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STUDIES ON THE MITE FAUNA OF HOUSE DUST IN SCOTLAND
WITH SPECIAL REFERENCE TO THAT OF BEDDING

BY

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INTRODUCTION

Several species of mites of widely differing habits have been recorded from house-dust. Some are species found in stored food-stuffs, some are usually associated with plants or soil and others, usually the most numerous, occur in nests or dens of warm-blooded animals and feed on animal debris such as skin scales. Of the latter, members of the Pyroglyphidae (Astigmata) predominate and are of considerable medical importance because they produce allergens which cause bronchial asthma in sensitive patients (VOORHORST et al. 1964, 1967, 1969; SPIEKSMAN and SPIEKSMAN-BOEZEMAN, 1967; MAUNSELL et al. 1968). They also are common in and around skin lesions but are not known to cause any skin diseases (FAIN, 1967). Pyroglyphids are world-wide in distribution and although numerous in general house-dust are particularly abundant in that from mattresses (MAUNSELL et al., 1968) or in that from beneath them (HAARLOV & ALANI, 1970). They become air-borne during bed-making, and presumably also when movements in bed occur, and may then be inhaled (CUNNINGTON & GREGORY, 1968). Several species occur and produce similar or identical allergens (VOORHORST et al., 1969; CUNLIFFE & DASGUPTA, 1970); one, Dermatophagoidespteronyssinus (Trouessart) is widely distributed and frequently, though not always, dominates populations in Europe where it is the most important source of house-dust allergen (VOORHORST et al., 1967; MAUNSELL et al., 1968).

In Britain, the fauna of house-dust from London, the home-counties and South Wales has been investigated (MAUNSELL et al., 1968) but there have been no previous studies in Scotland. The present work was initiated in November, 1968 at the request of Dr. J. W. KERR, Western Infirmary and Knightswood Hospital, Glasgow, for information on the mite content of dust from the homes of his asthmatic patients. Later its scope was extended to include samples from homes of healthy controls and, by request of Dr. R. L. CORMIE, Western Infirmary, Glasgow, from homes of patients suffering from the skin disease papular urticaria.

Comparisons could therefore be made between infestations associated with diseased and healthy persons and, as house-keeping standards vary, between those associated with differing levels of hygiene. Most homes sampled were in and around Glasgow; the rest were in Edinburgh and Aberdeen.

At first, dust samples collected by patients themselves were examined, but these proved

too varied in size, content and origin for quantitative work. A suction sampling device was therefore developed to enable « spot » sampling from specified substrates and, as beds seemed to be the main centres of infestation, work was mainly concentrated on these.

**METHODS**

*Extraction of mites from dust samples.*

Large particles such as grit and fluff were first removed from the dust samples by teasing and the mites were then extracted from a weighed quantity of the fine powder remaining, this being regarded as the «true sample». At first a benzene-water interface technique similar to that used for extracting small arthropods from soil was used (Raw, 1955) but this proved unreliable as some mites always remained in the water layer. It was therefore replaced by a technique in which the sample was placed in a petri dish containing 10 ml of 90 % lactic acid and twelve drops of lignin pink. The dish was kept at about 50°C for 24-48 hours and its contents were then centrifuged at 3200 r.p.m. for 5 minutes. The supernatant liquid was checked for mites and the residue was resuspended in deionised water from which the mites could be transferred to 90 % lactic acid on a slide for identification and counting. Although it was not possible to distinguish mites which were alive at the time of sampling from those which were dead, all contributed to the allergen content of the dust and were of importance.

*Suction apparatus for taking « spot » samples.*

This apparatus (Figs 1-3) enabled small discrete samples of dust to be collected from specific substrates. It consisted of two parts; the suction unit, a «Wolf» portable device fitted at the intake with a 2 m length of 1.2 cm internal diameter plastic pipe and the sampling unit, a hinge-capped 7.5 cm × 2.5 cm bottomless polythene tube fitted at both ends with plastic tube adaptors.

Figs. 1-3. — Suction device for taking spot samples.
1. Complete apparatus with suction and sampling units; 2. Enlarged view of sampling unit as when taking samples; 3. Enlarged view of sampling unit containing sample and sealed for storage.
The lower adaptor served as a nozzle and the upper one, covered internally with «mite-proof» nylon gauze (61 μ aperture), connected the sampling unit to the pipe. After each sample had been taken, the sampling unit was disconnected, the lower adaptor was removed and the hinge-cap was fitted. Separate units were used for each sample and could be transported and stored without risk of cross contamination.

Results

Species of mites found.

*Dermatophagoides pteronyssinus* was the most ubiquitous and abundant species found. Normally it is oviparous but twice fully developed larvae were seen within females. This phenomenon was also noted by Bronswijk and Sinha (1971). *Euroglyphus maynei* (Cooreman), as in the observations of Spieksma and Spieksma-Boezeman (1967) in Holland and Maunsell et al. (1968) in Britain, was second in abundance to, though much less numerous than, *D. pteronyssinus*. This, the only other species of pyroglyphid found, produces an allergen similar to or identical with that of *D. pteronyssinus* but in lesser quantity (Voorhorst et al., 1969).

Other species encountered frequently, but in lesser numbers were *Gohieria fusca* (Oud.), *Glycyphagus destructor* (Schrank) and *G. domesticus* (De G.); active stages and hypopi of the *Acarus siro* L. complex and *Tyrophagus* sp. (Astigmata, Tyroglyphidae). All these occur in stored foodstuffs, dried vegetation or fungi and were reported from house-dust by Spieksma et al. (1967) and Maunsell et al. (1968). They produce allergens but not those characteristic of house-dust (Voorhorst et al., 1969). Labidophoridae (Astigmata) occurred sporadically but have not been recorded from house-dust before. All were tritonymphs, probably Lophuromyopinae. Their biology is unknown. *Cheyletus* sp. (Prostigmata, Cheyletidae), predators of tyroglyphids (Hughes, 1961) and of pyroglyphids (Bronswijk, 1968), were common and *Tarsonemus* sp. (Prostigmata, Tarsonemidae), mycetophages found in cereal dust (Hughes, 1961), occurred occasionally, sometimes in abundance. Both groups were recorded from house-dust by the Dutch and English workers but have not been investigated immunologically.

Mites in dust samples submitted by patients.

38 samples were submitted from 36 homes of bronchial asthmatics. 19 were general dust samples, often contents of domestic vacuum cleaners, 13 were from floors and carpets and 6 were from mattresses and bedding. They varied greatly in size and content and about half of them contained no mites. Some were of dubious origin and possibly not samples of house-dust at all so only those which were infested will be considered further. Samples from beds contained much higher populations of mites (1539/g) than did either the general samples (174/g) or those taken from floors (179/g). *D. pteronyssinus* was dominant on each substrate forming from 70 % to 83.5 % of the populations but *E. maynei* occurred only in samples from beds where it comprised 20.2 % of the total. Other mites found in these samples were *G. fusca*, (0.1-3.3 %); *G. destructor*, (0.4-13.0 %); *G. domesticus*, (0.2-5.5 %); *A. siro* comp., (0.1-4.0 %); *Tyrophagus* sp., (0.1-5.3 %); Labidophoridae, (0.2-5.1 %); *Cheyletus* sp., (1.9-2.9 %) and *Tarsonemus* sp., (1.3-3.6 %).

Though of limited value, these samples gave some idea of the species and numbers of mites present and confirmed the importance of beds as centres of infestation. Subsequently sampling was carried out with the aid of the « spot » sampler.
Mite fauna of bedding.

Maunsell et al. (1968) found populations of pyroglyphid mites in dust from mattresses to be 100 times as great as in that from living rooms and suggested that the micro-climate of the mattress might be as important as that of the house itself. Spijksma (1967) showed that the optimum temperature for development and multiplication of *D. pteronyssinus* at 80 % RH was 25°C and Bronswijk & Sinha (1971) pointed out that although such a temperature would be unusual on house floors it could regularly be achieved in occupied beds. Observations made by us with a thermometer attached to the blanket immediately over the occupant of a bed showed that the temperature rose rapidly as soon as the bed became occupied and fluctuated around 31°C until it was vacated. The subsequent rate of cooling depended on how soon the bed was remade. If it was remade immediately, a typical cooling curve was produced with the temperature gradually approaching that of the room, if however, it was left open, cooling was much more rapid. Humidity was not measured, but evidently much moisture passes through bedding. When a waterproof sheet was placed over a bed, the clothes above the occupant became saturated.

Maunsell et al. (1968) examined dust from mattresses but not from other parts of the beds. Sesay (1969) found mites throughout bedding so samples were taken from all layers.

Sampling and statistical considerations.

To check on the accuracy of the spot sampling technique, 16 sets of duplicate samples were taken from various layers of beds and compared. The densities of mites varied greatly in the dust from different layers, but the values for duplicate samples agreed fairly closely (correlation coefficient, *r*, 30 d.f., +0.87, *P* < 0.001) and seemed likely to differ by a factor exceeding 2 in only about 5 % of instances. It was decided therefore that a single sample taken from each layer would suffice.

Bedding materials vary greatly and so did the relative proportions of dust and fluff in the samples. Whenever possible samples of 0.05 g were taken, but often, in cotton sheets, pillow-slip etc. only small samples, sometimes 0.01 g, could be obtained. These small samples showed greater errors in proportion to their size than the bigger ones but the differences were not excessive and were partly compensated by bulking data from several individual samples for analysis. Examination of the data from 12 beds selected at random showed that there was a marked regression of variance on the mean mite density so square root transformation of the data was used.

Altogether, 639 dust samples were collected from 81 beds (including a few visited twice) but not all of these could be included in a general analysis, the objects of which were to relate mite populations to patient health and household conditions. Beds in hospitals and lodging houses were excluded because they have a succession of occupants and are subjected to exceptional cleaning and disinestation, and so were new beds because they have an undeveloped fauna. To ensure statistical independence, only data from one bed in each house were considered. The final survey was then based on 486 dust samples from 60 beds in private houses.

Classification of beds.

Beds were classified according to health of occupants and standard of housekeeping. Only two standards of housekeeping were recognised, « good » and « bad ». At one extreme, floors, beds, furniture etc. were sound and immaculate, at the other filth abounded. Intermediates
were assessed on the amount of dust and dirt in the bed and under and behind furniture. This required some experience as superficial cleaning had often been carried out prior to sampling. 19 beds were of bronchial asthmatics, 20 of patients with papular urticaria and 21 of healthy controls; 38 were classed as «good»; the rest as «bad».

An undesirable characteristic of the data is the imbalance in the numbers of houses showing various combinations of attributes e.g. amongst asthmatics, 15 of the 19 houses were «good» compared to 8 of those of the 20 urticaria patients. With such disproportion, mean values are misleading so, wherever necessary, analysis was carried out with means weighted so as to enable unbiased comparisons to be made (Snedecor, 1956). Ideally a survey like this should be based on a stratified sampling scheme with all classes represented equally. This, however, was impossible for several reasons e.g. information relating to particular patients was required.

Results of survey of 60 beds.

Mite populations were compared between beds, enabling differences associated with the presence or absence of disease and with differences in housekeeping standard to be evaluated, and within beds, enabling differences between various parts of the beds to be assessed. Beds varied greatly; at one extreme, only divan, mattress and two blankets were present, at the other there were 11 layers. Some condensation of the data into a common pattern was necessary so, for analysis, each bed was regarding as consisting of 4 «standard» layers only viz. 1) the superficial, consisting of eiderdown, quilt or other topmost layer; 2) the intermediate, comprising all other layers above the occupant; 3) the lower, including all layers below the occupant and 4) the pillows.

Inter-bed comparisons.

Population densities are summarised for each disease/housekeeping-standard combination in Table 1. *D. pteronyssinus* was the most abundant species and except for «urticaria/bad» beds, formed over 75 % of the population in each combination. It was present in 59 of the 60 beds examined, was dominant in 55 and was the only species of Pyroglyphidae present in 34. Its maximum density in a whole bed was 1927/g dust. *E. maynei* was second in abundance and except for «urticaria/bad» beds was much less numerous than *D. pteronyssinus*. These beds however had populations of the latter comparable to those found in other combinations and the *E. maynei* was superimposed. *E. maynei* occurred in 27 beds, was dominant in 4 and was the only pyroglyphid found in one. Thirteen out of 22 «bad» beds (59 %) compared with 14 out of 38 «good» beds (37 %) were infested with it and for urticaria, asthma and control beds the proportions infested were 55 %, 37 % and 43 % respectively. Other species of mites occurred in much smaller numbers and their appearance was much less regular. Rather higher populations occurred in «bad» beds than in «good» ones, «urticaria/bad» beds showing the highest populations of all. Taking the data as a whole, the percentage ranges of occurrence of the less common species were: *G. fusca*, 0.4-3.0; *G. destructor*, 0.2-2.9; *G. domesticus*, 0.0-2.3; *A. siro* comp., 0.1-1.8; *Tyrophagus* sp., 0.1-1.1; *Labidophoridae*, 0.0-2.2; *Cheyletus* sp., 1.5-4.9 and *Tarsonemus* sp., 0.1-2.0.

The associations of mite populations with varying household conditions were evaluated by analysis of variance on the mean mite densities for individual beds and by comparison of the weighted means for disease/housekeeping-standard combinations. There appeared to be no significant differences between the populations of «total mites», *D. pteronyssinus* alone and
E. maynei alone in beds associated with the different diseases and controls (t for compared pairs ranged from 0.23-1.66), but "bad" houses had higher populations of "total mites" and of D. pteronyssinus than "good" ones (F values, 1/54 d.f.; "total mites", 3.5, P < 0.05; D. pteronyssinus, 4.1, P < 0.05). The differences for E. maynei, though in the same direction were not significant (F, 2.5).

TABLE 1.
Mean numbers of mites per gram of dust for different disease/household condition combinations.

<table>
<thead>
<tr>
<th>Disease Condition</th>
<th>Asthma</th>
<th>Papular Urticaria</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good</td>
<td>Bad</td>
<td>Good</td>
</tr>
<tr>
<td>D. pteronyssinus</td>
<td>587</td>
<td>653</td>
<td>593</td>
</tr>
<tr>
<td>E. maynei</td>
<td>96</td>
<td>98</td>
<td>43</td>
</tr>
<tr>
<td>Total mites</td>
<td>744</td>
<td>814</td>
<td>666</td>
</tr>
</tbody>
</table>

MAUNSELL et al. (1968) found no differences in the mite content of general dust samples from the homes of asthmatics and controls and CUNNINGTON & GREGORY (1968) observed a reduction in the mite content of bedroom air during bedmaking after a mattress had been vacuum cleaned regularly. Regular vacuum cleaning and washing, with special attention to the bedding is now recommended as a means of reducing exposure to house-dust allergens (e.g. Leading article, Brit. med. J., 12 June, 1971).

Intra-bed comparisons.

Mean densities for "total mites" were calculated separately for beds with from 4 to 11 layers. There was no correlation between the no. of layers present and mite density. To compare populations in different parts of beds, densities in each of the four "standard" layers were calculated for each bed and were examined by analysis of variance. As, with few exceptions, all four layers were present there were no problems of disproportion and the analysis was straightforward. Highly significant differences in population density between layers were found for "total mites" and for D. pteronyssinus, the highest densities occurring in the intermediate layer (Table 2). E. maynei also showed its maximum density in the intermediate layer but the differences observed were not significant. Data for other species were too few for analysis.

TABLE 2.
Mean numbers of mites per gram of dust from various bed layers.

<table>
<thead>
<tr>
<th>Layers</th>
<th>Superficial</th>
<th>Intermediate</th>
<th>Lower</th>
<th>Pillow</th>
<th>Ranking</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>D. pteronyssinus</td>
<td>335</td>
<td>686</td>
<td>276</td>
<td>155</td>
<td>I,S,L,P</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>E. maynei</td>
<td>26</td>
<td>63</td>
<td>20</td>
<td>10</td>
<td>I,L,S,P</td>
<td>N.S.</td>
</tr>
<tr>
<td>Total mites</td>
<td>510</td>
<td>924</td>
<td>402</td>
<td>210</td>
<td>I,S,L/P</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Ranking in order of magnitude. I/S means I significantly greater than S. I,S means no sig. difference.)
The high populations of pyroglyphids in the blankets etc. are of particular interest as previous workers have examined mattresses and bedsteads only. It must be remembered however that population densities measure the number of mites per unit weight of dust and not the amount of dust present. It is probable therefore that there are many more mites present on a dusty mattress than on an equal area of blanket.

**New beds, hospital and lodging house beds.**

A few observations were made on new beds in private houses, on beds in hospital wards and on beds in men's common lodging houses. The new beds revealed no mites but low populations were found in the hospitals (62/g) and in the lodging houses (173/g). In hospitals, low populations probably reflect high standards of hygiene, but in lodging houses are more likely to result from frequent disinestation against parasitic insects.

**Miscellaneous observations in bedrooms.**

In 9 of the 60 houses examined in the main survey, dust samples were taken from carpets immediately below the sides of the beds and from approximately one metre away. Mite densities were considerably lower than in the associated beds (means respectively 245 and 199/g compared to 720/g in the beds) and, as before, *D. pteronyssinus* predominated with *E. maynei* second in abundance.

Species in dust samples from other bedroom sites generally reflected those found in the corresponding beds e.g. a "Teddy Bear" doll infested with *E. maynei* only came from a house where this was the only species of pyroglyphid present. High numbers of *Tarsenemos* sp. on the window curtains of one house correlated with high populations of this species in the bed. No *D. pteronyssinus* were found on these curtains even though the bed was infested by it and, as this was a farmhouse, it seems probable that the *Tarsenemos* infestation came from outside. In contrast, at another house, *D. pteronyssinus* was common both on the curtains and in the bed.

**Sexes and immature stages.**

The percentages of sexes and of immatures of *D. pteronyssinus* and of *E. maynei* in populations in beds and carpets were examined. Females of both species outnumbered males in all situations except one and with *E. maynei* in lower layers of beds this disproportion was striking ($79 \Phi : 21 \sigma$). Immatures of *D. pteronyssinus* always composed at least 30% of the total of this species and were maximal in the superficial layers and on carpets. Those of *E. maynei* however formed a much lower proportion (9-18%) and, although common on the carpet were not abundant in the superficial bed layers. These observations suggest different environmental requirements of the two species and between the sexes and stages within each species, phenomena meriting more detailed studies. The proportions of immatures of both species were greater than those recorded from the floors of Dutch living-rooms (Voorhors et al., 1969) and though the stain used during extraction may have assisted in finding the small stages it also seems probable that our samples came from regions where the mites were breeding more actively.

**DISCUSSION**

These results suggest that the problems of mite infestation of house-dust in Scotland are essentially similar to those experienced by the Dutch and English workers, with much the same
species of mites appearing in similar numbers and order of importance. Although mites occur on carpets, in floor cracks etc. throughout the home and their numbers may be influenced by age and condition of the fabric, degree of dampness of the house and its environment and presence or absence of central heating (Voorhorst et al., 1969) the heaviest infestations occur in beds. Spieksma (1967) showed that at 17°C and 80 % RH, D. pteronyssinus breeds slowly, doubling its population in about 10 weeks, but at 25°C and 80 % RH, its population increased 17-fold within the same period. This suggests that in Britain as in the Netherlands (Brons­wijk & Sinha, 1971) conditions encountered on carpets etc. would usually be far from optimal for this species, but beds, with comparatively high temperatures and (presumably) high humidities for much of the day, and with abundant supplies of food in the form of skin scales, would present much more favourable breeding conditions. It may be that the micro-climate of the bed as a whole (not just the mattress) may be the most important factor determining the infestation found within a house and that the bed is the main centre of breeding.

Regular cleaning of the mattress and bedding should help to reduce infestation by removing the mites and their food, and the removal of contaminated dust should reduce the exposure of the patient to allergens. The real problem, however, is to prevent the mites from breeding in the bed and this is essentially a problem of applied ecology. Detailed knowledge of the biology of the mites is sadly lacking and practically nothing is known of the micro-climatology of the bed. Leaving a bed open after vacating it and allowing it to air and cool thoroughly should help to discourage the mites and in this connection the observations of Spieksma et al. (1971) are of interest. These workers found very low mite concentrations in dust collected from houses at high altitudes in Switzerland and suggested that this may be due to the cold outside air producing very low humidities indoors. It also seems likely that the Swiss habit of airing bedding by hanging it through an open window may contribute to eliminating infestations which might otherwise have survived in the microclimate of the bed.

Acknowledgments

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Summary

A survey was made of the mite fauna of house-dust collected from private houses in Scotland, mainly from the Glasgow area. Sampling was carried out largely with the aid of a suction device developed to enable discrete samples of dust to be taken from specific substrates.

The pyroglyphid Dermatophagoides pteronyssinus (Trouessart) was the most abundant and widespread species encountered, its relative Euroglyphus maynei (Cooreman) being second in abundance. Other mites found were species of Gohieria, Glycyphagus, Acarus, Tyrophagus, Cheyletus, Tarsonemus and undetermined Labidophoridae.

Beds showed much higher infestations than did carpets or other sites and their importance as centres of infestation is stressed. They were sampled by layer; the highest populations occurred in blankets but the number of layers present did not influence the level of infestation. Beds of bronchial asthma, of patients with papular urticaria and of healthy controls had similar infestations but those in ill-kept houses were more heavily infested than those in well-kept ones. New beds were free of mites,
hospital beds had low infestations and, possibly due to frequent disinfestation, so had beds in common lodging houses. Differing distributions of the sexes and immature stages of *D. pteronyssinus* and of *E. maynei* in beds suggested that these species and their immatures may have differing ecological requirements. A more thorough knowledge of the physiology of these mites and of bed microclimatology seems a necessary prelude to ecological control.

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