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Population fluctuation of the broad mite *Polyhagotarsonemus latus* (Banks) in *Capsicum annuum* (L.) in the province of Manabí, Ecuador

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ABSTRACT

The cultivation of pepper (*Capsicum annuum L.*) is among the most economically significant vegetable crops worldwide, driven by the high demand for its fruit for trade and export markets. However, this crop is constantly threatened by multiple factors, including pest infestations such as mites. *Polyphagotarsonemus latus* is a mite species that severely impacts pepper production, infesting plants from the seedling stage through to fruit harvest. This study aims to analyze the population dynamics of *P. latus* in pepper cultivation in Manabí Province, Ecuador. The research was conducted through field and laboratory phases, with samplings carried out between September and December 2022. Samples were collected from leaves, shoots, flowers and fruits. In the laboratory, the mites present were counted, and their different stages of development were identified. The results indicate that *P. latus* was present from the initial growth stages through to crop maturation. The highest mite populations were recorded during the flowering, fruiting and ripening phases, confirming that this species represents a major pest in pepper cultivation, significantly affecting yield and fruit quality.

Keywords: mite, phytophagous, solanaceae, biological states, seasonal distribution.

INTRODUCTION

Capsicum annuum L., commonly known as chili or pepper, has been utilized since ancient times as a food source, a natural colorant, and in traditional medicine (Hernández et al., 2020), due to its high content of vitamin C, vitamin A, zinc, iron, calcium, potassium, and other essential minerals (Agarwal et al., 2007; Kumar et al., 2019; Olaes et al., 2020). This species is native to tropical and subtropical regions, particularly Bolivia and Mexico (Khan et al., 2014; Zou and Zhu, 2022). In Ecuador, approximately 2.204 hectares are cultivated for pepper production (FAO, 2020). However, according to Reyes et al. (2017), low yields persist due to the presence of various pests that compromise both fruit quality and overall crop productivity.

Girish et al. (2014) highlight that infestation by phytophagous mites, especially *Polyphagotarsonemus latus*, can lead to substantial losses in sweet pepper yield. *P. latus* infestations can cause physiological stress that impacts crop vitality and yield, generated by a reduction in net photosynthesis by 50.5%, stomatal conductance by 46.2% and transpiration by 51.6% in affected plants (Evaristo *et al.*, 2013)

The phytopathological effects generated by *P. latus* result in significant economic losses for farmers (Gerson, 1992; Palevsky et al., 2001). Consequently, this mite species is recognized as one of the most critical phytosanitary threats to pepper cultivation (Breda et al., 2017; Rodríguez et al., 2008).

Despite their minute size and polyphagous nature, these mites go undetected until they cause significant damage, including necrosis at growth sites, floral abortion, reduced fruit development and deformations, as well as chlorosis, distortion and curl of the leaves. These symptoms indicate severe tissue alterations that extend beyond the epidermis (Alcantara et al., 2011; Jovicich et al., 2004). This species is predominantly found on the underside of the leaves, where it feeds on the epidermis, which reduces the photosynthetic capacity of the plant and alters its water stability (Grinberg et al., 2005). The seasonal and non-uniform infestation pattern can be attributed, as noted by Jovicich et al. (2009), to the pest´s tendency to primarily affect plants during their early developmental stages.

However, Rayo et al. (2015) indicate that the pest may also be more frequent during flowering and fruiting periods. The seasonal occurrence of this mite in crops is influenced by both biotic and abiotic factors, such as climatic conditions, the presence of natural enemies, crop phenology, and agronomic management practices (Abou-Awad et al., 2014; García et al., 2016; Rosado et al., 2015).

Given these challenges, understanding the population dynamics of agricultural pest species is essential, as it serves as a foundation for developing effective pest management programs. Therefore, this study aims to analyze the population fluctuations of the broad mite, *P. latus* (Banks), in pepper cultivation.

MATERIAL AND METHODS

The study was carried out between September and December 2022 in the “Arrastradero – Los Mangos” sector, located in the Bolívar canton (0°49’29.8”S and 80°09’36.2”W), province of Manabí. This area, located at approximately 22 meters above sea level, is characterized by a warm climate due to its proximity to the sea, with an average annual temperature of 25 °C and a relative humidity ranging between 76% and 81%.

Population fluctuation of the pest mite

To evaluate the population fluctuation of *P. latus*, monitoring was carried out in Kylie peppers crops in plots with and without application of phytosanitary products.

The methodology used was an adaptation of the one described by Acad et al. (2018). Field evaluations were carried out on pepper seedlings from the fourth day after transplantation and involved sampling leaves, shoots, flowers and fruits. Every 8 days, 100 leaves and shoots were collected. During the flowering and fruiting stages, 50 fruits and 50 flowers were sampled every 15 days for subsequent laboratory analysis.

The samples were placed on sheets of Kraft paper and then deposited in hermetically sealed sleeves to minimize moisture loss. Fruits were placed in egg trays to avoid friction between them. The samples were then stored in a thermal box to maintain freshness and facilitate transport. In laboratory, different developmental stages of *P. latus* were counted, recording the number of eggs, larvae, nymphs, and adults in each plant structure. In the leaves, both the upper and lower sides were evaluated (Figure 1).

Statistical analysis

Heat maps were developed to analyze the abundance of *P. latus* at different stages (egg, larva, nymph and adult) and its relationship with environmental variables (temperature, relative humidity and precipitation) under two treatments: with and without application of phytosanitary products. Pivot tables were generated to reorganize the data.

Python was used to construct heat maps. In particular, pandas, matplotlib, and seaborn libraries were used for data manipulation, graph generation, and statistical analysis. Independent graphs were created for each treatment. For environmental variable data, Pearson correlations were calculated between climatic variables and mite abundance at different stages. In the comparative correlation maps, side-by-side graphs were arranged to highlight differences between treatments, ensuring equivalent scales.

Figure 1. Methodology implemented in the study; (a) collection of plant material on the fourth day after transplanting, (b) sampling of mature leaves and shoots every 8 days, (c) sampling of fruits and flowers every 15 days in fruiting stage, (d) samples were placed in Kraft paper bags and sealed, (e) transport of fruits in egg trays, (f) counting of biological stages of mites

RESULTS AND DISCUSSION

P. latus was observed in leaves in both treated and untreated plots (Figure 2). Greater distribution and higher frequency of the mite were detected in the plot with the application of phytosanitary products.

At the end of the vegetative growth phase, on September 21, the presence of *P. latus* was recorded, with the immature stages, eggs (6) and larvae (15), being the most abundant. Throughout the study, the frequency of different developmental stages fluctuated. Egg abundance peaked on November 16–23 (flowering and fruiting), and December 21–28 (maturation). Larvae were most frequent when the mite first detected and remained present throughout the flowering, fruiting and maturation stages of the crop. Nymph abundance peaked on October 19, while adults were observed in almost all assessments, though with lower frequencies at different times.

On October 26, during the flowering and fruiting stage, only a single nymph was found. By November 30, also within this period, no mites or eggs were detected. This absence could be associated with the chemical control applied in the treated plot, which likely contributed to a temporary reduction of the mite population. However, the species was not entirely eradicated.

Despite these control efforts, mite frequency and distribution were highest during the flowering, fruiting and maturation stages. During these periods, farmers intensified pest control by applying various products, potentially facilitating the development of resistance in *P. latus* population. This observation is consistent with the findings

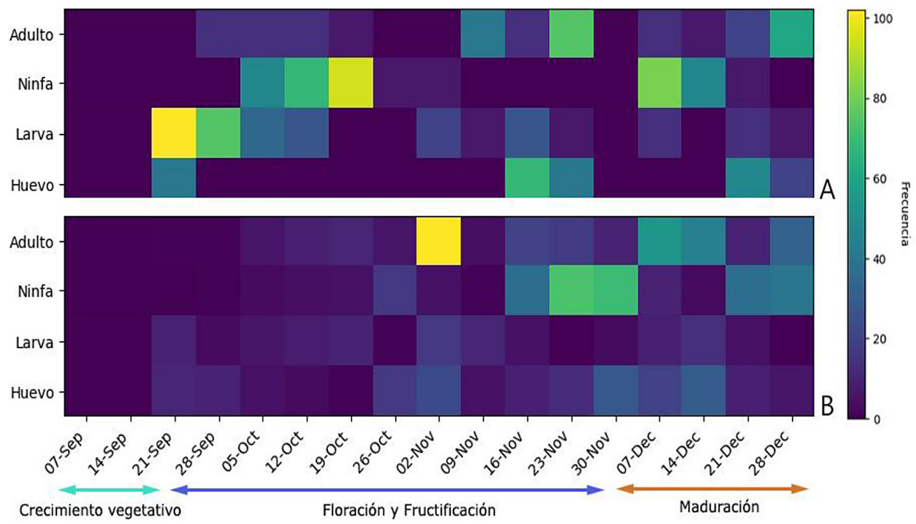

Figure 2. Population dynamics in pepper leaves from the lot, (a) with application, (b) without application

of Posos et al. (2016), who reported that despite applications of SC 72 sulfur for *P. latus* control, populations continued to increase, reaching high densities (129 mites/leaf). Similarly, Rodríguez et al. (2008) studied this pest in peppers and concluded that the lack of ovicidal effects of dicofol 18.5 CE failed to mitigate the issue, as populations increased after the suspension of treatments. Furthermore, Alshabar et al., (2021) highlighted that the genetic structure of *P. latus* contributes to resistance to chemical treatments, reducing the effectiveness of conventional controls methods. Consequently, due to genetic diversity and resistance mechanisms, chemical control alone is insufficient for effectively managing *P. latus* populations. Instead, an integrated pest management (IPM) strategy incorporating chemical, biological and physical control methods is necessary (Gobin et al., 2013; Rahman et al., 2020).

In the plot where no phytosanitary products were applied, mite frequency was lower, however, their distribution was broader during periods of significant population increase. The presence of *P. latus* was first recorded on September 21, during the final stage of vegetative growth, with 11 eggs, 10 larvae, and 1 adult. These individuals gave rise to new generations, leading to a progressive increase in population frequency over time.

Throughout the study, egg abundance remained low, except on November 30, during the flowering and fruiting stage, and on December 14, in the maturation stage, when the highest densities were recorded. Larvae were presented at low frequencies in all evaluations, with a total count of 102 individual. Nymphs were more frequently detected between November 16–30 (flowering and fruiting) and December 21–28 (ripening). Adult mites were present throughout the study, with peak abundance recorded on November 2, during the flowering and fruiting period.

These results indicate that mite infestations begin at the end of the vegetative growth stage and persist through flowering and fruiting and crop maturation, with these periods representing the most critical phases for *P. latus* infestation. Despite this, no mites were found in shoots or flowers, suggesting that mature leaves serve as the primary substrate for their development. Jovicich et al. (2004) reported that *P. latus* populations develop more rapidly on older, infested seedlings. Likewise, Karmakar (1995) emphasized that mite infestations at these stages poses a serious threat, as mites attack young developing tissues, causing the fall of flower buds, flowers and immature fruits, reducing yield.

Additionally, González et al. (2016) highlighted the importance of preventing and controlling infestation when the plant enters the flowering stage, as mite attacks during this phase can severely hinder plant recovery. Infestations can cause floral deformities and inhibit shoots development. Since this plot was not treated with pesticides, predatory mites from the family Phytoseiidae were present alongside their prey. However, their impact on *P. latus* control appeared limited, as only six predatory mites were recorded in November.

Environmental conditions also influenced the population dynamics of *P. latus*, as illustrated in Figure 3. In the treated plot, eggs development exhibited a positive correlation with temperature. Larvae showed a positive correlation with

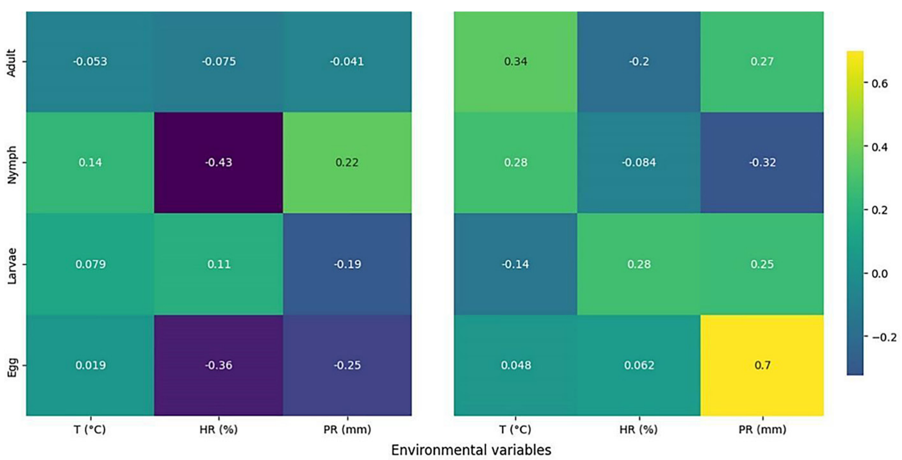

Figure 3. Correlations between the frequency of individuals in different developmental stages and environmental variables in leaf; (a) with application of phytosanitary products, (b) without application

both temperature and relative humidity, whereas nymphs showed a negative correlation with relative humidity. In contrast, adult mites exhibited a negative correlation with all climatic variables.

In the untreated plot, egg abundance was positively correlated with all three climatic variables, with the strongest correlation observed with precipitation. However, larvae exhibited a negative correlation with temperature. For nymphs, relative humidity and precipitation showed negative correlations, while adults displayed positive correlations with both temperature and precipitation.

These findings are consistent with those reported by Pal and Karmakar (2017), who demonstrated that *P. latus* population are significantly influenced by temperature, predominant relative humidity and precipitation, with these factors positively contributing to population growth.

Similarly, Nasrin et al. (2021) found that *P. latus* abundance is positively correlated with temperature but negatively correlated with relative humidity and precipitation, indicating that warmer and drier conditions favor mite proliferation. Jones and Brown (1983) reported that temperature of 23.7 °C is optimal for egg production and oviposition; however, fluctuations in temperature can be detrimental to the egg and nymph stages.

Fruit structures were evaluated every 15 days. revealing a lower mite population in the treated plot, with a more sporadic distribution across evaluation dates compared to the untreated plot (Figure 4). From October 19, when the first evaluations were carried out on fruits in the treated plot, *P. latus* mite was not detected in any developmental stage. However, by November 2, eggs (5), nymphs (1) and adults (2) were recorded, marking the onset of a population increase, as evidenced in subsequent samplings.

Regarding egg development, a progressive increase in frequency was observed throughout the evaluations, peaking at the end of the maturation period with 25 eggs. Larvae, on the other hand, maintained a low population frequency in most evaluations, with a notable increase on December 14. Nymphs reached their highest frequency on December 28, at the end of the maturation period, in contrast to previous evaluations.

Adults were the most predominant developmental stage, exhibiting higher frequency and wider distribution compared to the other stages. In addition, an increase in adult frequency was recorded on the final evaluation date, December 28.

These results revealed that, despite weekly applications pest management applications, *P. latus* control was insufficient, potentially promoting resistance development. This is consistent with the study of Augustine et al. (2024), which reported that laboratory-selected populations exhibited a 99.32-fold decrease in susceptibility to phenazaquine over successive generations, highlighting a significant risk of resistance. Similarly, Augustine et al. (2023) demonstrated high levels of resistance to various acaricides, including Diafentiuron, Dicofol, Phenazaquin, Propargite and Spimesifene, in *P. latus* in field populations from Karnataka, India.

This underscores the importance of *P. latus* as a major pest in pepper cultivation, causing severe damage and compromising fruit quality. According to Fadaei et al. (2024) and Patavardhan et al. (2020), infested fruits often exhibit reduced size

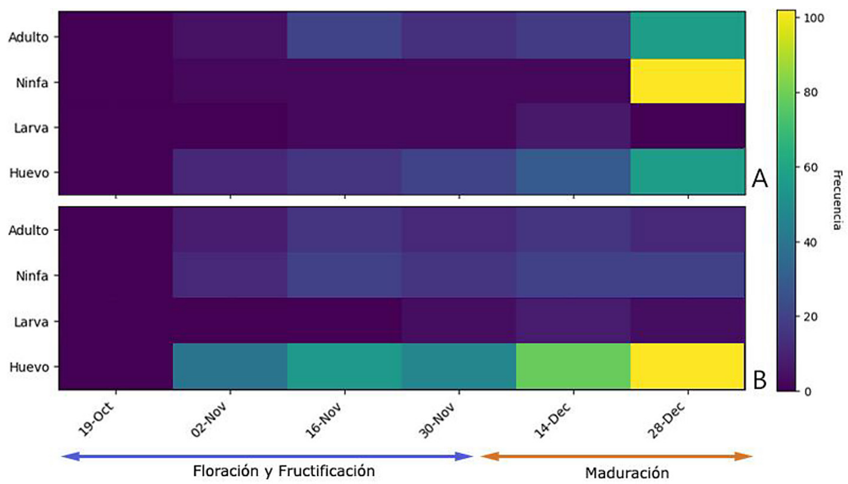

Figure 4. Population dynamics of *P. latus* on fruits, (a) in treated plots, and (b) untreated plots

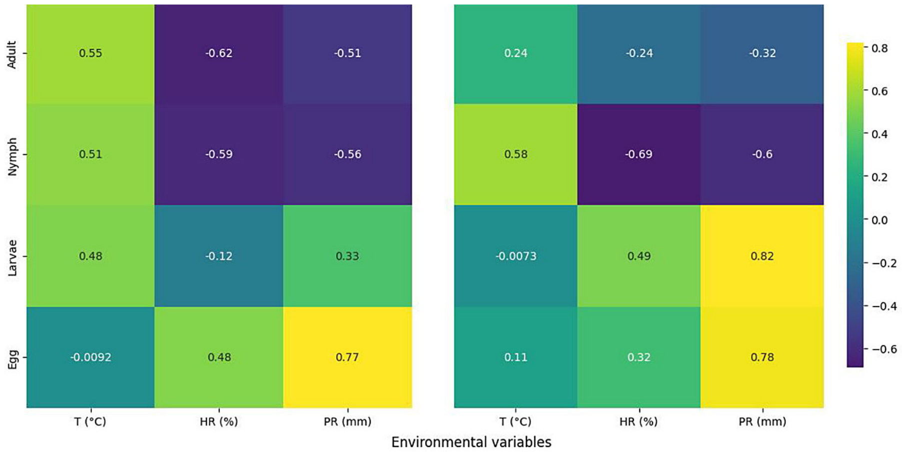

Figure 5. Correlations between frequency of different developmental stages of *P. latus* and environmental variables in fruits in (a) treated plots and (b) untreated plots

and a coppery appearance, rendering them unsuitable for consumption. This damage results from the mite's feeding activity, during which it injects toxic saliva into plant tissues, causing discoloration and giving the fruit a tanned or mummified appearance. Additionally, Jangra et al. (2017) reported a significant correlation between mite incidence and reduced fruit length.

In the untreated plot, mite frequency was higher with similar distribution patterns across sampling dates. As in the treated plots, P. latus was first recorded on November 2, with eggs (10), nymphs (3) and adults (2). Throughout the evaluations, egg presence was predominant, peaking on December 14 and 28. In contrast, larvae remained at low densities throughout the study period, while nymphs and adults maintained a relatively stable population frequency. Consequently, this population will give rise to a new progeny of mites in the crop, due to their short life cycle and high reproductive potential. These factors contribute to their ability to inflict significant damage within a short period (Rodríguez et al., 2017).

The presence of *P. latus* in fruits is of particularly concerning, because, as Hrnčić and Radonjić (2010) reported that infestation leads to fruit deformation and tanning, affecting marketability and increasing production costs.

A direct correlation was observed between environmental conditions and mite population dynamics. Figure 5 shows that in fruits from treated plot, egg abundance was negatively correlated with temperature, but positively correlated with relative humidity and precipitation, which favored their development. Larvae exhibited a negative correlation with relative humidity and positive correlations with humidity and precipitation. Nymphs showed a positive correlation with temperature, a trend also observed in adults.

In the untreated plot, eggs, nymphs and adults exhibited a positive correlation with temperature. Eggs showed a positive correlation with all climatic variables, while larvae displayed a positive correlation with relative humidity and precipitation. In contrast, nymphs and adults demonstrated negative correlations with relative humidity and precipitation.Ferreira et al. (2006) reported that mite abundance is positively correlated with temperature, as higher temperatures accelerate development and increase reproduction rates. Similarly, *P. latus* development and activity are highly dependent on temperature. At 11 °C, mite activity ceases, while at 36 °C, it significantly slows down. The optimal temperature for *P. latus* development is approximately 21 °C, with a relative humidity of 75% (Saloni et al., 2022). These findings align with the conditions of the study area, where the temperature ranged between 24 and 26 °C. Although slightly above the optimal range, these conditions favored mite development.

CONCLUSIONS

The broad mite, *Polyphagotarsonemus latus*, is a pest of major significance in pepper cultivation, as it is present throughout all phenological stages. Its highest population density occurs during the flowering and fruiting phases, directly impacting crop production, quality, and yield.

No mites were observed present in shoots and flowers, suggesting a feeding preference for mature leaves and fruits. This study provides a basis for future research on *P. latus* population dynamics, particularly in evaluating its incidence across dry and rainy seasons.

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