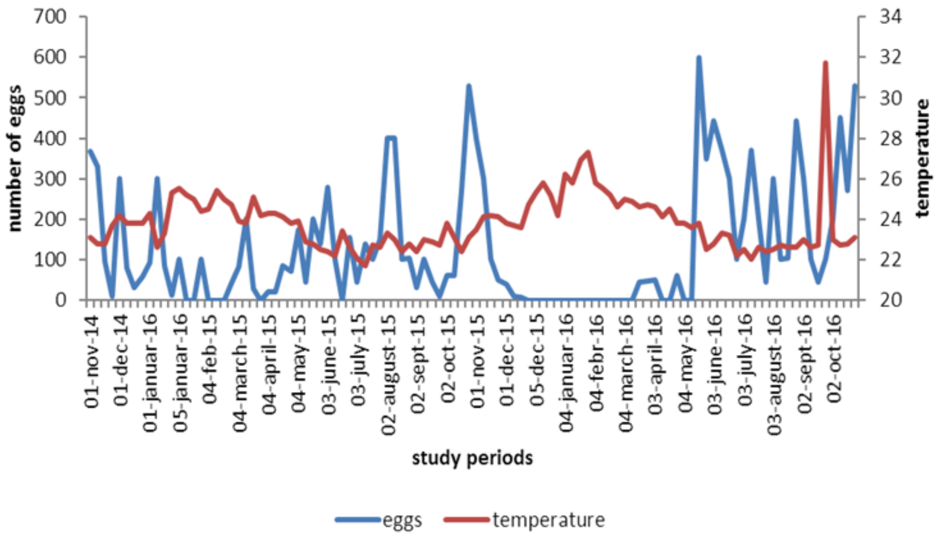

Figure 1. Fluctuations in the egg count of *H. cameroonensis* about temperature changes observed in a farmer's plantation in Nkolfoulou (Yaoundé) between November 2014 and October 2016.

Fluctuations in larval numbers

Changes in the population of first-stage larvae

The population of 1st stage larvae on each plant fluctuated weekly throughout the study period. The variation in the 1st stage larvae of *H. cameroonensis* exhibited six peaks in the first year of the study, occurring in November 2014, January 2015, April 2015, June 2015, August 2015, and October 2015. In the second year, four major peaks were observed, with the most significant outbreaks in May 2016, July 2016, August 2016, and September 2016 **(Figure 2)**.

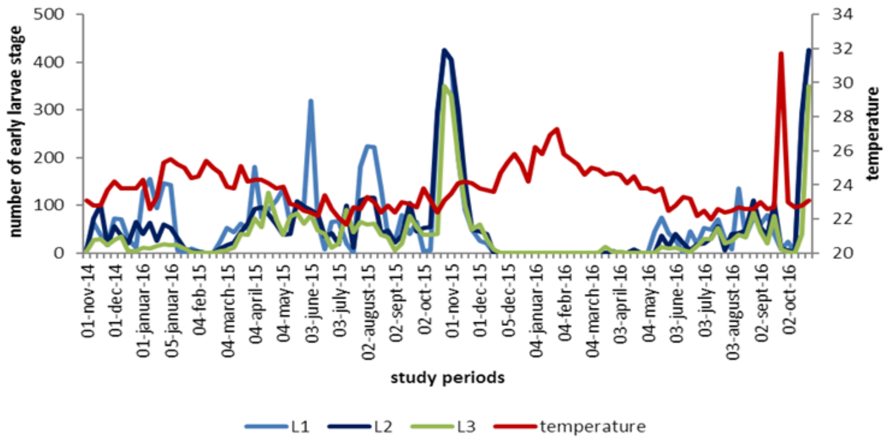

Figure 2. Fluctuations in the numbers of stage I, II, and III larvae of *H. cameroonensis* about temperature changes observed in a farmer's plantation in Nkolfoulou (Yaoundé) from November 2014 to October 2016.

Fluctuations in the population of second-stage larvae

The number of second-stage larvae counted on each plant fluctuated weekly throughout the experimental period. The population variation of second-stage larvae of *H. cameroonensis* showed 6 peaks in the 1st year of the study, occurring in November 2014, January 2015, February 2015, April 2015, June 2015, and October 2015. In the second year, four peaks were observed, with the primary peaks recorded in June 2016, August 2016, and October 2016 **(Figure 2)**.

Fluctuations in the population of third-stage larvae

The number of third-stage larvae counted on each plant fluctuated weekly during the study period. The population of third-stage larvae of *H. cameroonensis* demonstrated 6 peaks during the 1st year, occurring in November 2014, May 2015, June 2015, July 2015, September 2015, and October 2015. In the second year, three significant peaks were recorded, with the main peaks occurring in April 2016, June 2016, August 2016, and September 2016 **(Figure 2)**.

Fluctuations in the population of fourth-stage larvae

The number of fourth-stage larvae counted on each plant fluctuated from week to week throughout the study period. The population of fourth-stage larvae of *H. cameroonensis* showed 6 peaks in the first year, recorded in November 2014, January 2015, April 2015, June 2015, August 2015, and October 2015. During the 2nd year, four peaks were observed, with the main peaks recorded in March 2016, June 2016, August 2016, and October 2016 **(Figure 3)**.

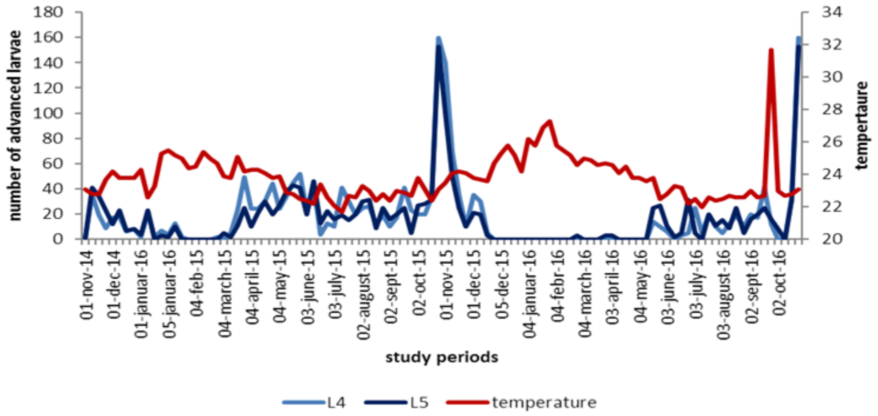

Figure 3. Fluctuation in the number of fourth and fifth-stage larvae of *H. cameroonensis* in response to temperature changes at a farmer's plantation in Nkolfoulou (Yaoundé) from November 2014 to October 2016.

Fluctuations in the number of fifth-stage larvae

The number of fifth-stage larvae observed on each plant fluctuated weekly throughout the study period. During the 1st year of observation, the number of stage V larvae of *H. cameroonensis* exhibited six peaks, which occurred in November 2014, January 2015, April 2015, June 2015, August 2015, and October 2015. In the second year, four significant peaks were recorded, with the highest numbers seen in March 2016, June 2016, August 2016, and October 2016 **(Figure 3)**.

Fluctuations in adult numbers

Variation in male population

The male population of *H. cameroonensis* on each plant showed weekly fluctuations throughout the experimental period. In the first year, the male population exhibited seven peaks, occurring in November 2014, January 2015, February 2015, March 2015, April 2015, August 2015, and October 2015. During the 2nd year, six significant outbreaks were recorded, with the primary peaks occurring in December 2015, May 2016, June 2016, July 2016, September 2016, and October 2016 **(Figure 4)**.

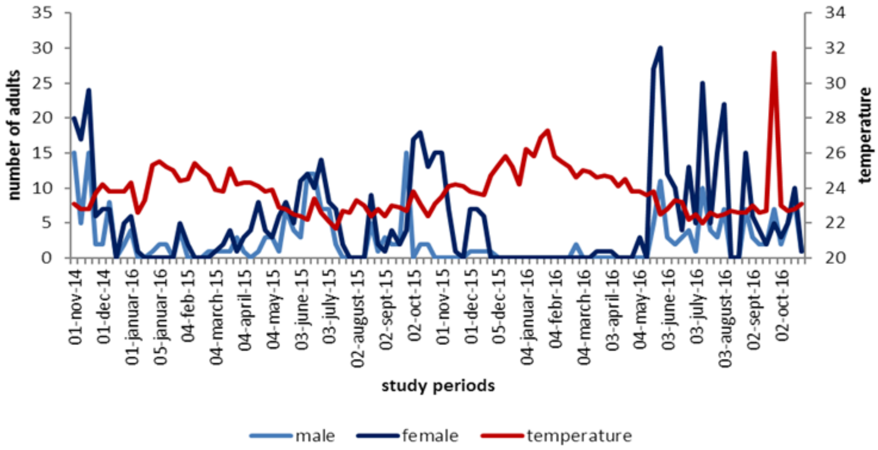

Figure 4. Fluctuations in the adult population (both male and female) of H. *cameroonensis* in response to temperature changes at a farmer's plantation in Nkolfoulou (Yaoundé) from November 2014 to October 2016.

Variation in female numbers

The count of female *H. cameroonensis* on each plant fluctuated weekly throughout the study period. In the first year, the female population exhibited seven peaks, occurring in November 2014, January 2015, February 2015, April 2015, June 2015, September 2015, and October 2015. In the second year, six peaks were observed, with the main outbreaks in December 2015, March 2016, June 2016, August 2016, September 2016, and October 2016 **(Figure 4)**.

These fluctuations likely correspond to the number of generations of *H. cameroonensis* in the study area. The number of generations fluctuated between the two years: 7 generations during the 1st year and 6 during the 2nd year.

Climatic factors variation

The Ombrothermic diagram **(Figure 5**) for Yaoundé revealed two distinct dry and rainy seasons in the region. The main dry season occurs from November to February, while a smaller dry season is from July to August. The primary rainy season runs from September to October, with a shorter rainy period from March to June. When comparing the average climatic data between the two years, no significant differences were found ($P > 0.05$), indicating that the climate remained relatively stable throughout the study period from November 2014 to October 2016.

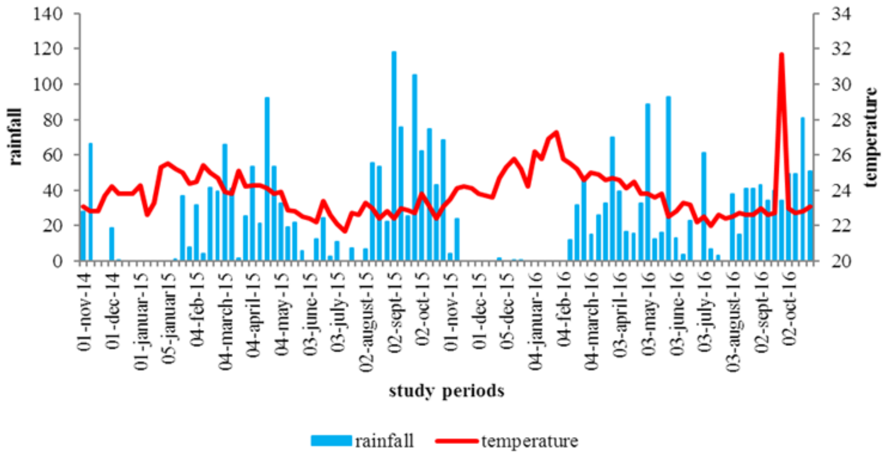

Figure 5. Rainfall and average temperature in the study area from November 2014 to October 2016.

Impact of climatic factors on the population fluctuations of H. cameroonensis

A strong and highly significant positive correlation (P ≤ 0.0001) was observed between all larval developmental stages and climatic factors during the 1st year (October 2014-November 2015) **(Table 1)**. In the 2nd year (October 2015-November 2016), a similarly strong positive correlation was found across all developmental stages, from eggs to adults **(Table 2)**.

Among the various climatic elements, temperature, relative humidity, rainfall, and wind speed consistently emerged as key factors influencing the population dynamics of this pest.

Table 1. Spearman correlation between *H. cameroonensis* populations and selected biotic factors at the study site from 2014 to 2015.

14-15	Eggs	L1	L2	L3	L4	L5	adults	Aver. T°	Rainfall	Winds	Rel.hum
Eggs	1.000										
L1	0,546**	1.000									
L2	0,476**	0,653**	1.000								
L3	0,293*	0,500**	0,749**	1.000							
L4	0,355*	0,437**	0,768**	0,851**	1.000						
L5	0,440**	0,378**	0,706**	0,675**	0,826**	1.000					
Adults	0,433**	0,028	0,226	0,292*	0,288*	0,433**	1.000				
Average T°	-0,710**	-0,247	-0,386**	-0,421**	-0,467**	-0,534**	-0,439**	1.000			
Rainfall	0,402**	-0,053	-0,028	0,148	0,168	0,151	0,173	-0,042	1.000		
Winds		-0,114	-0,106	0,037	-0,147	-0,196	-0,235	-0,041	0,308*	1.000	
Rel. hum	0,167	0,121	0,334*	0, 524**	0,494**	0,616**	0,543**	-0,710*	0,402**	0,167	1.000

*not significant; **significant; ***highly significant; L1, L2, L3, L4, L5: development stages

Temperature effect

The data collected over the two years indicated a highly important negative relationship between all developmental stages of *H. cameroonensis* and temperature ($P < 0.05$). This suggests that as temperatures rise, the population of the pest declines in our study area **(Tables 1 and 2)**.

Relative humidity effect

Throughout the two-year study, a positive correlation was found between relative humidity and the developmental stages of *H. cameroonensis*. These correlations were highly important for all stages in the 2nd year, while in the 1st year, only the 3rd, 4th, and 5th larval stages and adults exhibited highly significant correlations. Notably, eggs and 1st instar larvae didn't show an important correlation with relative humidity **(Tables 1 and 2)**.

Wind speed effect

In the second year, a highly important negative correlation was observed between the various developmental stages of *H. cameroonensis* and wind speed. This indicates that increased wind speeds likely led to a reduction in the number of insects present on the host plants **(Tables 1 and 2)**.

Rainfall effect

In the first year, the number of eggs displayed a positive and highly important correlation with rainfall ($P < 0.05$). In the second year, a similar positive and significant correlation was noted for the number of eggs, first instar larvae, and adults with the amount of rainfall in the region **(Tables 1 and 2)**.

Table 2. Spearman correlation between the populations of *H. cameroonensis* and various biotic factors at the study site during 2015-2016.

15-16	Eggs	L1	L2	L3	L4	L5	adults	Aver.T°	Rainfall	Winds	Rel. hum
Eggs	1.000										
L1	0,752***	1.000									
L2	0,757***	0,868***	1.000								
L3	0,706***	0,852***	0,924***	1.000							
L4	0,616** *	0,847***	0,895***	0,917***	1.000						
L5	0,679***	0,809***	0,866***	0,866***	0,889***	1.000					
Adults	0,764***	0,554***	0,598** *	0,598***	0,568***	0,628***	1.000				
Aver.T°	-0,701** *	-0,650***	-0,625***	-0,619***	-0,558***	-0,568***	-0,675***	1.000			
Rainfall	0,421***	0,284* *	0,242*	0,182 *	0,153*	0,233*	0,286**	-0,354***	1.000		
Winds	-0,414***	-0,477***	-0,435***	-0,371***	-0,441***	-0,455***	-0,376***	0,300**	-0,184 *	1.000	
Rel.Hum.	0,661***	0,606***	0,522***	0, 472***	0,413***	0,453***	0,522***	-0,766***	0,631***	-0,234*	1.000

*not significant; **significant; ***highly significant; L1, L2, L3, L4, L5: development stages

The population dynamics of *H. cameroonensis* on *V. amygdalina* were investigated over two years, from November 2014 to October 2016, in the Yaoundé area of Cameroon. *H. cameroonensis*, a pest of *V. amygdalina*, was identified as a new species within the family Tettigometridae [4]. Like other Tettigometridae species, *H. cameroonensis* feeds, lays eggs, and develops on its host plant, *V. amygdalina*. The Asteraceae family is well-known as a preferred host for Tettigometrids of the genus *Hilda*. Aléné *et al*. [3] documented the presence of *Hilda* spp. on *V. amygdalina*, but mistakenly identified the species from the Yaoundé region as *H. patruelis*, a pest of groundnuts in South Africa. The species involved in the Center Region of Cameroon was later described as *H. cameroonensis* by Tamesse & Dongmo [4]. The study covered all developmental stages, from eggs to adults, and since *V. amygdalina* is the primary host plant for *H. cameroonensis*, it provides food, shelter, and protection, and is a necessary site for mating and spawning [19, 20]. No important difference was observed in the number of eggs laid between the two years, suggesting consistency in the egg-laying pattern of *H. cameroonensis* females on their host plants.

The investigation into *H. cameroonensis* population dynamics revealed that seven generations occurred during the 1st year of research (2014-2015) in the Yaoundé region, while six generations were recorded in the second year (2015-2016). The number of generations varied between the two years. A similar trend was reported by Tamesse and Messi [21] in their research of the population dynamics of the African citrus psyllid, *Trioza erytreae,* in Yaoundé, where seven generations were observed in the 1st year and three in the second. Other studies in the region also observed similar patterns: Elisabeth *et al*. [22] on *Phytolyma fusca*, Joly *et al*. [23] on *Diclidophlebia eastopi* and *D. harrisoni*, and Soufo and Tamesse [24] on *Blastopsylla occidentalis*, pests of *Milicia excelsa*, *Triplochiton scleroxylon*, and *Eucalyptus* spp., respectively. The dynamics of *H. cameroonensis* populations are likely influenced by both biotic and abiotic factors that impact the insect's biology, with the number of generations indicating that *H. cameroonensis* is polyvoltine. In contrast, other insect species on *V. amygdalina*, such as *Sphaerocoris annulus*, are monovoltine, as noted by Mbondji and Pluot-Sigwalt [25].

The comparison of each developmental stage of *H. cameroonensis* across different seasons within the same year revealed a significant difference, with the most pronounced differences observed in the 2nd year of the study. Seasonal changes significantly impact the development of individual insects and, by extension, the overall population size [26]. This influence can be direct, meaning the climatic conditions of a particular season directly affect the development of the insect at all stages. Additionally, the seasonal changes also affect the phenology of the host plant. During the rainy season, most plants undergo leaf renewal, providing new, preferable sites for egg-laying and better conditions for the nymphal development of *H. cameroonensis*. Tamesse and Messi [21] observed similar effects of citrus phenology on the population dynamics of *Trioza erytreae*, a citrus psyllid. Similarly, Miller *et al*. [27] and Cirino and Miller [28] demonstrated that the phenology of *Opuntia mesacantha* (cactus) influenced the sexual dimorphism, size, and reproduction of *Narnia femorata* (Coreidae). As a result, the limited number of eggs during the major dry season and the smaller dry season could be attributed to the effects of the plant's phenology.

The correlation between the number of individuals in various developmental stages of *H. cameroonensis* and weekly recorded temperatures was negative and important. This suggests that temperature increases may negatively affect the development of *H. cameroonensis*. During the major dry season, when temperatures are typically high in the region, the number of insects counted was particularly low. From January to March each year, the population of *H. cameroonensis* remained low. Several studies, including those by Tamesse and Messi [21] on citrus psyllids and by Nurhayati and Koesmaryono [29] on brown rice borers, have observed similar reductions in survival from egg hatching to larval stages when exposed to consistently rising temperatures.

The correlation between the numbers of individuals in various developmental stages of *H. cameroonensis* and relative humidity was significant and positive. This indicates that higher relative humidity levels are likely to contribute to an increase in the pest population. Similar observations have been made by Tamesse and Messi [21] and Benhadi-Marin *et al*. [30], who found that low relative humidity reduced the development of citrus psyllids, *Trioza erytreae*, in Cameroon and South Africa, respectively.

Rainfall exhibited positive correlations with the various developmental stages of *H. cameroonensis* across both years of the study, emphasizing the role of rainfall in influencing the flushing cycle of the host plant, which in turn supports the growth of the pest population. This finding aligns with previous research on the bionomics of insect pests in tropical plants [22, 23].

A negative correlation was observed between weekly variations in wind speed and the adult population of *H. cameroonensis*, suggesting that an increase in wind speed may adversely affect the adult population. Specifically, as the wind speed rose, the number of adults declined. This observation supports the work of Faivre d'Arcier *et al*. [31], who noted that pear psyllid populations tend to reach higher densities in regions where wind speeds are lower, as strong winds inhibit their ability to fly. Wind speed, among other factors, plays a significant role in the passive transport of *H. cameroonensis* adults from one *V. amygdalina* plant to another.

Conclusion

H. cameroonensis completes its full life cycle on the host plant *V. amygdalina*, where it feeds and develops. A total of 826 adults, including 260 males and 566 females, were recorded on *V. amygdalina*. The egg count reached 13,186, while the early-stage larvae (1st and 2nd instars) totaled 16,367, and the advanced-stage larvae (third, fourth, and fifth instars) numbered 3,595. Weekly counts of individuals across developmental stages varied, with seven generations observed during the 1st year (2014-2015) and six generations during the 2nd year (2015-2016). The number of generations differed between the two years. The study identified key biotic and abiotic factors—temperature, relative humidity, wind speed, and rainfall—as significant regulators of the pest's population dynamics. These factors should be incorporated into integrated pest management strategies, with attention to the peak outbreak periods of *H. cameroonensis* in the Yaoundé region for effective control. An important future step will be to identify natural predators of *H. cameroonensis* for potential biological control of this Tettigometrid pest.

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Conflict of Interest: None

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Ethics Statement: The study was conducted following established research ethics guidelines.

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