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The perception of *Pelargonium citrosum* (Lin) and *Ocimum basilicum* (Lin) as mosquito repellent plants

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Abstract
Because of their repellent compounds, diverse plants have been recognized as an alternative for mosquito control. In 2017, three experimental groups were established with allocation per plant: 1) *Pelargonium citrosum*, 2) *Ocimum basilicum*, and 3) *P. citrosum* plus *O. basilicum*. The inhabitants´ perception of the plant´s repellent properties were evaluated twice. Three categories for plant repellent perception according to the number of mosquitos were established: 1) no change, 2) reduction and 3) increase. A median of six inhabitants per household was found with a median of two rooms per household. 84.6% of plants were placed in rooms and 19.6%. In front of the house. No significant difference was found between measures of perception; however, *O. basilicum* had the highest percentage of repellent perception compared to *P. citrosum. O. Basilicum* is an alternative mosquito repellent for household use.

Keywords: Repellent, perception, *P. citrosum*, *O. basilicum*, mosquitos

1. Introduction
Chemical repellents are considered a tool for reducing and preventing bites from mosquitos that are vectors of diverse diseases, dissuading the insect from flying and landing on the human to eat [1]. However, this is not always possible. Changes in vector behavior that lead to a reduction or loss of vector repellence after continuous stimulation have been reported [2]. *A. aegypti* has demonstrated changes in its behavior when exposed to the compound N, N-Diethyl-m-toluamide (DEET), particularly after a second exposure which brings us to suggest the species has the ability to "overcome" the repellent effect of DEET [3].
One alternative to chemical control is the use of natural products that come from plants [4]. The repellence shown by some plants has been used by man for generations as a measure against mosquito bites [5]. Traditionally, basil has been used in food and traditional medicine [6]. Recently, its action as a bioinsecticide [7], an antimicrobial [8], and an antioxidant [9] has been documented. Among the secondary compounds present in *O. basilicum* plants, there is linalool, eugenol, methyl eugenol, geraniol, geranial, neral and methyl-chavicol [10]. The protection against mosquito bites provided by diverse plants of the genus *Ocimum* has been reported [11] in species such as *O. gratissimum*, which has shown larvicidal activity against *A. aegypti* [12]. *O. basilicum* has a repellent activity of up to 50% for adult mosquitos of *A. stephensi*, *A. aegypti* and *C. quinquefasciatus* [13]. In 1996, Matsuda *et al.* [14] reported *P. citrosum* as a mosquito repellent against *Aedes*; it was named *Pelargonium citrosum* (Van Leeni), a plant with a fragrance of citronella and a repellant capability of 1 m. The objective of this work was to evaluate the perception of *Pelargonium citrosum*, known as citrosa, and *Ocimum basilicum* or basil as mosquito repellents.

2. Materials and methods
A quasi-experimental study was carried out during the months of April to June 2017 in the area of Palzoquiapa, Huejutla, Hidalgo. Using an open invitation to the community, three experimental groups were formed in the following way: 1) *P. citrosum*; 2) *O. basilicum* and 3) *P. citrosum* plus *O. basilicum*. Species were randomly assigned to the participants by drawing names. Plants were located in patios near the entrance of ventilated and well-lit homes or rooms.

The number of inhabitants and rooms per home was recorded. Three home visits were carried out once a month. The first visit was done to locate the plants and the other two were for supervision and assessment. During the visits, the status of the plant was verified and the inhabitants were questioned about their perception regarding the plant´s repellent capabilities against mosquitoes. If the plants were found dehydrated during the visit, they were replaced with new plants up to a maximum of two times. In each visit, *A. aegypti* mosquitoes were intentionally searched for visually, especially in areas near the plant. The variable repellent perception was categorized with the opinion of the participants about the number of mosquitoes in the room or near the plant: 1) No change - when the participant did not observe any change in the presence or number of mosquitoes; 2) reduced - when the participant observed a reduction in the number of mosquitoes, and 3) increase – when, according to the participant, an increase was seen in the number of mosquitoes present in the room. Finally, a statistical association between the variables was determined using the chi-square test. This work was approved by the Ethics in Research and Research Committees of the Health Services of Hidalgo.

3. Results & Discussion

A total of 48 homes distributed into three experimental groups participated in the study. Group 1 (G1) was composed of the species *P. citrosum*; group 2 (G2) of *O. basilicum* plants and group 3 (G3) comprised both of *O. basilicum* and *P. citrosum* with 16 homes per group. The median per home was two rooms and six inhabitants. Sixty percent of the *P. citrosum* plants dried up during the study followed by 53.3%. of *O. basilicum.* In regard to the general location of the plants, 84.6% were in a room and 19.6% were at the front of the house. Regarding location by group, 61.5% of *P. citrosum* (G1) was located in a room and 38.5%. At the front of the house. 94.4% of the species *O. basilicum* (G2) remained in a room and 5.6% at the front of the house. In the *O. basilicum* and *P. citrosum* group (G3) 84.6% were in a room and 15.4% were at the front of the house.

On the other hand, regarding the results of the participant´s perception of the plant´s repellent capability, G1 of *P. citrosum*, during the first measurement, there was no change at 0%; a figure that increased to 71.4% in the second measurement. In the same group, the category of reduction of mosquitoes registered 88% in the first measurement and 14.3% in the second; the category of increased mosquitoes was similar in both measurements with 13% in the first measurement and 14.3% in the second.

In the G2 *O. basilicum* group, the category of no change represented 38% in the first measurement and 14.3% in the second; in reduction of mosquitoes 50% was registered in the first measurement and 71.4% in the second and in the increased mosquito category it was 13% and 14.3%, respectively. In the G3 group of *P. citrosum* y *O. basilicum*, 44% observed no change in the presence of mosquitoes in the room with this percentage decreasing to 12.5% in the second measurement; in addition, the category of reduction of mosquitoes registered 55.6% in the first measurement and 87.5% in the second. In the category of increase, no frequency was registered in either measurement. Finally, no significant difference was found between the first and second measurements of perception recorded in the three groups (Table 1).

Table 1: Repellent perception of plants

Group/ Species	Categories	Measure		*p*
		First	Second	
G1 – *P. citrosum*	No change	0	71.4	.435
	Reduction	88	14.3	
	Increase	13	14.3	
G2 – *O. basilicum*	No change	38	14.3	.856
	Reduction	50	71.4	
	Increase	13	14.3	
G3 – *P. citrosum* + *O. basilicum*	No change	44.4	12.5	.375
	Reduction	55.6	87.5	
	Increase	0	0	

All values are percentages (%) unless otherwise noted.

The use of repellent plants is linked to tradition and culture in different parts of the world [15, 16]. In the state of Hidalgo, plant branches that hang from different parts of the room are used to repel or drive away insects [17]. Our results show that *O. basilicum* had a lower loss of individuals in comparison to *P. citrosum* and was the species with greater acceptance representing 94% of the plants in rooms. Although the results of repellency perception did not show statistical significance, the category of mosquito reduction stands out, since there was an increase in frequency between the first and second measurements of groups 2 and 3. For the same category, G2 showed an increase from 50% to 71.4% and G3 from 55.6% to 87.5%, respectively. The results on repellent perception of *O. basilicum* reflected an increase in participant perception with regard to the reduction of mosquitoes in areas where there previously was no plant. These results are in agreement with the efficacy reported for *O. basilicum* and the efficacy of mosquito repellence, which has been documented in different ways including the burning and use of oil from leaves [18-20]. Contrary to that observed with *O. basilicum*, *P. citrosum* registered a reduction in frequency in the category of mosquito reduction by decreasing from 88% to 14.3% in the second measurement as well as an increase in the category of no change in the second measurement with 71.4%; this is because the repellent efficacy of *P. citrosum* is controversial. In 1996 Matsuda *et al.* reported a repellence of 90% of mosquitoes of *Aedes* spp., at a distance of up to 1 m^2 from the presence of *P. citrosum* [21]; however, in 1994 Cilek and Schreiber did not find any significant difference between the number of mosquitoes of the species *Aedes albopictus* and *Culex quinquefasciatus* that perch on the forearms of humans in areas where *P. citrosum* was present compared to areas without the plant [22].

One of the limitations of this work was that the ethnobotanics of the participating area was not previously obtained. The authors consider that the traditional knowledge that inhabitants have on the plants and their usefulness, particularly those that act as mosquito repellents, could modify both the selection and perception of repellence that they have. Another limitation of this work was the sample size and the duration of the study which could be increased to provide better statistical significance to the perception of repellence that the inhabitant has.

4. Conclusions

This work suggests the use of *O. basilicum* as a mosquito repellent plant inside the home. The use of plants as repellents is not a new strategy. On the contrary, traditional knowledge that populations have accumulated from generation to

generation as an alternative for using mosquito repellents represents a low cost and feasible strategy. Although the efficacy of *P. citrosum* as a mosquito repellent is controversial, plants such as *O. basilicum* are capable of repelling mosquitoes and of reducing the risk of mosquito bites and transmission of diseases such as dengue, chikungunya and zika.

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