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Bio-ecology of black scale insects *Parlatoria ziziphi* Lucas (Homoptera: Diaspididae) on three varieties of mandarin trees in a Foumbot orchard (West Cameroon)

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Abstract
The study of the bio ecology of black scale insects *Parlatoria ziziphi* (Lucas, 1853) was carried out for one year (2018) in a citrus orchard of Foumbot on three varieties of mandarin including two exotic (Beauty and Emperor varieties) and one local (Obala variety). The method used consisted of removing two leaves with twigs and counting all of the living mealybugs using a binocular magnifier. It turns out that the climate influenced the global dynamics of living populations. In the Obala variety, mealybugs were more accentuated and distributed evenly in the west, north, south and center of the tree. They pullulated more and equally in the East, South and Center directions for the Beauty variety and more colonized the North side of the Emperor variety. Furthermore, scale insects preferred to settle on the lower parts of the leaves, and did not colonize the twigs. It would be advisable to whosoever wishing to establish orchards to put the improved varieties more and to accentuate the treatments in the dry season by spraying the leaves, especially the lower parts and the most shaded cardinal directions.

Keywords: *Citrus reticulata*, ecology, Foumbot, mealybugs, population dynamics

Introduction
The cultivation of fruit trees is a widespread practice in the world, due to its decorative quality, fragrance, medicinal properties and taste [1]. In Africa, it is of paramount importance, especially since it is a source of income for small producers [2]. It also plays an important role in providing nutritional quality, marking land properties, restoring ecological balance [2]. It is used as palaver trees and is a source of employment for young people [2]. In 2011, the FAO ranked Nigeria and Guinea Conakry among the top five African citrus producing countries in the world [3].

However in Cameroon, the drastic fall in the prices of cocoa, coffee and cotton in the years 1987-1990 led a large number of producers to convert to citrus production first for the local market, then in the sub-region and even Europe. Tangerine and mango together form the third group of fruit with economic profitability after the first group consisting of orange and papaya and the second group comprising pineapple, African plum and avocado [4]. They are mainly supplied by small producers. However production remains very low and far from meeting national demand. The low productivity of mandarins is linked to the lack of control over the technical itinerary, the poor choice of plant material, the poor accessibility to agricultural inputs and above all the presence of bio-aggressors [5]. Furthermore, among all the diseases and pests listed on mandarin, black mealybugs (*Parlatoria ziziphi*) or black lice of the orange tree are very dangerous [6]. Indeed, by a discreet but constant action, they endanger the existence of the orchard [6]. In Cameroon data on this insect is almost nonexistent, so it seems important to look into the study of this population of mealybugs and finally to master its ecology in order to find the appropriate control periods.

The general objective of this study was to increase the production of mandarin trees, by evaluating the degree of varietal sensitivity in three varieties of mandarin trees chosen. More specifically, it involves: (i) identifying periods of high activity for *P. Ziziphi*; (ii) to identify the global fluctuation of these on the four cardinal directions and the center; (iii) to highlight

the global variations as a function of the sides of the leaves and to give the distribution of these as a function of the organs.

Materials and Methods

Study site

The experiment took place in the experimental orchard of the Institute of Agricultural Research for Development (IRAD) in Foumbot, located in the West Cameroon Region, Noun Division, Mangoum village. The orchard is located at an altitude of 963 m from Latitude 05 ° 29'034" and Longitude 010 ° 33'33.0". The soil is of volcanic type. The climate is characterized by a rainy season (mid-March to mid-November) and a dry season (mid-November to mid-March). The average annual rainfall is 1,538.8 mm and the temperature is 22.35 ° C.

The natural vegetation is dominated by the formation of grassy plant species, grasses such as: *Pennisetum purpureum* as well as many broad-leaved species such as *Tithonia diversifolia* and *Mimosa* spp. The gallery forests are encountered along the rivers beyond the natural vegetation, the artificial vegetation consists of annual, semi-perennial and perennial crops.

Study plot

The test was carried out in one year, from January 31 to December 30, 2018, i.e. 23 outings, in a citrus orchard of almost 15 years of age on three varieties of mandarin including two exotic ones (Mandarin Beauty and Emperor) and a local (Obala mandarin). It was performed according to a completely randomized block system with six repetitions. The plants were from grafting on *Citrus volkameriana*, the planting distances were 5.5 m x 6 m. Each block was surrounded by border pummelo.

Fig 1: Foumbot citrus orchard

Methods

The method used for the sampling of *P. ziziphi* populations consisted in taking with a pruner a sample containing a branch 10 to 15 cm long and two adult leaves taken from each of the four cardinal orientations of the tree as well as in the center of the tree. They were placed into plastic bags containing the coordinates of the sample (date, direction and variety) and brought directly to the laboratory [7]. The frequency of sampling was done every 15 days for one year. The method used was that established by Vasseur and Schvester [8]. All the samples were examined in the laboratory using a binocular magnifier with a magnification of 40. The harvested leaves and twigs were carefully examined, the different stages of scale development were identified, quantified and noted on sheets bearing the release date, variety, block, and different directions. The count was mainly based on living individuals from the egg stage to adult males and females. The observation of these different stages was made on the lower and upper sides of the leaves and on the twigs. The infestation rate was calculated using the following formula [9]:

$$\text{Infestation rate} = \frac{\text{Number of infested leaves}}{\text{Number of observed leaves}}$$

Data analysis

Data on the global fluctuation of individuals as a function of cardinal directions, sides and organs were subjected to an analysis of variance (ANOVA) using STATGRAPHIC software version 16. The mean values were separated by the Student test at 5% probability threshold ($P \leq 0.05$).

Results and Discussion

1. Activity period of *Parlatoria ziziphi*

Obala variety: The data obtained throughout 2018 showed that in Mandarin Obala (Fig. 2) which is a local variety, *P. ziziphi* mealybugs evolved in a saw-tooth fashion with three fairly marked peaks. They show the periods of intense activity which were the months of January with 212 individuals, May with 217 individuals and the month of December with 207 individuals. In addition, we noted the months of low intensity of mealybugs, namely the months of June (55 individuals), July (44 individuals) and the month of October (9 individuals).

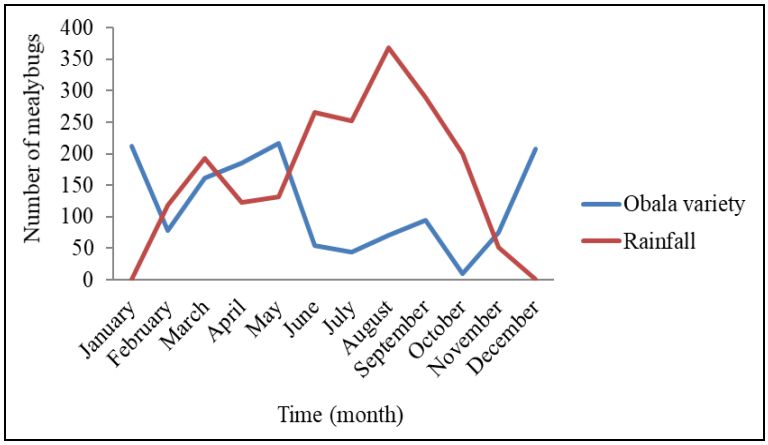

Fig 2: Evolution curve of mealybugs and rainfall on the Obala variety.

Beauty variety: In the case of the Beauty variety (Fig. 3), we observed three months of intense mealybug activity, namely the months of March with 215 individuals, April with 305 individuals and May with 275 mealybugs. However, we observed months where the activity of mealybugs was very weak in occurrence the months of June (8 mealybugs), July (14 mealybugs) and August (12 mealybugs).

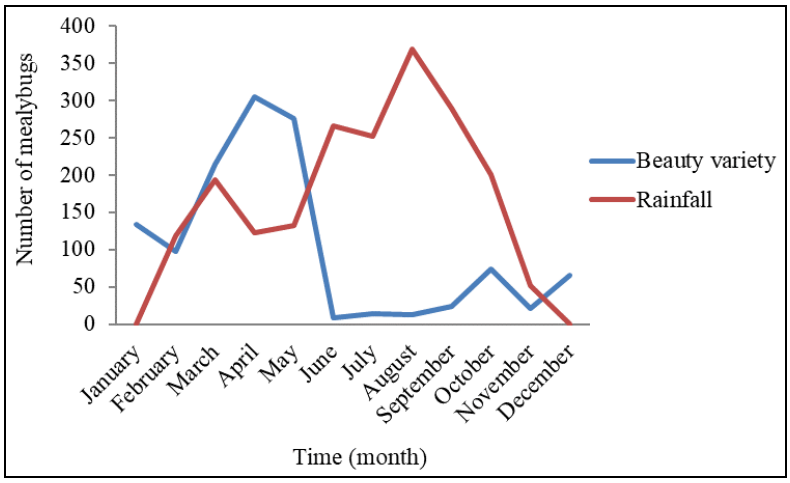

Fig 3: Evolution curve of mealybugs and rainfall on the Beauty variety

Emperor variety: In addition, for the Emperor mandarin (Fig. 4), the months of May (330 mealybugs), March (127 mealybugs) and August (116 mealybugs) were the months of intense mealybug activity. And, the weakest months were September (7 scales) and June (14 scales).

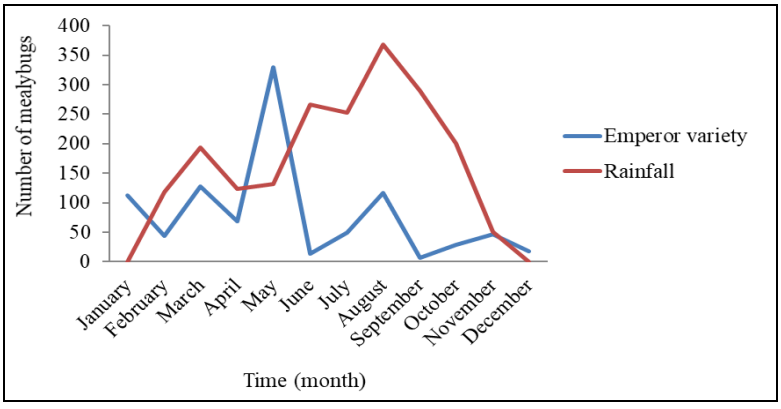

Fig 4: Evolution curve of mealybugs and rainfall on the Emperor variety

Interpretation of rainfall during the study period: Analysis of rainfall records during this period shows that no precipitation was recorded during the month of January. Then, the rainfall increased to reach 193 mm in March. It relapsed and became constant in April and May. It raised again to wait for a peak of 368.5 mm in August, and gradually relapsed the following months to reach a zero value in December.

The global analysis of the different varieties as a function of time reveals that rainfall had a remarkable influence on the evolutionary process of mealybugs. Indeed, for the Obala,

Emperor and Beauty varieties, the level of mealybugs was high during dry periods of the year, and this rate decreased when the rainfall increased. This phenomenon is believed to be due to certain environmental factors. Indeed, the deviations of a few degrees of temperature, the relative humidity of the air, high intense insolation, and a high sudden wind are susceptible to determine in all the species a significant mortality and to annihilate the whole generations [10]. The morphology of the host plant can also be mentioned because the shape cannot allow the mealybugs to settle well and therefore rapid leaching by rainwater. This aspect can also be justified by the decrease in the nutritional value of the host plant, the presence of toxins, repellents of an unpleasant taste in the tissues of the plant during the rainy period. Indeed, Biche and Sellami [11] have shown that the host plant can act on the duration of the cycle, on size, fertility and sex-ratio. Furthermore, certain natural enemies can act on the fluctuation of mealybug populations, especially when no chemical and size treatment has been carried out in this plot for several years.

Infestation rate data shows percentages below 20%, which indicates a relatively low infestation rate. The Obala variety is at the top with a 4.1% infestation rate, then the Beauty variety with 3.6% and finally the Emperor variety with 3.4%. The population difference between the three varieties is quite substantial, 1,410 for the Obala variety, 1,244 for the Beauty variety and 960 for the Emperor variety. This difference is due to the biochemical and chemical composition of the host plant which plays a significant role in the distribution of the different stages of evolution of *P ziziphi* [6].

2. Global fluctuation of the populations of *Parlatoria ziziphi* according to the cardinal directions (South, East, West, North and Center)

Statistical analysis of the mealybug's fluctuation as a function of the cardinal directions shows that for the Obala variety (Fig. 5), the East of the tree is less affected compared to the other cardinal directions. The directions North, South, West and Center were more attacked but equally. These results are similar to those found by Medjdoub [12] and Belabbas [13] at Tlemcem in Algeria who found the scale insects distributed in the same way on all the cardinal directions of the tree.

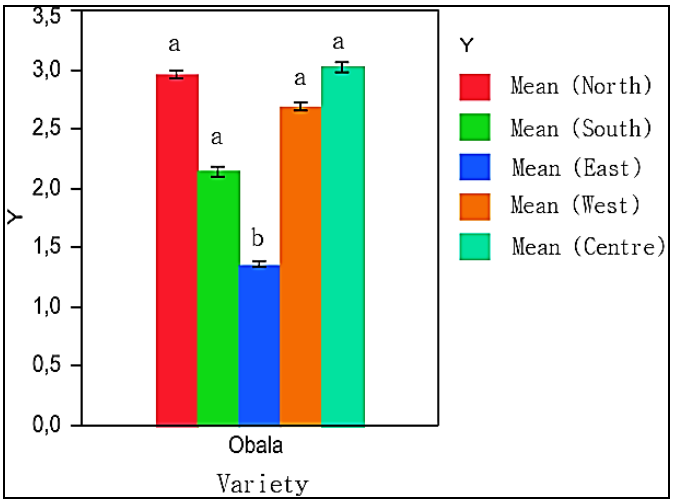

Fig 5: Distribution of the populations of *Parlatoria ziziphi* in the Obala variety

For the Beauty variety (Fig. 6), the North and East directions were less attacked by mealybugs, while the South, East and Center directions were affected equally. These results are similar to those found by Adnan [14] in Egypt who in his study found that the South and East were more attacked by mealybugs. In addition, Ahmed *et al*. [15] in Algeria rather found that the southern direction is more attacked by mealybugs. However, other authors [6, 16-19] in their respective works have found a particular affection of the cochineal for the Center of the tree.

These results can be explained by the fact that these different directions are found to be shaded either by the tree or in their position in the orchard, thus creating favorable conditions for the development of the cochineal.

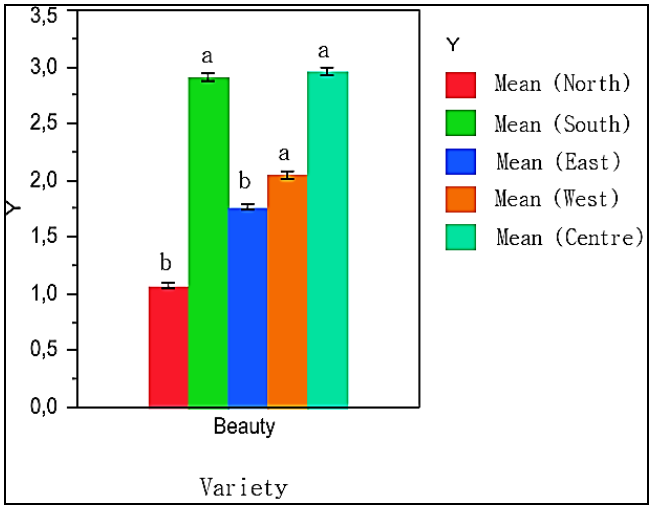

Fig 6: Distribution of the populations of *Parlatoria ziziphi* in the Beauty variety

For the Emperor variety (Fig. 7), the North direction is the most attacked, the South direction is the least attacked. These results are similar to those of Meziane [20] who also found that mealybugs are fond of the northern and central parts.

Statistical analysis of the three varieties shows that there is a significant difference between the Obala variety and the other varieties in the South direction (P = 0.04).

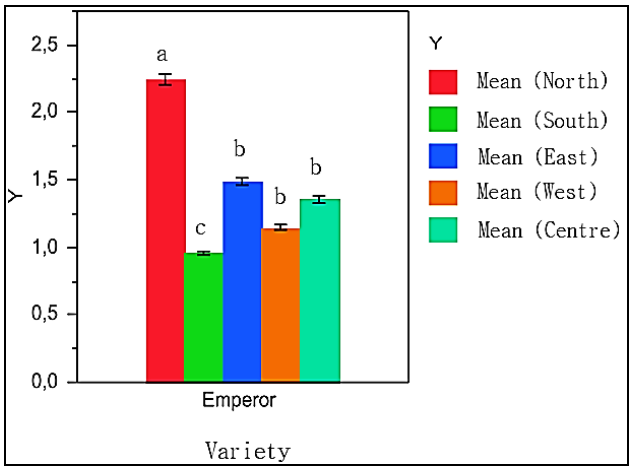

Fig 7: Distribution of the populations of *Parlatoria ziziphi* in the Emperor variety

3. Global fluctuations of the populations of *Parlatori ziziphi* on the different sides of the leaves

Scale insects attacked the lower side more than the upper side of the leaves on the different varieties (Fig. 8). This would be due to the non-thermophilic nature of mealybugs. These

results are in agreement with those of Quilici [21] who states that most of the scale insects are located on the underside of the leaves, the upper side being colonized only during heavy infestations. It is also the same with those of Dirar [22] who indicates that the lower part of the leaf is the most attacked by *P. ziziphi*. He adds that the strong attacks affect the leaves and fruits and cause the premature loss of leaves and fruits. This is equally the case with Berrabah [13] and Ahmed [15] who emphasize in their respective works that the outer side of the leaves is more infested with mealybugs than the inner side. This could be explained by the fact that, like most scales, other sedentary hemiptera like *Diaphorina enderleini* Klimaszewski, 1964 (Hemiptera: Psyllidae) prefer the underside of the leaf which shelters them from the sun which can be harmful for their blooming and certain predator and parasitoïde less vigilant.

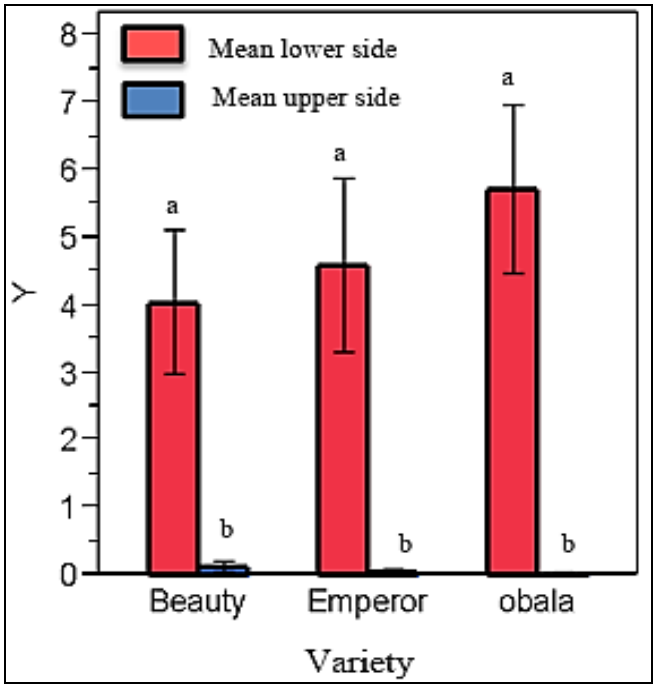

Fig 8: Distribution of mealybugs according to the leaf sides

4. Distribution of *Parlatoria Ziziphi* according to organs

During the entire sampling period, no scale was observed on the stems. This result would certainly be due to the nutritional conditions sought by the cochineal in this case the elaborate serve which is much more on the leaves than the stems. In addition, we can also cite the ease of the stylus to introduce itself into the leaf blade which has a very fine texture compared to the stem. These results are similar to those found by Belguendouz [6]; Takarli [18] and Boukhabza [19].

Conclusion

The study of the bio-ecology of *Parlatoria Ziziphi* in Foumbot's orchard, on three varieties of tangerines reveals that the improved varieties are less susceptible to attacks by scale insects compared to the local variety. It would therefore be recommended to populations wishing to create orchards to put the improved varieties more and to accentuate the treatments in the dry season by spraying the leaves, especially the lower parts and the most shaded cardinal directions.

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