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Mite control with low temperature washing. I. Elimination of living mites on carpet pieces

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Summary

Background Washing of delicate textiles at low temperature combined with mite control is one of the important aims for domestic mite prevention.
Objectives Estimation or assessment of mite numbers without and after the application of detergents or detergents with mite control additive. Trials at low temperature, detergents and washing as usual at household conditions (programme of a household washing machine).
Methods The domestic mite *Dermatophagoides farinae* can be cultured on carpet samples under favourable conditions, and the breeding success monitored in terms of population and distribution using the free mite mobility test. The mite containing carpets were cut into pieces in order to investigate the effects of washing at low temperature with different commercial detergents with and without an additive for mite control. The heat escape method was used to assess the number of mites remaining on the carpet pieces.
Results The estimation of the mite populations on different carpet pieces before and after washing showed that between 40 and 60% of the mites were able to resist washing, rinsing, spinning and drying. The allergen containing dust, however, was flushed out. In contrast, complete mite control was achieved by the application of the same detergents together with an additive.
Conclusion Mite control by low temperature washing is possible with a mite control additive provided that a concentration of benzyl benzoate of about 0.03% is achieved in the washing suds.

Keywords: washing and mite control, low temperature washing, washing additive with benzyl benzoate, mite counting, mobility test, heat escape method, prevention

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Introduction

The problems of house dust mite control and the roles of heat and washing have been discussed in several papers [1–5] and at various congresses [7–10] for a number of years. Special investigations concerning the effectiveness of washing procedures were made in Australia [6,12] and in Germany [10,11]. On each occasion the same conclusion was reached: only in cases when temperatures of 60°C [1,2,4,5], 55°C [6] and 70°C [3] were applied for at least 1 h during the washing procedure, were domestic mites killed and eliminated from the textiles. The application of slightly lower temperatures, between 40°C and 45°C [6,10], has no effect on living mites.

Mite excreta are easily flushed away by washing and spinning since their behaviour corresponds with that of other inanimate particles composing the dirt in textiles. In contrast living mites are able to cling to the textile

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fibres and resist washing and rinsing [6]. Only when the mites are killed are they eliminated from the textile together with other dirt particles during the washing procedure.

Washing at temperatures of 60°C can only be achieved with washing machines equipped with thermostatically controlled heaters. In some instances washing machines are designed to use warm water provided by public or domestic supplies which are not disposed to supply hot water [6]. Furthermore, many textiles, including natural fibres such as wool or silk and certain synthetic fibres, cannot be washed at high temperatures. In some cases the textile fibres used in bed covers or cushions can withstand hot-washing, but fibres in the filling tend to clump and the desirable qualities of the bedding material are lost. This problem is particularly prominent with childrens' beds. People prefer to use synthetic materials which may be washed easily at lower tempertures, but if mite problems exist with sensitive or asthmatic children mites cannot be controlled by these washing procedures.

These various problems concerning the survival of mites at low wash-temperatures were confirmed by McDonald and Tovey [6]. They used normal laundry powders in washing machines with standard washing programmes with a wash, rinse, spray and spin cycle. After drying for 5 h in the sun mite numbers were estimated using the heat escape method [13]. They found that the majority of the mites were not killed either by the application of water or by water together with detergents.

The use of elevated washing temperatures was the only way of achieving control. The authors proposed the use of wash-additives and they studied this possibility in a new investigation [12]. It was found that mite control was possible through the application of some natural oils and especially of benzyl benzoate. However, the practical problems were not resolved. The quantities of additives used, 240 mL benzyl benzoate per 50 L washing-suds, were impractical for both financial and ecological reasons.

Mite control by washing is the object of a patent application of one of us [11]. In this instance the washing suds contain 0.1% of an additive providing a final concentration of about 0.03% benzyl benzoate in the washing solution, representing 25 mL additive with 7.5 mL benzyl benzoate per 25 L. The object of this study was to evaluate this method of mite control.

The efficacies of the procedures were assessed using carpets infested with large numbers of mites in conjunction with mobility test and the heat escape method [13–15].

Two questions should be answered:

1 Does washing with detergents alone — at low temperatures — diminish the mite numbers in comparison with washing without detergents?
2 Does the combination of a detergent and an additive reduce mite numbers more effectively than a detergent alone?

Materials and methods

Seeding and breeding of mites on carpets

Domestic mites of the species *Dermatophagoides farinae* were cultured in our own laboratory and separated from the culture medium as described previously [13–15]. Approximately 1000 mites were counted and spread over a carpet of 2600 or 3000 cm^2 in size, and left to breed. The carpets were composed of a foam-rubber backing 2.5 mm thick, supporting a 5 mm thick white polyamide fibre layer. A mixture of mite free natural house dust, checked with the flotation method [17] collected at high altitude and additional nutrients (Daphnia) were applied to the carpet prior to the addition of the mites [13–15].

The mites were left to breed for ≈3 months at a temperature of 25°C and 75% relative humidity. Previous investigations had shown that the mite populations obtained in this way are normally very large, ≈20 000–100 000 mites [15]. Superficial vacuum cleaning eliminated only a small proportion of the mites, leaving the surface of the carpet free from particles and suitable for mobility experiments which provided the basis for counting the mites. This ensures a higher degree of certainty than can be achieved with other methods like dust flotation [15].

Preliminary estimation of mite populations prior to washing

After cleaning the carpet surface the adhesive foil for the mobility test was positioned and left in place for 24 h. Mite migration was assessed by direct mite counting on the foils (Figs 1 and 3) as described previously [13–15]. When the mite population density was deemed to be high enough (about 10 000 per carpet) and distributed over the whole area of the carpet the carpet was cut into 10 pieces for different washing trials (Tables 3 and 4, column 2).

Detergents and washing treatments

Commercial detergents were used for the washing trials in accordance with the producer's instructions. The compositions of the detergents as indicated on the packages are shown in Table 1. Trials were made in a washing

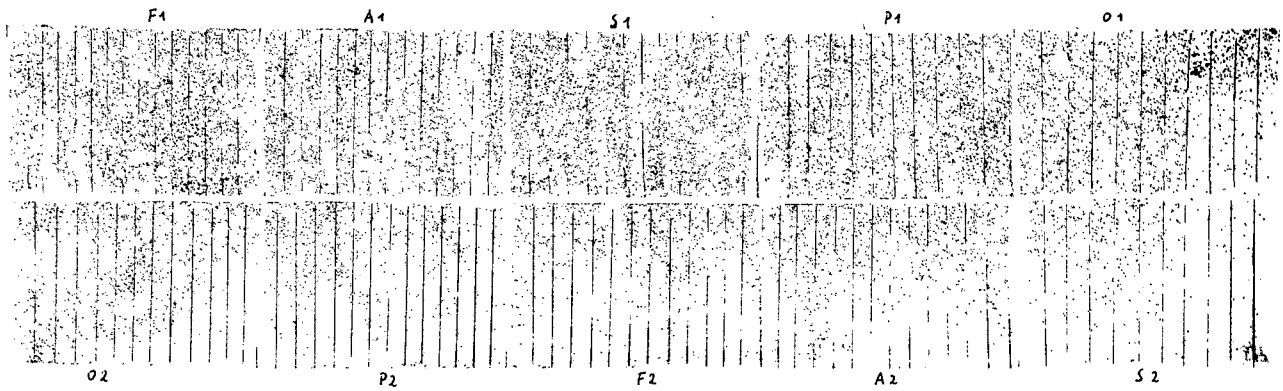

Fig. 1. Mites directly found on the adhesive foil, migrated during 24 h out of the carpet (3000 cm^2). Carpet sections prepared following washing trials. Detection by mobility test. Codes in Table 3, column 1.

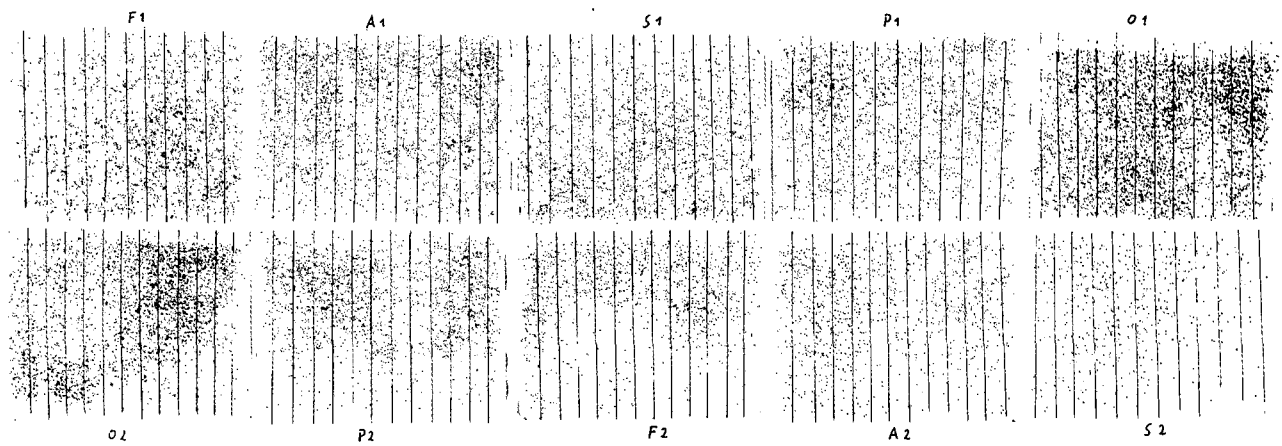

Fig. 2. Mites directly found on the adhesive foil, after application of heat. Carpet sections without (O1 + O2) and after washing with detergents (A,F,P,S – Table 3). Detection by heat escape method. Codes in Table 3.

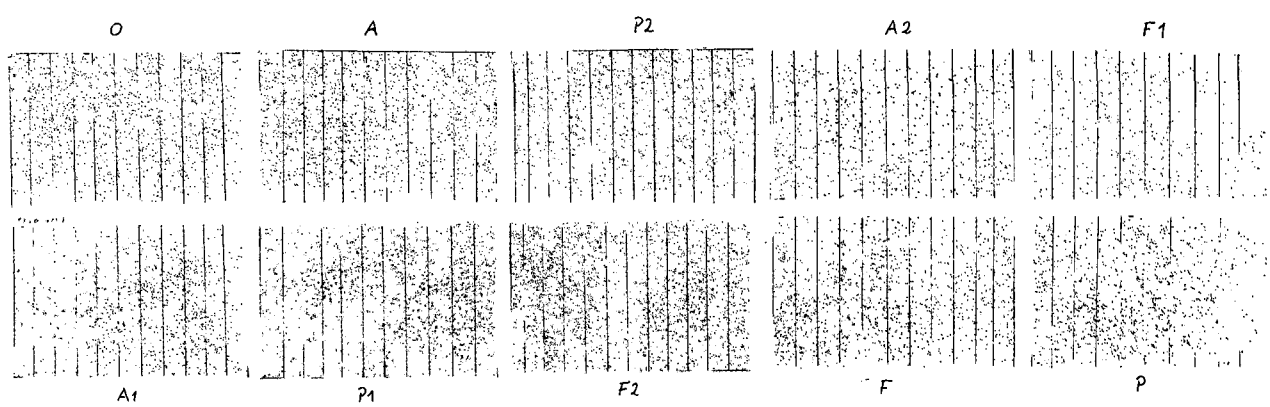

Fig. 3. Mites directly found on the adhesive foil, migrated during 24 h out of the carpet (2600 cm^2). Carpet sections prepared following washing trials. Detection by mobility test. Codes in Table 4, column 1.

Table 1. Used detergents

Name	Producer	Composition	Quantity per 25 L. Temperature suitability
Ariel Flüssig (liquid)	Procter Gamble	Anionic and non-ionic surfactants, enzymes, opt. brighten.	120–180 ml. 30, 60, 95°C, all laundry
Frosch (liquid detergent)	Werner & Mertz	Anionic and non-ionic surfactants, additives, etc.	120–180 ml. Up to 60°C, wool, silk, viscose, synthetics, other laundry
Persil Flüssig (liquid)	Henkel	Anionic and non-ionic surfactants, soap, phosphonates	120–180 ml. Up to 60°C modern textiles, natural based textiles.
Sunil Flüssig (liquid)	Lever	Anionic and non-ionic surfactants. polycarboxylate	120–180 ml. 30, 40, 80°C, fine and coloured

Table 2. Composition of the additive

Additive experimental number	115
Non-ionic surfactants:	
EO-adduct of natural fatty acid	50%
Ionic surfactant:	
Natural fatty alcohol ether sulfate	6%
Benzyl benzoate	30%
Water	14%

machine (Miele, Type XJS 2000), using the programme for washing fine fabric at 30°C. The detergents were added in a dispensing ball with or without 25 mL of the additive for mite control. The quantity of the additive was independent of the hardness of the water. The additive can be included in a pre-wash cycle in the washing machine and when hand-washing delicate fabrics or large items of bedding. The composition of the additives is shown in Table 2.

In the washing trials with detergents alone 120 mL detergent per 25 L solution were used. For the series of investigations with 25 mL of additive the quantity of detergent was reduced to 90 mL without a visible influence on the cleaning effect. After washing, rinsing and spinning the carpet pieces are dried at about 20°C in the open air during the course of one day.

The experiments without and with detergents alone were executed on carpet sections of 300 cm^2 (carpet no. 167). Each experiment was conducted twice (Table 3,

Table 3. Number of mites (*D. farinae*) on carpet pieces without washing and after washing (30°C/86°F) with detergents alone

Carpet piece	Detergent/ treatment (120 ml)	Mite number before washing (mob. test)	Normalized mite-number before washing	Mite number after washing HEM (calc.)	Normalized mite number after washing	Survived mites before/after (%)
Blank 1 + 2 (mean)	Non, no washing	3966	100	12128	100	100
A1 + A2 (mean)	Ariel, washing 30°C	3740	94.3	5206	42.9	45.5
F1 + F2 (mean)	Frosch, washing 30°C	3850	97.1	5169	42.6	43.8
P1 + P2 (mean)	Persil, washing 30°C	3425	86.6	4595	37.9	43.8
S1 + S2 (mean)	Sunil, washing 30°C	2833	71.4	2877	23.7	33.2
Mean						41.6

Table 4. Number of mites (*D. farinae*) on carpet pieces without washing and after washing (30°C/86°F) with detergents and with detergents and additive

Carpet piece	Detergent/ treatment, additive	Mite number before washing (mob. test)	Normalized mite-number before washing	Mite number after washing HEM (calc.)	Normalized mite number after washing	Survived mites (%)
Blank	None, no washing, no additive	1316	100	2589	100	100
A	Ariel (120 ml), no additive	1367	104	1425	55.0	52.9
F	Frosch (120 ml), 30°C, no additive	1294	98.3	802	31.0	31.5
P	Persil (120 ml), 30°C, no additive	1154	87.7	1895	73.2	83.5
Mean						56.0
A1 + A2 (mean)	Ariel (90 ml), 30°C, additive	1199	91.1	0	0	0
F1 + F2 (mean)	Frosch (90 ml), 30°C, additive	1655	125.8	1	0.04	0
P1 + P2 (mean)	Persil (90 ml), 30°C, additive	2390	181.6	1	0.04	0
Mean						0

columns 1 & 2). The experiments without and with detergents or detergents and additive were executed on carpet sections of 260 cm^2 (carpet no. 170). The trials with additive were executed twice.

One or two pieces of every carpet were not subjected to a washing process and served as controls for the determination of the baseline mite populations (Tables 3 and 4, line 1). The same samples were used for assessment of the quantities of dust on the carpet-pieces and for the determination of the mite excreta content in the dust by the measurement of guanine [16] (see Results, section 1, and Table 5).

Assessment of mite populations after washing or without washing

After processing the carpet pieces the heat escape method was applied as described previously [13–15]. A hot plate that achieved a temperature of 65°C after 8 min was used in the experiments [14]. A carpet piece placed on the hot plate reached an interior temperature of 65°C after 30 min. During this time the mites migrated to the carpet surface and became stuck to the adhesive foil on which they are then counted. The final mite numbers were calculated by multiplication of the numbers of mites found on the foil with the factor 100/65 (1.54) found for *D. farinae* [13–15]. Tables 3 and 4 indicate in column 3 the mite numbers found on the adhesive foil by the application of the mobility test without or before washing and in column 5 by the application of the heat escape method without or after washing with detergents.

Results

Washing with detergents alone

Breeding and preliminary mite numbers by mobility test

The results of the mobility tests conducted on the whole carpet (3000 cm^2) are shown in Fig. 1. The mites directly found on the adhesive foil were distributed over the whole carpet with a preponderance in one-half, but nevertheless every part of the carpet was infested with a sufficient number of mites for the investigations (about 1000). Each experiment was made twice using one carpet-piece with a large number of mites and one with fewer mites (see Fig. 1). The results obtained are

Table 5. Dust (mg) and guanine (%) found on carpet pieces without washing and after washing at 30°C with detergents and with detergents and additive

Carpet	Treatment	Dust (mg)	Guanine (%)
O	Blank	556	1.01
A	Ariel, 30°C no additive	8.6	0
F	Frosch, 30°C, no additive	2.3	0
P	Persil, 30°C, no additive	4.0	0
A1	Ariel, 30°C, additive	0	0
A2	Ariel, 30°C, additive	0	0
F1	Frosch, 30°C, additive	3.0	0
F2	Frosch, 30°C, additive	1.9	0
P1	Persil, 30°C, additive	2.5	0
P2	Persil, 30°C, additive	0.4	0

presented in Table 3, column 3. The mite numbers found by free mite migration (mobility test) (3966 mites) correspond to about 25% of the whole mite population (number obtained by heat escape method + number obtained by mobility test) (12 128 + 3966 = 16 094 mites).

Washing and the residual mite population

The washing trials were conducted twice with every detergent listed in Table 1. The numbers of mites remaining in the carpet-pieces (260 cm^2) were assessed by the heat escape method (HEM). The results of the direct findings on the adhesive foil after the washing trials with detergents (Table 1) are to be seen in Fig. 2.

The results (Table 3, column 5 & 6) show that washing alone did not achieve effective mite extermination. In the unwashed control samples about 12 000 living mites were found with the heat escape method (HEM, calculation factor 100/65). After washing with the different detergents ≈42% of the original mite populations were still present. The experiments also showed that the different detergents supplied by different companies were almost comparable in terms of their ability to eliminate living mites. This result was obtained with four detergents in eight different trials.

Measurement of the quantities of dust present before and after washing and the corresponding guanine content showed that 500–600 mg of dust with guanine contents in the range 2.32–3.78 mg were present on the carpet pieces before washing. After washing these dust quantities were reduced to 20–50 mg. Guanine was not detectable.

Comparison of the effects of washing with detergents alone and together with a mite control additive

Breeding In this case the mites were found by mobility test to be distributed evenly over the whole carpet (2600 cm^2, see Fig. 3). After cutting the carpet into 10 pieces, one piece was designated as the unwashed control. In this case the number found by HEM (calculated) was about 2600. The remaining nine carpet pieces were used for washing trials with three of the four original detergents which had given comparable results when used alone (SUNIL was omitted). Each of the

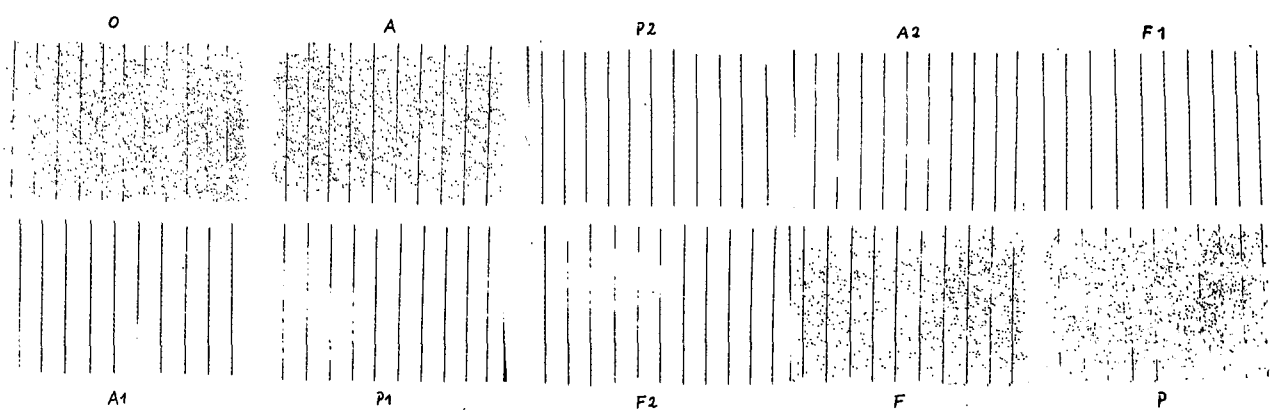

Fig. 4. Mites directly found on the adhesive foil, after the application of heat. Carpet sections without (0) and after washing with detergent (A, F, P) and with detergents and mite control additive (A1, A2, F1, F2, P1, P2). Detection by heat escape method. Codes in Table 4.

detergents was tested alone and twice in combination with an additive.

Washing and residual mite population

Three carpet pieces were washed with three detergents (Table 1), six with the same detergents and the mite control additive (Table 2). In this case too washing with a detergent alone confirmed that the mites were not eliminated (see Fig. 4). After washing approximately 56% of the mites were found. They were able to resist the whole washing procedure, including drying, and remained on the textile (see Fig. 4).

However, after washing with the same detergent together with the mite control additive 0 and 1 mite, respectively, were detected on the carpet-pieces. This corresponds to 0% of the original mite numbers. This final result was obtained six times (Table 5, columns 5 & 6). Dust quantities and related guanine contents are shown in Table 5.

Discussion and conclusion

These studies were conducted using carpets since these provide an ideal environment for mite breeding and a convenient material on which to determine mite numbers and mite distribution. Surely not carpets, but delicate textiles (see introduction) are the items which should be washed at low temperature. Principally similar investigations are possible with different kinds of textiles as we have shown in many cases [14,15]. The experiments on carpets do not change the results but they enable a higher degree of accuracy. For this we preferred them for a basic investigation.

The numbers of mites assessed quantitatively by the mobility test and the heat escape method show that washing of mite infested carpet pieces at low temperature (about 30°C) using commercial detergents does not provide an effective means of controlling the mite population. Approximately 40–60% of the mites survive the washing, rinsing, spinning and drying process, clinging to the fibres. This shows that washing with detergents diminishes mite numbers to about half of unwashed samples, which represents the answer to question 1 posed in the introduction.

Nevertheless, these mites are living and able to migrate to the surface of the carpet as is shown by the results of the heat escape trials. Even after the application of each of the detergents the surviving mite population is large enough to reestablish the former mite population as soon as the exterior conditions are favourable again.

However, if the same detergents are applied together with a special additive, providing a final concentration of about 0.03% benzyl benzoate, mite control is achieved. This result provides the answer to question 2 posed in the introduction: detergents alone reduce mite numbers during low temperature washing, but detergents combined with a special additive enable a complete mite control. On the other hand, washing in the absence of the additive is sufficient to eliminate dust containing mite excreta.

Additives giving a concentration of 0.03% benzyl benzoate in the normal low temperature washing with detergent provide a complete and inexpensive method of mite control. A large series of toxicological studies (Reports Research and Consulting Company -RCC-CH 4452 Itingen, Switzerland) has shown that benzyl benzoate is non-toxic and non-sensitizing [18]. Natural breakdown products of benzyl benzoate are benzyl alcohol and benzoic acid, substances with mite controlling and disinfectant properties.

In the next phase of these studies mite control by low temperature washing of clothing and bulky textile objects such as pillows will be presented.

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