Acarologia
Open Science in Acarology

House dust mites (Acari: Astigmata) from mattresses in Panama

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Original research

ABSTRACT

The name "house dust mites" is commonly used to refer to species of mites belonging mainly to the Pyroglyphidae family (Astigmata) that are found in association with dust in the human dwellings. They represent the main source of allergens in the home and can cause allergic diseases. Mattresses often provide ideal conditions for mite colonization. In order to compare the diversity of house dust mites in the provinces of Panama and Panama Oeste in 2015, we collected dust from the surfaces of mattresses over an area of one square meter using the vacuum method. We obtained 50 samples using the vacuum method and recovered 10,225 mites. We found that the mites in our samples belonged to 15 families, 15 genera and 22 morphospecies. Relatively, high mean densities of mites per gram of dust on mattresses were obtained in the provinces of Panama (3,577 mites/g of dust) and Panama Oeste (6,273 mites/g of dust). The mite *Blomia tropicalis* was the most abundant species in mattresses in the Province of Panama and *Dermatophagoides pteronyssinus* was the most frequent one in Panama Oeste. Our results indicate that the mite community in mattresses is similar between PA and PO. However, our results differ significantly from those found in bedroom floors in a previous study. These differences correspond to a lower species richness, higher density and relative abundance of Astigmata mites in mattresses.

Keywords house dust mite; mattresses; *Blomia tropicalis*; *Dermatophagoides*

Introduction

Domestic mites are microscopic arachnids that occur in various households microhabitats and are traditionally grouped according to their ecological preferences as house dust mites (Pyroglyphidae), and storages mites (Acaridae, Glycyphagidae, Echimyopodidae and Chortoglyphidae (Arlian *et al.*, 1992; Miranda *et al.*, 2002; de Oliveira *et al.*, 2003; Navarro *et al.*, 2008; Colloff, 2009; Thomas, 2010). Abiotic factors such as high levels of humidity (above 75%), and temperatures (ranging from 25 to 30 °C) are ideal conditions for the proliferation of mite populations (Arlian, 1992; Colloff, 2009). Moreover, social practices or cleaning behavior may also affect the composition of the diversity of the mites that inhabit homes (Herbosa and García, 2008; Colloff, 2009).

Fecal pellets of mites are the main source of allergens in house dust and may cause allergic rhinitis, asthma, conjunctivitis and atopic dermatitis (Fernández-Caldas *et al.*, 2014; Gandhi *et al.*, 2013). The feces of these mites contain a wide variety of allergenic compounds, mainly proteins, that triggers allergic respiratory disease (Sánchez-Borges *et al.*, 2017). Sensitization occurs in the respiratory tract and on mucous membranes when mite feces are inhaled.

It has been estimated that 2-10% of the global human population suffers some type of allergy to dust mites (Sánchez-Borges *et al.*, 2017; Ling *et al.*, 2018). Moreover, a global initiative to assess future trends in the prevalence and severity of allergic diseases through International Study of Asthma and Allergies in Childhood (ISAAC), estimates that cases of

Received 29 October 2019
Accepted 23 July 2020
Published 06 August 2020

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Academic editor
Roy, Lise

DOI
10.24349/acarologia/20204386

ISSN 0044-586X (print)
ISSN 2107-7207 (electronic)

allergic rhinitis and rhinoconjunctivitis in Latin America are increasing each year, ranging from 12.7% for 6-7 year old to 18.5% for those over 14 years of age (Katelaris *et al.*, 2012). In Panama, the impact of allergies to house dust is generally unknown and is typically reported as unspecified allergic rhinitis (Ministry of Health of Panama, MINSA, 2016).

Mattresses are recognized as one of the most important habitats for house dust mites (Sun and Lue, 2000; Nadchatram, 2005), since these structures provide ideal microenvironmental conditions for mite proliferation. Mites also feed upon skin scales, dander, and bodily fluids. In addition, the microclimate of the mattress is also affected during the time in which it is occupied, with an increase in temperature and relative humidity compared to the rest of the room (Colloff, 1988). Communities of mites vary between mattresses, with variation affected by characteristics of the homes (macroenvironment), quality of the mattress (microenvironment) as well as the habits of people who live in the households (Colloff, 2009).

The main Metropolitan Area in Panama includes the cities of Panama (Panama province, PA), Arraijan and La Chorrera (Panama Oeste province, PO), among other administrative areas. PO was created by law in December 2013, which has encouraged demographic and urban growth in the west side of the Panama Canal (Law Nº 119, 2013). This work was developed under the hypothesis that differences in mites community composition in mattresses between houses of PA (developed urban area) and PO (a growing urban center) depend on human movements that occurs between the two provinces. We also sought to compare our results with other published studies done in the bedrooms of houses in Panama.

Materials and methods

PA and PO comprise the principal cultural and economic center of Panama. PA has a total geographic area of 2,561 km^2. The mean annual ambient temperature is 27 °C (21 to 33 °C) and the mean annual relative humidity is 83% (data from the Hydrometeorology Department of ETESA, the Electrical Transmission Company, 2015). PO is often known as "dormitory towns" and has a total area of 2,467.1 km^2. The mean annual average is 28 °C, and ranges from 19-34 °C. The mean annual relative humidity is 80.3% (data obtained from the Hydrometeorology Department of ETESA, 2015). The average number of human inhabitants per dwelling in the PA is 3.6. However, since PO was created in 2013, this value is unknown (National Statistics and Census Institute, INEC, 2010).

In both provinces, we selected 25 houses, taking one mattresses sample per home. Sampling was carried out from 21-26 September 2015. An area of 1 square meter (1 m^2) on the upper surface of the mattresses was vacuumed for 2 min (Colloff, 2009). Coffee filter paper was attached to the nozzle of the vacuum cleaner's hose. After vacuuming, the paper filter containing the dust was removed, placed in a sealed plastic bag, and labeled with the collection data. Subsequently, the nozzle was cleaned before collecting the next sample. Temperature and relative humidity data on the upper surface of the mattresses was recorded.

The samples were transported in coolers at 4 °C to the Medical Entomology Research Department of the Gorgas Memorial Institute for Health Studies (DIEM-ICGES). The method described by Fain and Hart (1986) was used to collect the mites from an aliquot of 0.1 g from each sample and expressed as mites/g of dust.

All data was tabulated in Microsoft Excel 2010. The communities of mites were described on basis of species composition and density of mites for each mattress. Diversity of mites includes species richness, relative abundance, and dominance. The comparison among mattresses by province were made using the Bray-Curtis similarity index and between provinces through the Mann Whitney-Wilcoxon's test for two independent group on Simpson dominance index. The indices were calculated, and statistical tests were carried out using the software Past version 4.03. Box plots of species richness, density of mites/g of dust were elaborated using ggplot2 in R environment. A literature review on domestic mite diversity in PA and PO was conducted.

This Project was approved for Bioethics Committee under No. 077/CBI/ICGES/14.

Results

We collected 10,225 mites with 41.54% recovered from PA samples and 58.4% obtained from PO samples. Fifteen genera and 22 morphospecies were identified, representing 15 families of mites (Table 1). Of these morphospecies, 13 were identified at the species level, five at the genus level, three at the family level, and one not identified.

In PA mattresses, the median of species richness per mattress was 4, with a range of 1-6 species detected (Figure 1.A.). Density ranged from 150 to 39,000 mites/g of dust, with 92% of the mattresses with high densities (> 500 mites per gram of dust). The average was 3,577 ± 7,751 mites/g of dust, with a median of 1,390 mites/g of dust (Figure 2). The most abundant species in order of decreasing prevalence were *Blomia tropicalis* Bronswijk, Cock and Oshima, 1973, *Dermatophagoides pteronyssinus* (Trouessart, 1897), and *Cheyletus malaccensis* Oudemans, 1903 (Table 1).

In PO mattresses, the median of species richness was 3, with a range of 1-7 species detected (Figure 1.A.). The density ranged from 340 to 42,000 mites/g of dust, with an average of 6,273 ± 8,687 mites/g of dust, a median of 4,000 mites/g of dust (Figure 2). In 88% of the mattresses the density exceeded 500 mites/g of dust. The most abundant species were *B. tropicalis*, *D. pteronyssinus*, *C. malaccensis*, with the most prevalent species being *D. pteronyssinus* and *B. tropicalis* (Table 1).

Simpson's indices greater than 0.65 were considered positive for dominance by one species (Figure 1.B.). In seven mattresses in PA and five in PO, *B. tropicalis* and *D. pteronyssinus* were the dominant species.

A score above 0.65 in the Bray Curtis index corresponds to a high similarity between each pair of samples (mattresses). Similarities of the mattress samples are shown on dendrograms

Table 1 Richness, relative abundance (RA) and prevalence (P) of Acari collected from mattresses in the provinces of Panama (PA) and Panama Oeste (PO), Panama.

Order	Family	Genera	Species	RA (%) PA	RA (%) PO	P (%) n=25 PA	P (%) n=25 PO
	Pyroglyphidae	*Dermatophagoides*	*pteronyssinus*	41.15	36.35	88 (22)	92 (23)
		Dermatophagoides	*siboney*	0.17	1.38	4 (1)	4 (1)
		Malayoglyphus	*intermedius*	-	5.98	-	4 (1)
Sarcoptiformes	Echimyopodidae	*Blomia*	*tropicalis*	41.99	39.72	96 (24)	88 (22)
(cohort Astigmata)	Aeroglyphidae	*Glycycometus*	*malaysiensis*	0.17	-	4 (1)	-
	Acaridae	*Tyrophagus*	*putrescentiae*	-	0.15	-	4 (1)
	Suidasiidae	*Suidasia*	*pontifica*	0.67	1.1	12 (3)	16 (4)
	Glycyphagidae	Unidentified	Unidentified	1.18	-	4 (1)	-
	Cosmochthoniidae	*Cosmochthonius*	*reticulatus*	0.17	-	4 (1)	-
Sarcoptiformes	Listrophoridae	*Listrophorus*	sp.	-	0.15	-	4 (1)
Trombidiformes	Cheyletidae	*Cheyletus*	*malaccensis*	6.91	7.82	80 (20)	44 (11)
		Cheyletus	sp.	6.07	6.44	40 (10)	64 (16)
		Grallacheles	*bakeri*	0.17	-	4 (1)	-
		Eucheyletia	sp.	-	0.15	-	4 (1)
	Bdellidae	*Spinibdella*	*bifurcata*	-	0.15	-	4 (1)
	Tetranychidae	Unidentified	Unidentified	-	0.15	-	4 (1)
	Tydeidae	Unidentified	Unidentified	-	0.15	-	4 (1)
Mesostigmata	Laelapidae	*Androlaelaps*	sp.	0.51	-	12 (3)	-
	Phytoseiidae	*Typhlodromus*	*transvaalensis*	0.34	-	8 (2)	-
		Typhlodromus	sp.	0.34	-	8 (2)	-
	Unidentified	Unidentified	Unidentified	-	0.15	-	4 (1)
Ixodida	Ixodidae	*Rhipicephalus*	*sanguineus*	0.17	0.15	4 (1)	4 (1)

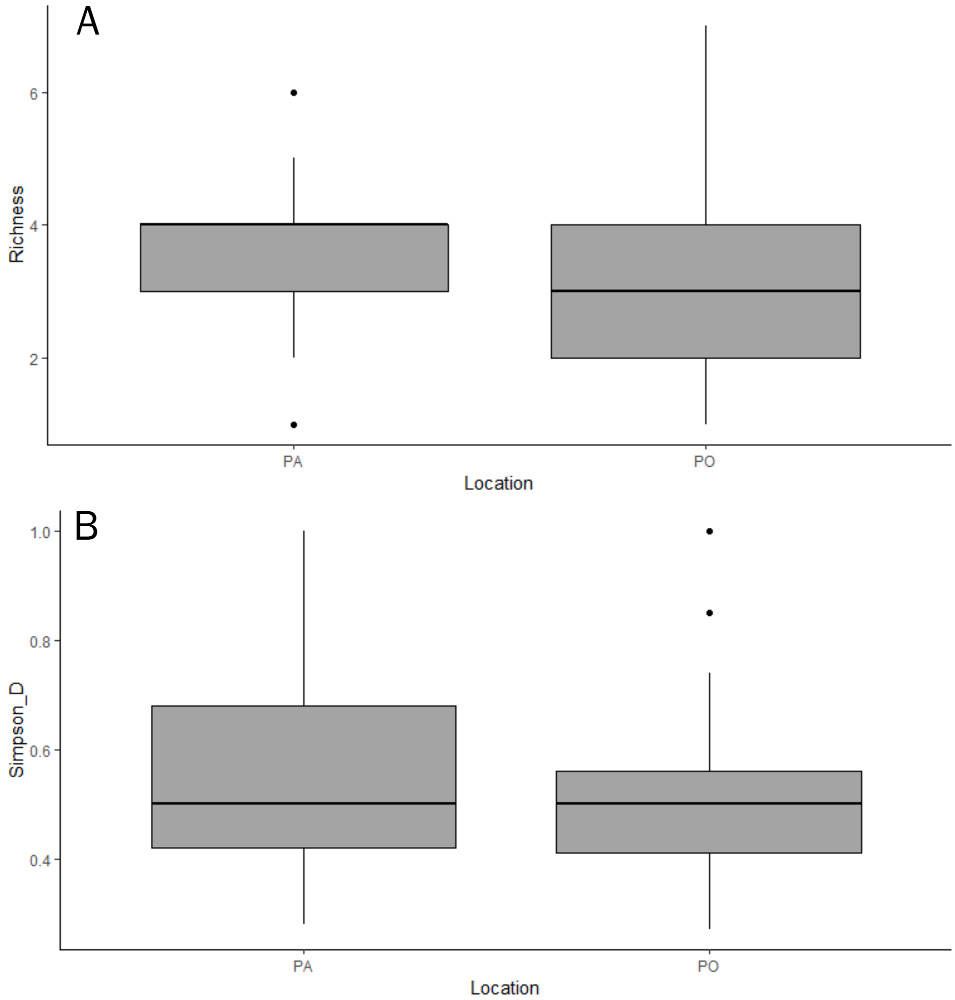

Figure 1 Diversity indices from mattresses sampled in PA and in PO (n=25 in each). A – Species richness; B – Simpson's D index.

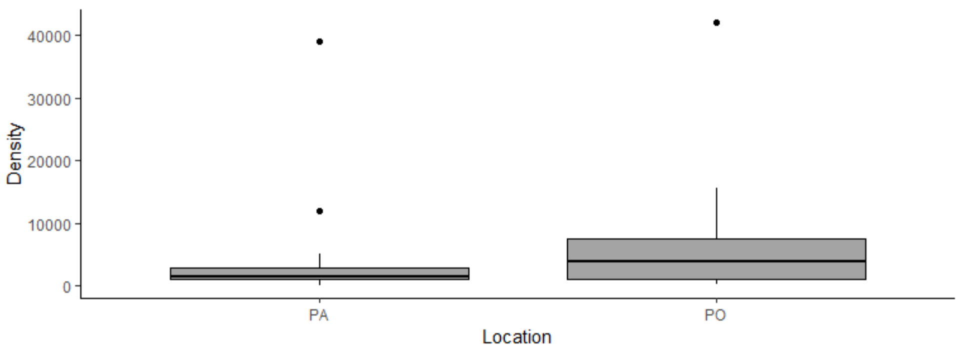

Figure 2 Density of mites per gram of dust from mattresses in PA and PO.

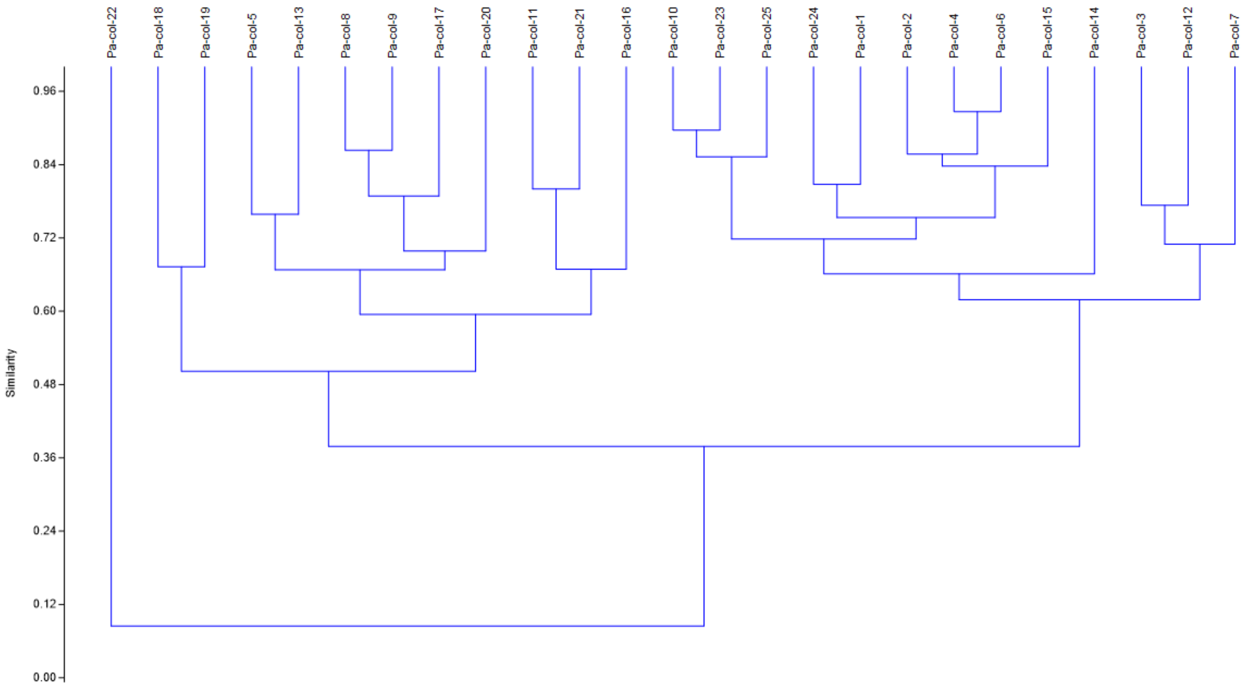

Figure 3 Dendrogram obtained from cluster analysis of mite communities in Panama (PA) based on Bray-Curtis similarity measure. Cophenetic correlation = 0.831

for each province (Figures 3, 4). The PA mattress samples are divided into two large groups, mainly due to the relative proportions of abundance of *B. tropicalis* and *D. pteronyssinus*. In contrast, the grouping of the samples in PO was influenced by the presence of rare taxa (less abundant and less prevalent).

Discussion

In our study, we found no significant differences between the mite communities inhabiting the mattresses of PA and PO. This is consistent with the fact that both provinces share similar climatic and microclimatic conditions, making both areas ideal for the proliferation of mites (Lafosse Marin *et al.*, 2006; Navarro *et al.*, 2008; see Table 2).

Regarding the density of mites/g of dust, our results indicated an average density higher in PO (6,273 mite/g of dust) than PA (3,577 mite/g of dust). PO continues to be a dormitory town, with large part of the human population working in the PA. It is possible that this difference is due to the short time that people spend at home or alternatively to poor housekeeping practices providing more homogeneous conditions for mattresses in PO. However, further studies will be necessary to test this hypothesis.

In addition, the average densities of mites in PA and PO mattresses were relatively high and were similar to those reported for tropical countries in different parts of the world (Table 2). In both provinces, 72% of mattresses had densities greater than 1,000 mites/g of dust. According to Platts-Mills and Chapman (1987), densities above 500 mites/g of dust have been associated with the development of allergic symptoms. In this sense, our measurements of mite densities represent significant findings that may have important implications for public health. The high risk of sensitization of people in these areas deserves further study.

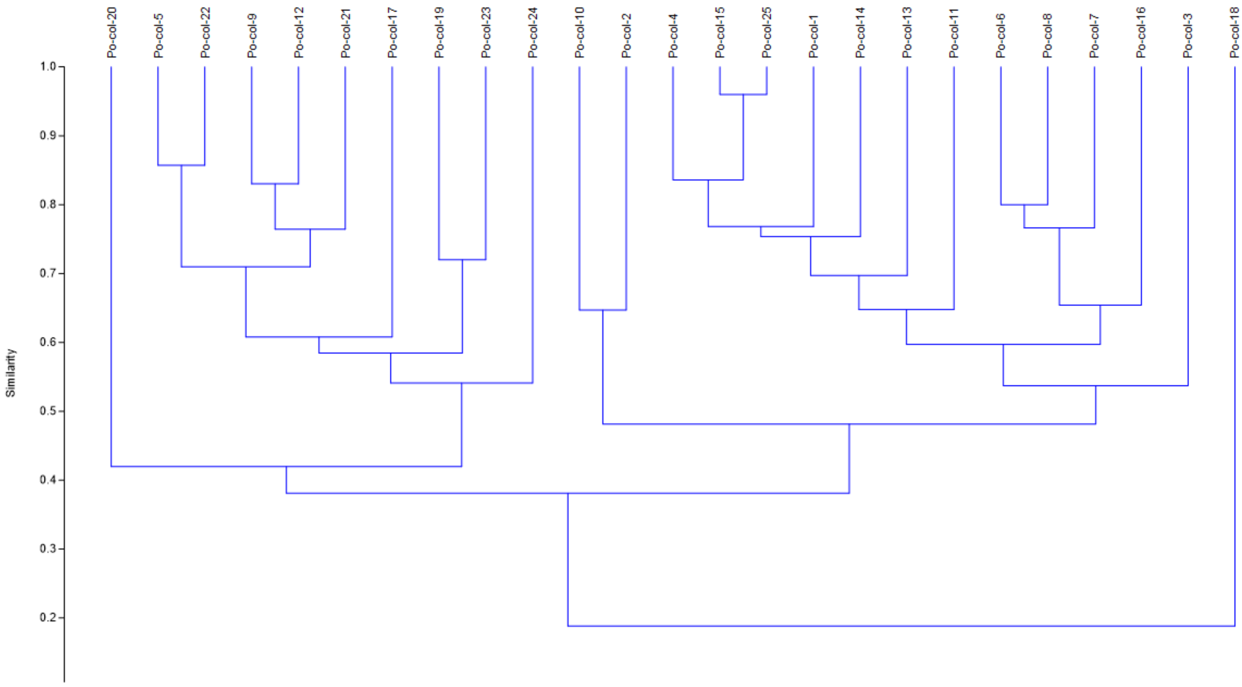

Figure 4 Dendrogram obtained from cluster analysis of mite communities in Panama Oeste (PO) based on Bray-Curtis similarity measure. Cophenetic correlation = 0.7551.

Regarding diversity, communities of house dust mites and other species of mites were similar between mattresses, with 85% of Astigmata mites, the group of mites known to be associated with the development of allergies (Table 1). No significant difference was found when comparing the dominance values of Simpson's indices for the mite communities in PA and PO mattresses (Mann Whitney-Wilcoxon's test) for two independent groups: PA: 13.4; PO: 12.1; U= 280; p= 0.5345. Codominance of *B. tropicalis* and *D. pteronyssinus* observed in PA and PO, has been reported in other studies with mattress mite communities in Singapore and Colombia (Fernández-Caldas *et al.*, 1993; Chew *et al.*, 1999). This fact demonstrates that both species are common and important components of mite communities in mattresses in the tropics.

In public health, allergic studies using the skin prick test with mite extracts and a serum IgE measurement have determined that the humans may exhibit sensitization to both *B. tropicalis* and *D. pteronyssinus* (Fernández-Caldas *et al.*, 1993; Kidon *et al.*, 2011). Consequently, our study is important in identifying the relevance of both species as causing allergies in tropical cities (Thomas, 2010).

Records of relative humidity inside the houses in PA have a range of 48-89%, with an average of 65.8%. In PO, the range is 50-76% and average of 65%. These values are optimal for the development and propagation of the mites. According to Mumcuoglu *et al.* (1999), humidity is the main limiting factor in the growth and development of mites. The average temperature of the houses studied in PA was 32 ± 3.04 °C and PO 32 ± 2.38 °C (Table 2), also ideal for mites such as *D. pteronyssinus* and *B. tropicalis*. In laboratory conditions, with the temperature of 25 °C and 75% relative humidity, *B. tropicalis* and *D. pteronyssinus* had generation times of 19.3 ± 2.5 and 22.9 ± 6.4 days, respectively (Arlian *et al.*, 1990; Mariana *et al.*, 1996). According to Puerta *et al.* (2008), the high humidity and temperature, characteristic of the tropics, are conducive for the proliferation of this species.

Mites mattresses vs bedroom floors in Panama

When comparing our results with those of previous studies conducted in Panama (Miranda *et al.*, 2002; Murgas and Dutary, 2014), it appears that mattresses have a higher density of mites in comparison to bedroom floors. The average density in bedroom floors were 1,840 and 630 mites/g of dust in urban and rural areas of La Chorrera District (PO), respectively (Miranda *et al.*, 2002). While, Murgas and Dutary, (2014) report a density 205 mites/g of dust in PA. The differences between mattresses and bedroom floors could also reflect differences in the methods of collection.

The species richness found in mattresses of PA and PO was lower than that reported by Murgas and Dutary (2014) and by Miranda *et al.*, (2002). Even though the same Astigmata species are presented in these studies, the richness of predatory mites is higher in the bedroom floors, mainly represented by Prostigmata families: Cheyletidae, Cunaxidae, Stigmaeidae and Bdellidae. Additionally, these mites encompass almost one third of the total abundance of the individuals found in these environments. Whereas in mattresses, the predatory mites account for less than 15% of the total abundance, almost all belonging to the genus *Cheyletus*. Relative abundance of Astigmata mites in bedroom floors is fewer than mattresses (Table 3).

The same species were found in these microhabitat, mainly *B. tropicalis* and pyroglyphid mites, but they were less abundant than in mattresses, because the bedroom floors can be affected by other factors such as the frequency of cleaning the house and the type of floor in each room. Instead, the mattress it is a multi-layered structure that is not cleaned as frequently and represents an area that can retain humidity for longer periods. Thus, mattresses provide more opportunities to mites for feeding, favorable microclimates as shelters and act as reservoirs for allergens (Fernandez-Caldas *et al.*, 2014; Wahongan *et al.*, 2017).

In both Miranda *et al.* (2002), Murgas and Dutary (2014) and the present study, the most important families of mites were Echimyopodidae, Pyroglyphidae, Aeroglyphidae, Suidasiidae in the astigmatid mite communities (Table 3). *D. pteronyssinus* is known as the European house dust mite and has been studied extensively worldwide, since it has a wide distribution in both temperate and tropical zones (Arlian *et al.*, 2002; Thomas, 2010). It has an important role as a sensitizing agent, besides presenting a very high cross-reactivity with other Pyroglyphidae (Ferrándiz *et al.*, 1995; Colloff, 2009).

It is important to note that *D. pteronyssinus* was not the only species of Pyroglyphidae in our study, since we also found *D. siboney* Dusbabek, Cuervo and Cruz, 1982. This latter

Table 2 Mite density and most abundant species in mattresses recorded with environmental temperature in studies from different parts of the world, including the present one.

City	Density (mite/g of dust)	Most abundant species	Mean temperature	Reference
Campinas (Brasil)	932	*D. pteronyssinus*	25°C	De Oliveira *et al.*, 2003
Cartagena (Colombia)	418	*B. tropicalis*	28°C	Fernández-Caldas *et al.*, 1993
Santa Marta (Colombia)	>500	*D. farinae*	28°C	Navarro *et al.*, 2008
Guayaquil (Ecuador)	4 586	*D. pteronyssinus*	24°C	Valdivieso *et al.*, 2006
Manado (Indonesia)	640	*D. pteronyssinus*	31°C	Wahongan *et al.*, 2017
Israel	415	*D. pteronyssinus*	30-32°C	Mumcuoglu *et al.*, 1999
Martinica	383	*D. pteronyssinus*	25-27°C	Lafosse Marin *et al.*, 2006
Panama	3 577	*B. tropicalis*	27°C	This work
Panama Oeste (Panama)	6 273	*B. tropicalis*	28°C	This work

The average temperature of the mattress surfaces studied in *PA was 32 ± 3.04°C and **PO 32 ± 2.38°C.

species has been reported in Cuba, Puerto Rico, Algeria, and Panama (Miranda *et al.*, 2002; Colloff, 2009). Furthermore, we found *Malayoglyphus intermedius* (Fain, Cunnington and Spieksma, 1969), a species reported in houses in South America, Singapore, Malaysia and Indonesia (Fain *et al.*, 1969; Mariana *et al.*, 2000). Our results represent the first report of this species in Panama.

Regarding to *B. tropicalis*, despite being considered a storage mite, it is widely distributed within houses in tropical and subtropical areas and is often very abundant in house dust (Mariana *et al.*, 2000). In addition, three other species of the so-called storage mites were found including *Glycycometus malaysiensis* (Fain & Nadchatram, 1980), *Tyrophagus putrescentiae* (Schrank, 1781) (both with a single individual), and *Suidasia pontifica* Oudemans, 1905. Together, these three species represented only 1% of the total identified mites.

Among predatory mites, Cheyletidae was the most common family in mattresses, represented mainly by *C. malaccensis*. In Mexico it was found that *C. malaccensis* and *C. eruditus* (Schrank, 1871) were frequent inhabitants in mattresses of allergic patients in six states (Fernández-Duro *et al.*, 2013), while in Santa Marta, Colombia, Cheyletidae were the most abundant predatory mites in mattresses and pillows of allergic children (Navarro *et al.*, 2008). Some species of *Cheyletus* are used as a biological control for pests in stored products (Cebolla *et al.*, 2009). However, there are reports of cheyletid species (*C. malaccensis* and *Chelacaropsis* sp.) that are able to feed on human body fluids and cause papular urticaria (Yoshikawa, 1985; Htut, 1994).

Table 3 Comparison of Astigmata mites based on studies of mattresses and bedroom floors in Panama.

	Mattresses		**Bedrooms floors**		
	PA	**PO**	**PA + San Miguelito**	**La Chorrera (urban)**	**La Chorrera (rural)**
Species by family	(N= 25)	(N= 25)	(N= 265)	(N= 35)	(N= 35)
Acaridae					
Tyrophagus putrescentiae	0	0.15	0.63	0	0.83
Acaridae unidentified	0	0	0.12	0	0
Aeroglyphidae					
Glycycometus malaysiensis	0.17	0	12.04	6.37	0.83
Chortopglyphidae					
Chortoglyphus arcuatus	0	0	0	0	0.83
Glycyphagidae					
Tropilichus aframericanus	0	0	0	0	0.83
Glycyphagidae unidentified	1.18	0	0	0	0
Listrophoridae					
Lynxacarus radovskyi	0	0	0	0	0.83
Listrophorus sp.	0	0.15	0	0	0
Echimyopodidae					
Blomia tropicalis	41.99	39.72	31.42	36.93	38.84
Pyroglyphidae					
Dermatophagoides pteronyssinus	41.15	36.35	13.57	1.91	0
Dermatophagoides siboney	0.17	1.38	0	0.96	0
Malayoglyphus intermedius	0	5.98	0	0	0
Suidasiidae					
Suidasia pontifica	0.67	1.1	8.6	11.46	3.3
Total	85.33	84.83	66.38	57.63	46.29

Parasitic mites were found on mattresses, including the tick *Rhipicephalus sanguineus* s. l. (Latreille, 1806) known as the dog tick, a common ectoparasite found in domestic dogs and a vector of human diseases which can be found often inside of houses (Bermúdez and Miranda, 2011). Other non-parasitic species include the hair mite Listrophoridae which feeds from sebaceous gland secretions on its host hair and is explained by the presence of pets (dog and cats) inside the bedrooms (Miranda *et al.*, 2002).

In summary, the results obtained in the present study indicates a strong presence of mites belonging to the order Astigmata which occurred at high densities in almost all mattresses reviewed. Predatory mites, mainly *C. malaccensis* (Order Prostigmata), only accounted for less than 15% of the total and parasitic species amounted to less than 1%.

Conclusions

Our results point to mattresses as a microhabitat that has a higher density of mites/g of dust, but a lower species richness than bedroom floors. Furthermore, the relative humidity and temperature at the regional level and even on the mattress surface indicate optimal conditions for development of mites in both PA and PO, with no significant difference recorded between mite communities in both provinces.

In the provinces of PA and PO, *B. tropicalis* and *D. pteronyssinus* were the most abundant and prevalent mites. These species are recognized for their relevance in the etiology of allergic diseases within houses. Consequently, it is clear that the exposure to the house dust mite allergens is almost inevitable inside houses, thus, it is necessary carry out studies of skin prick test or specific IgE blood test for the diagnosis and treatment of allergic symptoms in Panama. This study represents the first examination of mites in mattresses in Panama. Further research is needed to evaluate diversity of mites inside houses.

Acknowledgments

To House-dust mite project funded by the Ministry of Economy and Finance (MEF), code SINIP: 9044.043. To Ana Aguilar and Milagros Vargas for the fieldwork and Sergio Bermúdez for his suggestions and comments on the manuscript. To Victor Townsend for English review.

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