

Observations on dust mites (Acari: Pyroglyphidae) in coastal hospitals in South Africa

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Surveys of houses in South Africa have shown that dust mites and mite-derived antigens are more common along the eastern and southern coastal lowlands than on the central Highveld plateau. The present study extended this research to hospitals in the three major coastal cities, to determine whether or not dust mites were present in ward furnishings and on floors, and if so, at what densities. Sampling, over 22 months, in provincial and private hospitals in Durban, Port Elizabeth and Cape Town recovered 10 mite species, including the cosmopolitan pyroglyphids, *Dermatophagoides farinae*, *D. pteronyssinus*, *Euroglyphus maynei* and *Malayoglyphus intermedius*. Mites were found in all sampled habitats without any apparent preferences, but mean densities were mostly below 10/m², lower than found previously in houses along the coast. To characterise mite habitats in these coastal hospitals, preliminary environmental data were collected in wards and from inside mattresses. These showed nearly constant environments, with moderate temperatures and relative humidity and narrow annual ranges. Temperature and relative humidity levels decreased with increasing latitude from Durban to Cape Town.

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Introduction

House dust mites (family Pyroglyphidae) and their metabolic products have a reputation for being allergenic, and for being counted among the major causes of respiratory disease in humans. In their review of the medical importance of mites in South Africa 60 years ago, Zumpt and Graf¹ acknowledged the increasing importance of respiratory problems caused by inhalation of mites with house dust, and reported mites in sputum samples taken from both asthma and bronchitis sufferers. These sentiments have since been repeatedly stressed by allergists and others who are concerned with respiratory disease in the country. The body of quantitative data on mite allergen levels in South Africa has increased substantially. However, this does not apply to living dust mite populations. Knowledge of their ecology in South Africa remains sketchy. Surveys carried out since the 1970s²⁻⁴ have shown that four medically important species are found in the country. Three of these species, *Dermatophagoides farinae*, *D. pteronyssinus* and *Euroglyphus maynei*, have been known in South Africa for many years, while the fourth, *Malayoglyphus intermedius*, was reported for the first time during the present study.⁵

These surveys also showed differences in dust mite occurrence in different climatic regions of South Africa. Ordman² was the first to report higher mite densities in coastal, than inland, areas, and this was supported, sometimes indirectly, by antigen assays^{6,7} and Viljoen^{4,5} (unpublished data). In terms of actual habitat types, mites were more commonly found in dust from bedding, mattresses, soft furnishings and carpets, on the subtropical east coast at Margate, Ramsgate, Pinetown, Ballito and Zinkwazi (KwaZulu-Natal), than on the central Highveld plateau at Edenvale and Boksburg (Gauteng). The dominant species found during these studies was the pyroglyphid, *D. pteronyssinus*. Relative humidity is a major factor determining dust mite abundance, and Viljoen⁴ showed that the numbers of dust mites sampled in houses in Margate were > 50% higher than those in Boksburg, where humidity was lower. Peak densities were recorded in September, which coincides with the increasing relative humidity in spring.

Bedrooms and living rooms had the highest dust mite density, because of large areas that were covered by textile materials.⁸ There was a distinct relationship between dust mite density, humidity, and temperature. Houses in hot and wet climatic

regions of the world normally show a high level of mites and their allergens.⁹

By way of contrast, hospital environments should support few, if any, mites. Hospitals are expected to maintain a high standard of hygiene, and should make use of cleaning and laundry programmes. This was the finding of several studies on living dust mites^{10,11} and mite allergen levels^{12,13} in hospitals in England, Singapore, Japan, and the USA. Regardless of whether mite densities or allergen levels were investigated, the measurements were always low, relative to houses in the same area. Research laboratories also demonstrated the importance of temperature, and the population growth and dynamics of allergen production in mite cultures.¹⁴ The aim of the present study was to extend Viljoen's 1996 work on the epidemiology of dust mites in South Africa by firstly investigating their occurrence in hospitals in coastal cities (Cape Town, Port Elizabeth and Durban), and secondly, if present, characterising their habitats in terms of temperature and relative humidity.

Method

Sampling programme

Six hospitals, one private and one provincial, were selected within 15 km of the sea in each of three major coastal cities in South Africa, namely Durban, Port Elizabeth and Cape Town. The sampling programme was designed to measure the diversity and abundance of house dust mites (Pyroglyphidae) and other arthropods in five micro-habitats in three wards of each hospital. Samples were taken every three months in each hospital over a 22-month period from September 1999–June 2001. There were two collections each in spring (September 1999 and 2000), summer (December 1999 and 2000), autumn (March 2000 and 2001) and winter (June 2000 and 2001). All hospitals had air conditioning, and complied with national building regulations, but on average, the private hospitals were newer and smaller, and had fewer wards than the provincial ones. Permission to carry out the study was given by each individual hospital's management, subject to its identity being kept confidential.

On each occasion, duplicate dust samples were taken from each of the following habitats, namely bedding, mattresses, upholstered furniture, blinds or curtains and floors, in each of three wards: 30 in each hospital and a total of 180 samples during each three-monthly sampling round. In total, 480 dust samples were collected from each city, giving 1 440 samples collected over the study period.

An area of 1 m² was vacuumed for two minutes on each of the five selected habitats, using an electric Vorwerk® model VTF 732 vacuum cleaner. Dust was collected on a filter positioned between the base of the vacuum cleaner and the sampling pipe. After a particular surface had been vacuumed, the filter was removed and the dust sample was placed in 70% ethanol in a plastic vial. The container was then numbered, and the

temperature and relative humidity were measured. Antigen levels were not measured.

Recovery of mites

Compared with houses, where mite densities can be high,⁴ it was expected that relatively few mites would be found in the hospital environment. Because of this, and the likely loss of mites when using flotation recovery techniques,^{15–17} samples were sorted exhaustively under a dissecting microscope. The vial containing the sample was shaken thoroughly to suspend the mites, and examined in aliquots in 30 mm Petri dishes, with a grid marked underneath. Mites were recovered using a number 0-00 camel hair brush, with all but a few hairs trimmed away, so that the mites could be extricated from dust on these remaining long hairs. Recovered specimens were cleared and mounted on slides for identification purposes, using standard techniques. Counts were expressed as the number of mites per m² of habitat surface. Dust samples were not weighed.

Measurement of environmental factors

Duplicate ambient air temperature and relative humidity measurements were taken in each of three wards, of each hospital, with a mercury-in-glass thermometer and swing hygrometer respectively, at a height of one metre on each three-monthly sampling occasion; in other words, 24 per hospital per year. In addition, to assess the micro-climate of a typical dust mite habitat, continuous measurements of temperature and relative humidity were taken inside a covered mattress, on a standard bed, in the Durban private hospital, over a week in October 2000, using a Supco model DLTH Multiprobe Datalogger®.

Statistical analysis

Zero-inflated negative binomial (ZINB) regression models were fitted to the mite density counts from the five habitats, and three independent variables (type of hospital, city and season) using Stata® version 10.¹⁸ However, the results were too variable to be reliable, so the mite density data for each habitat were split into two categories of zero mites/m², and one or more mites/m². These new variables were tested with respect to season, city, and type of hospital, using the chi-square test of independence.

Results

Diversity of mites in hospital dust

Ten species of mites, belonging to seven families, were recovered from dust samples from the investigated hospitals.

They were:

- Order Astigmata
 - Family Pyroglyphidae
 - D. pteronyssinus*
 - D. farinae*

- E. maynei*
- M. intermedius*
- Family Acaridae
- Tyrophagus putrescentiae*
- Order Prostigmata
 - Family Tetranychidae
 - Eutetranychus* sp.
 - Family Tydeidae
 - Tydeus* spp.
 - Family Tarsonemidae
 - Unidentified
- Order Mesostigmata
 - Family Phytoseiidae
 - Amblyseius neolargoensis*
 - Family Laelapidae
 - Androlaelaps casalis*

Densities of dust mites in hospital wards

Pyroglyphid dust mites were found in all habitats in the six study hospitals, with *D. pteronyssinus* being the most abundant species. However, for the purpose of the analysis, the densities of the four pyroglyphid species recovered, *D. farinae*, *D. pteronyssinus*, *E. maynei* and *M. intermedius*, were pooled as “house dust mites” or Pyroglyphidae. Provincial hospitals consistently yielded more mites than private hospitals, but there was little agreement on habitat preference in individual hospitals of either type in the three cities (data not shown, but see Table I).

The only common feature was that in all cases, floors yielded the lowest mite densities. Therefore, the data are combined in Table I and Figure 1 to show the mean dust mite densities $\pm$ standard deviation (SD) for each habitat type (zeros included) across both hospital types from the three cities.

Following the fitting of ZINB regressions to the mite density data, several estimated coefficients had large standard errors, suggesting excessive variability in the samples. Therefore, the density data were reduced to either of the two categories mentioned earlier, namely zero mites/m², or one or more mites/m². Chi-square tests of independence were then performed to evaluate relationships between these two density categories (in all habitats), and hospital type, city and season (see Table II).

The feature of the results presented in Table II is that mite densities in all habitats, except floors, varied significantly depending on the city or geographic location of the hospital. The most significant of these was for mite densities in

furniture, and the least significant was for those in bedding. Beyond this, the only significant association was between “furniture” and “hospital type”. No associations were found between mite densities on floors and any of the variables. No significant associations involved “season”.

Environmental data

Table III compares the environment inside the sampled wards, in terms of ambient temperature and relative humidity, in each study hospital, on each sampling occasion.

Mean ward temperatures in the Durban hospitals ranged between 23.5–26.5°C, higher than those in Port Elizabeth (21.5–23.5°C), which were in turn higher than those in Cape Town (18–24°C), with an outlier of 26.5°C in spring 2001. In other words, temperatures decreased with increasing latitude. Annual variation in mean temperature, i.e. the range across all seasons, was evident in both hospital types in all three cities, but was mostly small, 2–4°C, though it reached 8.5°C coincident with high temperatures in the Cape Town private hospital in spring 2001. Mean relative humidity in wards was low, generally below 55%, but occasionally rising to between 69–73%. There was no evidence of any latitudinal trend in relative humidity. Annual variation in mean relative humidity inside wards ranged between 27–29.5%, but reached 49% in the Durban provincial hospital in autumn 2000.

A preliminary assessment of the micro-climate inside a representative mattress showed that mean temperatures $\pm$ SD ($n = 5$) at 01:38 and 19:38 were $23.8 \pm 0.9^\circ\text{C}$ and $24.1 \pm 0.6^\circ\text{C}$, respectively, showing a daily range of between 0.2–1.6°C. Mean relative humidities $\pm$ SD ($n = 5$) at 01:38 and 19:38 were 72.2 ± 2.4 and $72.1 \pm 1.0\%$, respectively, giving a daily range of 0.2–4.2%. The micro-climate inside the mattress

Table I: Mean dust mite densities (pooled with zeros included) $\pm$ standard deviation in the five sampled habitats, in all hospitals and cities

Habitat	Mean mite density (number per m ²)	Standard deviation
Curtains or blinds	2.55	5.54
Furniture	1.91	3.55
Bedding	1.83	6.03
Mattresses	1.22	4.49
Flooring	0.375	0.86

$n = 144$ for each habitat

Table II: Chi-square analysis of associations between mite densities in the five habitats, and the variables of hospital type, city, and season

Habitat	Bedding			Furniture			Curtains or blinds			Floors			Mattresses		
	χ^2	df	p-value	χ^2	df	p-value	χ^2	df	p-value	χ^2	df	p-value	χ^2	df	p-value
Hospital	3.51	1	0.061	10.03	1	0.002 ^b	0.920	1	0.338	2.112	1	0.146	0	1	1.0
City	9.06	2	0.011 ^a	22.89	2	0.00001 ^b	14.76	2	0.001 ^b	4.232	2	0.121	16.25	2	0.0003 ^b
Season	4.97	3	0.174	7.42	3	0.06	1.58	3	0.663	4.62	3	0.202	5.70	3	0.127

a = p-value ≤ 0.01 , b = p-value ≤ 0.001

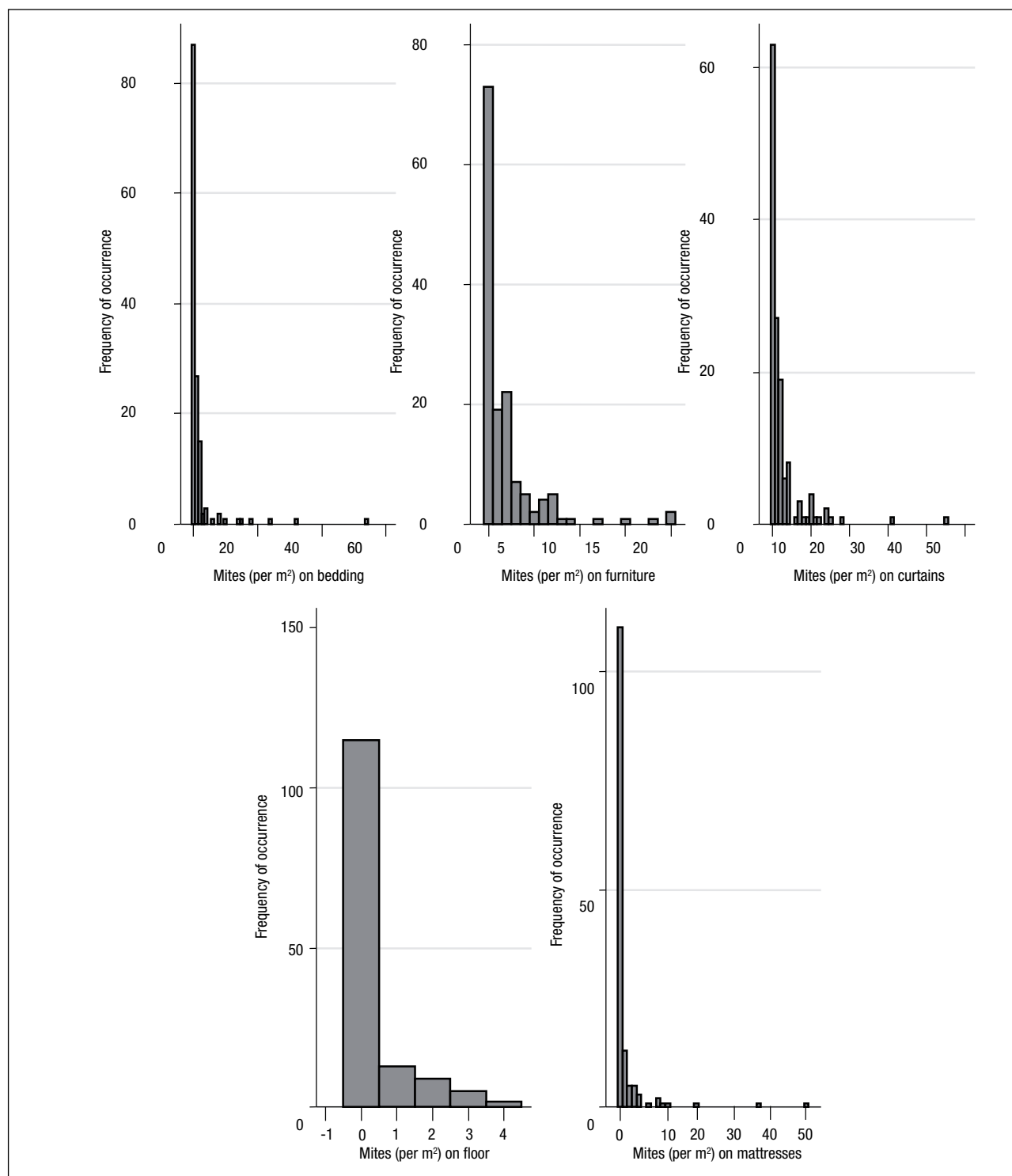


Figure 1: Frequencies of occurrence of pyroglyphid mite densities (per m²) (zeros included) in the five sampled habitats, in all habitats, hospitals and cities combined

over the observation period (spring) was nearly constant with respect to both temperature and relative humidity.

Seasonal density fluctuations

Figure 2 shows the pooled mean pyroglyphid densities (number/m²) from all habitats in both provincial and private hospitals for each city. It is apparent from this that mite

populations in Durban hospitals exhibited clear seasonal abundance, with greatest densities in late summer, and the lowest in winter. This seasonality is not as well defined in either Port Elizabeth or Cape Town, since no peaks in density were recorded in these cities during the 1999/2000 summer. Because of the small sample size ($n = 6$ per hospital per sampling occasion), these density measurements must be seen as preliminary.

Discussion

Pyroglyphid mites were recovered from all sampled hospitals during the study period, but densities were low, mostly below 10/m², compared to those reported by Viljoen⁴ and taken from houses in South Africa. This is probably because the hospital environment is subject to hygienic management, featuring

Table III: Mean ward temperature and relative humidity $\pm$ standard deviation in the six hospitals, on each sampling occasion

City, hospital type	Season	Temperature (°C)	Relative humidity (%)
Durban, provincial	Spring	25.0 $\pm$ 1.10	42.5 $\pm$ 19.17
	Summer	26.0 $\pm$ 1.10	26.0 $\pm$ 1.10
	Autumn	26.5 $\pm$ 0.55	73.0 $\pm$ 4.38
	Winter	24.0 $\pm$ 2.19	48.5 $\pm$ 24.65
Durban, private	Spring	23.5 $\pm$ 0.55	25.5 $\pm$ 1.64
	Summer	26.5 $\pm$ 0.55	26.0 $\pm$ 1.10
	Autumn	26.5 $\pm$ 1.64	44.5 $\pm$ 22.46
	Winter	22.5 $\pm$ 0.55	24.0 $\pm$ 0.00
Port Elizabeth, provincial	Spring	21.5 $\pm$ 0.55	57.5 $\pm$ 13.69
	Summer	22.5 $\pm$ 0.55	36.0 $\pm$ 9.86
	Autumn	23.0 $\pm$ 1.10	61.5 $\pm$ 20.27
	Winter	21.5 $\pm$ 1.64	49.0 $\pm$ 0.00
Port Elizabeth, private	Spring	23.5 $\pm$ 1.64	47.5 $\pm$ 22.46
	Summer	23.0 $\pm$ 0.00	34.5 $\pm$ 10.41
	Autumn	23.0 $\pm$ 1.10	53.0 $\pm$ 28.48
	Winter	23.0 $\pm$ 0.00	54.5 $\pm$ 3.84
Cape Town, provincial	Spring	24.0 $\pm$ 2.19	59.5 $\pm$ 13.69
	Summer	20.5 $\pm$ 2.74	47.5 $\pm$ 24.65
	Autumn	21.0 $\pm$ 4.38	69.0 $\pm$ 4.38
	Winter	23.5 $\pm$ 0.55	44.5 $\pm$ 22.46
Cape Town, private	Spring	26.5 $\pm$ 6.01	54.5 $\pm$ 15.88
	Summer	18.0 $\pm$ 2.19	47.5 $\pm$ 16.98
	Autumn	18.0 $\pm$ 2.19	45.5 $\pm$ 19.17
	Winter	22.0 $\pm$ 1.10	39.5 $\pm$ 20.27

n = 6 for each hospital

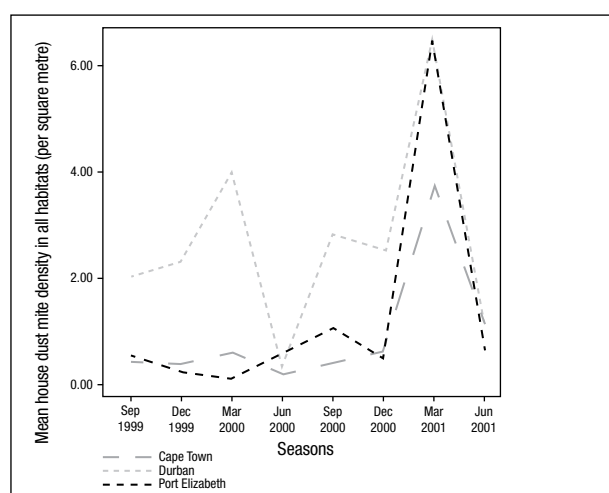


Figure 2: Seasonal fluctuations in mean dust mite density (per m²) in the three coastal cities (both hospital types pooled) over the sampling period

routine cleaning with detergents. Low mite densities, relative to those in houses, were also reported to be found in hospitals in other countries.^{10,11} Nevertheless, the outlying density of 766/m² on blinds in the Port Elizabeth provincial hospital in March 2001, indicates that high dust-mite densities can, and do, occur in hospitals. Similar short-lived outlier measurements were recorded for house dust mite antigen in houses in the Gauteng highveld by Cadman et al,⁷ and, as in the present case, could not be explained. The lower numbers of mites collected in private hospitals, compared with those in provincial hospitals, may relate to the higher standards of ward hygiene in the former.⁵ Similarly, regular cleaning of furniture and carpets, and decreasing humidity in homes, may have decreased the dust mite density.⁹ However, even low numbers of dust mites can cause respiratory problems for an allergic person. Nevertheless, it could be argued that the small numbers of recovered mites were transported into the hospitals by people, having originated in their homes, where mite densities were higher. However, we believe that the paucity of mites is due to regular cleaning. Whether or not mites are imported could be clarified by tests conducted on screening staff, patients, and visitors, who enter the hospitals.

The fact that mite densities in four of the five habitats, sampled in the wards were significantly associated with the geographic locations of the hospitals (see Table II) draws attention to the influence of the climate on dust-mite bionomics, even in environments such as hospital wards, where air conditioning has a moderating effect. The three cities involved lie on a latitudinal gradient from Durban, latitude 33° 54' 49" S (-29.8508°S), with the highest temperature and relative humidity regimes, to Cape Town, latitude 29° 51' 03" S (-33.9136°S), with the lowest as shown in Table III. The association between "furniture" and "hospital type", namely provincial or private, may relate to the less thorough cleaning programmes found in provincial hospitals.⁵ The lack of any significant associations for mite counts on floors is presumably because these densities were consistently the lowest encountered.

The absence of a clear dust mite preference for any of the five sampled habitat types supports the opinion that dust mites colonise habitats opportunistically, probably after being distributed within the ward by wind or air currents created by air conditioning, cleaning, and bed making. Floors were consistently the habitat with the lowest mite densities, probably because the regular use of vacuum cleaners and detergents keeps mite numbers down. There is some agreement with Blythe et al¹⁰ and Babe et al¹¹ who also found low pyroglyphid densities in dust from hospital wards in the United Kingdom and the USA. Densities in the UK hospitals¹⁰ were nevertheless higher (44.5 100/mg) in dust on soft chairs, than that on floors (3.9 100/mg) or inside mattresses (0.5 100/mg) in the same wards. Babe et al¹² sampled only floors in a USA hospital, and found 0-80 (mean 30) and 0-143 (mean 25) 100/mg on carpeted and non-carpeted floors respectively, but only during summer. The apparent lack of habitat preference by dust mites in the present study

must also apply to the distribution of mite-derived antigens, but this has not been investigated in South Africa.

The data presented in Table III help to characterise exposed mite habitats inside wards (blinds, furniture and floors) in terms of temperature and relative humidity, but probably not habitats like mattresses, which are insulated from these conditions by mattress covers. Temperature and relative humidity were both nearly constant, with mean temperatures inside the wards of the Durban hospitals being slightly higher (22.5–26.5°C) than those in hospitals in Port Elizabeth (21.5–23.5°C) and Cape Town (18–26.5°C). This reflects the hospitals' increasingly southern location. Annual mean temperature ranges varied across the six hospitals, but were lowest (0.5–1.5°C) in the two Port Elizabeth hospitals. Relative humidity was generally low (< 50%) in all hospitals, and since it is a major determinant of dust mite abundance, mite densities inside hospitals were expected to be lower than those in homes.

The available data indicate that the temperature regimes in the wards of the study hospitals were moderate with limited annual ranges, whereas those inside a representative mattress, a habitat insulated from ambient ward conditions by covers, were nearly constant at 23–24°C. The mean annual relative humidity in provincial hospitals was considerably higher than that in private hospitals, especially the maxima, which reached 70% on occasion. As with temperature, relative humidity inside the study mattress was nearly constant, though in this case, generally higher at 71–73%, than that in the ward ($\pm 25.5\%$). These are suboptimal conditions for dust mites in spring,¹⁶ when populations are expected to expand.

Another important finding was that although mites were recovered throughout the year from all hospitals, densities reached clear peaks in late summer (March) of both years in Durban (see Figure 2), but only in 2001 in Port Elizabeth and Cape Town. As noted earlier, this follows the latitudinal gradient from the subtropical climate of Durban to the temperate climates of Port Elizabeth and Cape Town, a situation reflected in the ward temperature and relative humidity data as well. Presumably some components of the Port Elizabeth and Cape Town climates are marginal for dust mite survival, so mites are not always able to build up their populations in summer. Nevertheless, the finding of peak mite densities in late summer in hospitals in the present study conflicts with the early spring density peaks (September) reported in houses in KwaZulu-Natal and Gauteng.⁴ This may be because the environmental conditions inside wards are more or less constant throughout the year, so that low winter temperatures and the relative humidity experienced in houses do not limit mite survival.¹⁹

Conclusion

Several conclusions regarding the status of pyroglyphid dust mite infestations in provincial and private hospitals in South Africa's coastal cities can be drawn from this study.

Four species of pyroglyphid dust mites were found in coastal hospitals in South Africa. The most common was *D. pteronyssinus*, also found in homes in all or most regions. All four are of known importance in the epidemiology of allergic respiratory disease.

No evidence was found that dust mites preferred any of the sampled habitats in the hospital wards, but floors consistently yielded the lowest mite densities. Mite densities were low compared with those reported to have been found in South African houses.⁴

Durban hospitals yielded the highest mite densities, followed by those in Port Elizabeth and Cape Town. Thus, densities decreased with increasing latitude. Higher mite infestations were recorded in provincial hospitals, than private hospitals, regardless of the geographic location, probably because of better ward hygiene in the latter.

The highest mite densities were recorded in late summer, which differs from the early spring peak densities recorded in houses by Viljoen.⁴ This may be because hospital wards are air conditioned and have a more or less constant climate throughout the year. They do not experience the drops in temperature and relative humidity expected of houses in winter. A fluctuation in mite density was more pronounced in Durban hospitals, where clear peaks occurred in late summer, in both study years. In Port Elizabeth and Cape Town, peaks were only recorded in 2001, which may be because they are cooler cities.

Mite habitats in hospital wards are characterised in terms of temperature and relative humidity.

Conflict of interest

None of the authors have any commercial or other association with the work reported here that might pose a conflict of interest.

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Declaration

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