

ON THE ABUNDANCE OF *DERMATOPHAGOIDES*
PTERONYSSINUS (TROUESSART, 1897)
(PYROGLYPHIDAE: ACARINA) IN HOUSE DUST

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INTRODUCTION

In the last 5 years much attention has been paid to the mite fauna of floor and mattress dust in houses. Most abundant mites in these habitats are Pyroglyphidae—in particular *Dermatophagoides farinae* HUGHES, 1961, *D. pteronyssinus* (TROUESSART, 1897) and *Euroglyphus maynei* (COOREMAN, 1950)—which are responsible for the production of housedust allergen, a common cause of asthma and allergic rhinitis (VOORHORST *et al.*, 1969; BRONSWIJK and SINHA, 1971). Large numbers of Pyroglyphidae have not been found in houses before 1952 (BAKER *et al.*, 1956). Earlier analyses (CARTER and D'ABRERA, 1948; DEKKER, 1928; HORA, 1934; OUDEMANS, 1896, 1897, 1928; TROUESSART, 1895) suggest that Pyroglyphidae were fairly rare in those days, the most abundant were the house mite, *Glycyphagus domesticus* (DE GEER, 1778), the flour mite, *Acarus siro* L., 1758 and the cheese mite, *Tyrophagus casei* (OUDEMANS, 1910). SPIEKSMAN (1967), when reporting a Dutch study over the years 1962–1967, found much more Pyroglyphidae in damp, mostly old, houses than in dry, new houses.

The rarity or absence of Pyroglyphidae from former descriptions could be the result of inadequate methods of sampling and of misidentification, or an indication for a much lower incidence and abundance of the Pyroglyphidae at earlier times. Changes in the environmental conditions of the ecological niche “house-dust” in the last century, e.g. the replacing of natural products like feathers, horse hair, straw, hay, seagrass by rubber and plastic, improving insulation against moisture from soil and air, improvement of temperature control, introduction of the vacuum cleaner, increasing use of insecticides, could be responsible for changes in the mite fauna of houses.

In this study the ecological limits of *Dermatophagoides pteronyssinus* in comparison with other inhabitants of the niche are described together with a preliminary discussion of changes in mite fauna within the house dust habitat during the last century.

MATERIALS AND METHODS

The mite fauna of house dust was analysed according to SPIEKSMAN (1967) with

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some modifications : the fraction on the 0.075 mm sieve was weighed, sand particles were washed, dried and weighed, and the numbers of mites were calculated in 1 gram of the dust fraction on the 0.075 mm sieve and adjusted for the weight of the sand.

Sampling took place every fortnight from February 1968 till January 1969 in 3 cottages of the Center for Asthmatic Children "Eykeloord" near Nijmegen, and in 2 one-person rooms in the same town. Both rooms were used as bed- and livingroom. One of them was on the main floor of a 120-year-old house and was heated by a charcoal stove. Apart from sampling, no cleaning took place between February and the first week of November 1968. The second room was on the third floor of a 10-year-old apartment building. It had central heating and was regularly cleaned during the experimental period. In the 2 one-person rooms both temperature and relative humidity were recorded from April 1968 to January 1969 at approximately 12 cm above the floor surface with a thermohygrograph.

D. pteronyssinus, *Acarus siro* and *Glycyphagus destructor* were obtained alive from cultures supplied by F. Th. M. SPIEKMA (Leiden, The Netherlands) and maintained in the laboratory on a mixture of human skin scales and yeast powder according to SPIEKMA (1967), and kept at 25°C and 75 % R. H. *Cheyletus eruditus* (SCHRANK, 1781) was obtained from old-hay dust from a nearby farm. Experiments were done at 25°C, unless stated otherwise. Different relative humidities were obtained with saturated salt solutions (RAUEN, 1956).

Interaction experiments were done in glass dishes 4.5 cm wide, 2.0 cm high, and closed with nylon wire (aperture 0.01 mm or less), which were filled with 180 mg of food : the mixture of human skin scales and yeast powder. Studies on the influence of relative humidities on different life stages were performed in small dishes 1.0 cm wide and 0.5 cm high. A minute amount of food and 1 mite were added to every dish. For the experiments with insecticides perspex culture chambers were used with cover glasses which had been immersed in acetone solutions of lindane or D. D. T. The perspex culture chambers were made by cutting funnel shaped holes (6-14 mm wide) in 25×35 mm perspex sheets. The bottom side was covered with nylon wire.

In the following study *Dermatophagoides pteronyssinus*, *Euroglyphus maynei*, *Acarus siro*, *Glycyphagus destructor* and *Cheyletus eruditus* will be referred to by their generic names.

RESULTS AND DISCUSSION

1. Development of Mite Populations on the Main Floor

In the Center for Asthmatic Children high numbers of mites in late summer, fall, and early winter contrast with low numbers in winter and spring (Fig. 1). Similar population developments have already been described by SPIEKMA (1967). Most of the mites (drawn out line) are Pyroglyphidae (*Dermatophagoides* and *Euroglyphus*). There are only small numbers of Parasitiformes, Oribatei, Tarsonemini,

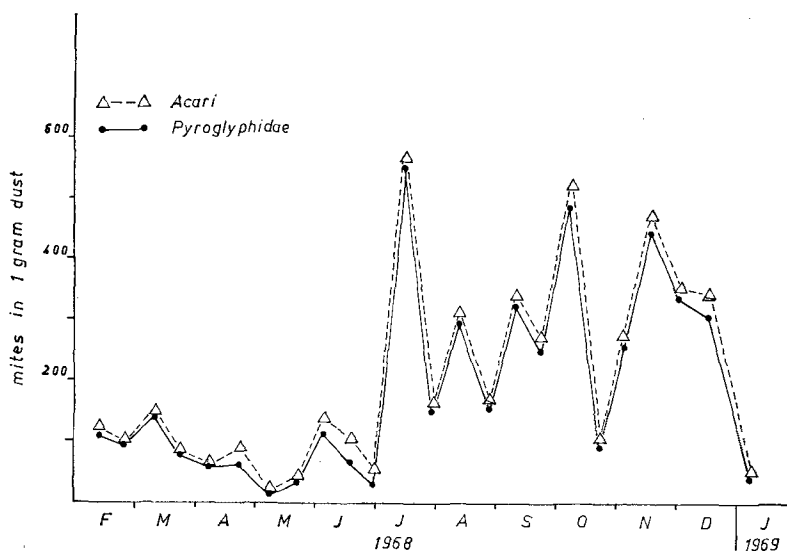


Fig. 1. Average number of mites from the main floors of 3 cottages of the Center for Asthmatic Children. Total Numbers of Acari and numbers of Pyroglyphidae are given per 1 gram dust.

Cheyletidae, Tetranychidae, Glycyphagidae and Acaridae.

In a classroom and a gym (both located on the main floor) only very small numbers of mites were present during the whole year. House dust of these rooms contained very high percentages of sand.

2. Comparison of Main and Higher Floors

Rooms on the main floor of houses without a basement and on second and higher floors differ strongly in temperature and relative humidity as measured near the floor surface. During the whole year the relative humidity is markedly higher in a charcoal heated main floor than in a central heated third floor (Fig. 2). Coldness and moisture from the soil provides in summer higher humidities on the main floor than outdoors and prevents drying out to third floor level during the heating period.

Observations on *Dermatophagoides* in house dust (Fig. 3) show high numbers of mites on the main floor and very low numbers on the third floor. Additional samples taken occasionally from 2 main floors and 4 higher floors further confirm such a difference in mite densities. Low numbers of mites were found on a main floor under which a basement was located, with the stove of the central heating system.

3. Limiting Factors

a. Temperature

Most of the experiments with *Dermatophagoides* were done at 25°C, the optimum temperature of this species according to SPIEKSMAN (1967), who studied the population development between 17°C and 32°C. We found *Dermatophagoides* to survive even at 4°C for 1 month but no reproduction took place.

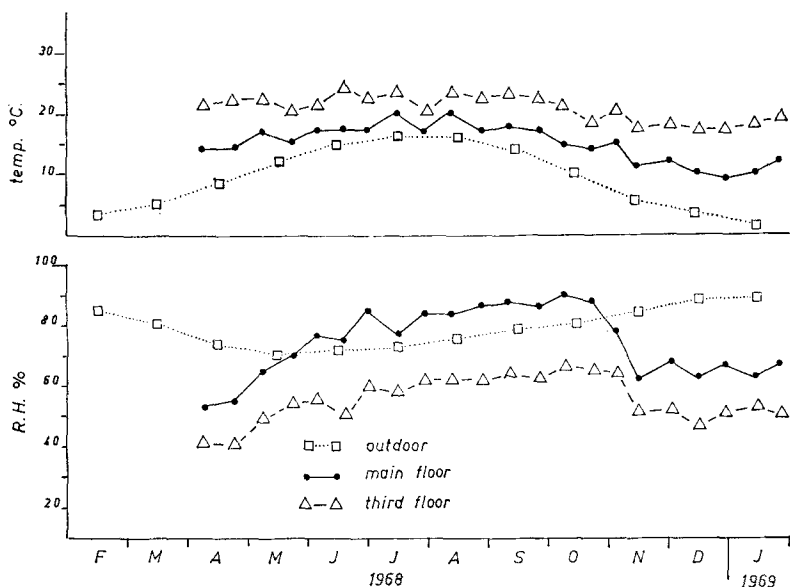


Fig. 2. Temperature and relative humidity. Measurements of a main and a third floor were made at approximately 12 cm above the floor surface. Median for every two weeks is given in the graph. Outdoor monthly average is shown according to the record of Koninklijk Nederlands Meteorologisch Instituut (1962-1965).

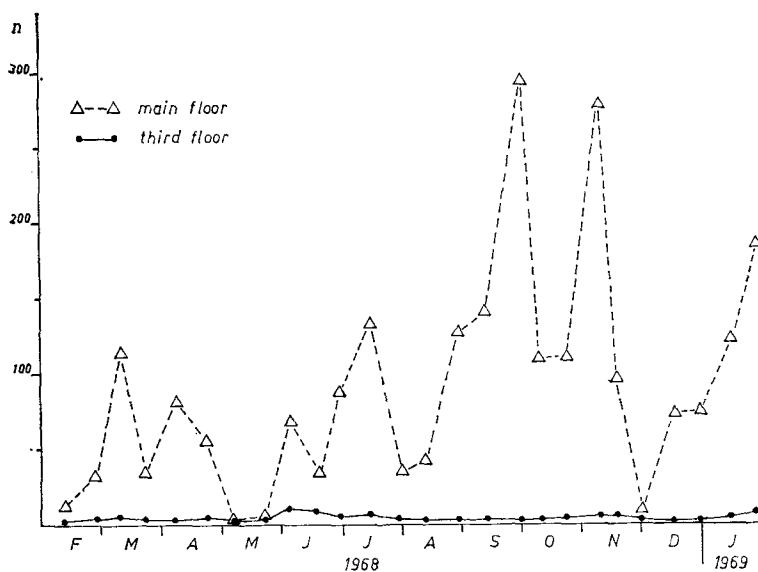


Fig. 3. Numbers of *Dermatophagoides* mites per 1 gram dust on a main and a third floors.

The important predator in house dust, *Cheyletus*, has the same optimum temperature, and can multiply between 8°C and 32°C (BOCZEK, 1959; SOLOMON, 1960 ;

SMARAGDOVA, 1936). We could confirm data of these authors.

b. Humidity

The plain survival has been studied on 43-45 specimens of the most important house-dust mites : *Dermatophagoides*, *Euroglyphus*, *Cheyletus*, *Acarus* and *Glycyphagus*, by exposing them in solitary cages without food to different humidities (Table 1). *Acarus* and *Glycyphagus* are highly sensitive to low humidities and even at 50% R. H. all individuals died in 48 hours. Pyroglyphidae and *Cheyletus* survived in high numbers, *Euroglyphus* being most resistant to dryness. In mass incubations at 33% R. H., however, only 6 % (3 out of 50) of *Dermatophagoides* specimens died within 48 hours. In the other species no differences between mass cultures and single specimen incubation were found. A relative humidity of 75% seems to be suitable for comparative investigations of these species.

Table 1. Survival percentages at 25°C of single mites kept without food.

R. H.	Incubation time	Mite				
		<i>Euroglyphus</i>	<i>Dermatophagoides</i>	<i>Cheyletus</i>	<i>Acarus</i>	<i>Glycyphagus</i>
33%	24hr.	95	95	80	5	5
	48hr.	95	50	40	0	0
50%	24hr.	95	87	95	15	5
	48hr.	95	87	90	0	0
75%	24hr.	100	100	95	100	100
	48hr.	100	100	95	100	100

Ten eggs and larvae, and 20 nymphs of *Dermatophagoides* were singly incubated at 33%, 50%, 75%, 80%, 90% and 100% R. H. Between 70% R. H. and 80% R. H. the embryonic, larval and nymphal periods were approximately 6, 6, and 12 days respectively, as reported by SPIEKMA (1967) at 80% R. H. The development is retarded and hatching and molting are diminished at 50%, 85% and 90% R. H. A few eggs hatch and some larvae molt at 33% R. H., but only some egg hatching occurs at 100% R. H.

The oviposition was studied on the females of 10 pairs of *Dermatophagoides* at the above mentioned conditions. At 70% R. H. 9 females oviposited, and at 85% and 90% 2 and 1 respectively. No eggs were observed at 50% and 100% R. H. After incubating 20 pairs at 33% R. H. we found 1 female ovipositing.

Eggs of *Cheyletus* were singly incubated at 33% R. H. (11 eggs), 50% R. H. (29 eggs), 75% R. H. (40 eggs), 85% R. H. (6 eggs), 90% R. H. (9 eggs), 95% R. H. (11 eggs) and 100% R. H. (17 eggs). Embryonic period was shortest (77 hrs.) at 95% R. H., and somewhat longer (91 hrs.) at 75%. HAFIZ (1935) found that it was 96 hrs. under these conditions. The larval period lies between 4-5 days at all humidity levels. Nymphal development did not occur at 33% and 50% R. H. as already described by BOCZEK (1959) and SOLOMON (1960).

c. Food

Dermatophagoides has been reared on a mixture of yeast powder and defatted human skin scales. Fatty compounds of fresh skin scales prevent development. However, monophagy is not absolute in this species; small populations can be maintained on a variety of media (van BRONSWIJK, unpublished). In laboratory animals fungus spores have been found in the alimentary channel. Pollen grains and mold spores were found in the alimentary channel of mites captured in houses (SINHA *et al.*, 1970). Addition of spores and mycelium of *Aspergillus amstelodami* (MANGIN) THOM and CHURCH to the human skin scales-yeast medium improved the population growth of *Dermatophagoides*, whereas no positive effect was observed in *A. niger* van TIEGHEM and *A. tamaraii* KITA (van BRONSWIJK, unpublished).

The human skin scales-yeast powder mixture is not only a suitable food for *Dermatophagoides*, but also for *Glycyphagus* and *Acarus*, thus making interaction tests of the mite species of house dust possible. It is not clear if the 3 mite species use the same components of this culture medium.

4. Predators

Cheyletus is the most abundant species among the possible predators of *Dermatophagoides* in this habitat (house dust). For the control of stored product mites it has been introduced successfully (SOLOMON, 1946; PULPAN & VERNER, 1965). Introduction of *Cheyletus* into *Dermatophagoides* breedings in predator : prey ratios of 1 : 10, 1 : 50, and 1 : 200 resulted in a reduction of the prey within a short time. However, *Dermatophagoides* populations were not exterminated even after 58 days of introduction at the ratio of 1 : 10, since *Cheyletus* became cannibalistic and allowed slight recovery of the prey.

WOODROFFE (1953) mentioned that *Tyrophagus* is a suitable prey for *Cheyletus*, but *Glycyphagus domesticus* moves too fast and its setae are too long to be a good prey. The same author found that *Mealia* sp. (most likely *Dermatophagoides chelidonis* (HULL)) moves too slow to make *Cheyletus* aware of its presence. To study the prey preference of *Cheyletus*, predators were introduced into small mixed breeds of *Dermatophagoides* and *Glycyphagus* but no obvious preference was observed (Table 2). In larger mixed breeding of *Dermatophagoides*, *Acarus* and *Glycyphagus*, introduction of *Cheyletus* resulted in the extermination of *Dermatophagoides* within 2 month.

Table 2. Predation of *Cheyletus* on *Dermatophagoides* and *Glycyphagus* reared on human skin scales-yeast powder at 25°C and 75% R.H.

Incubation time (hr)	Number of mites		
	<i>Dermatophagoides</i>	<i>Glycyphagus</i>	<i>Cheyletus</i>
0	25	25	5
24	16	17	5
48	4	5	5

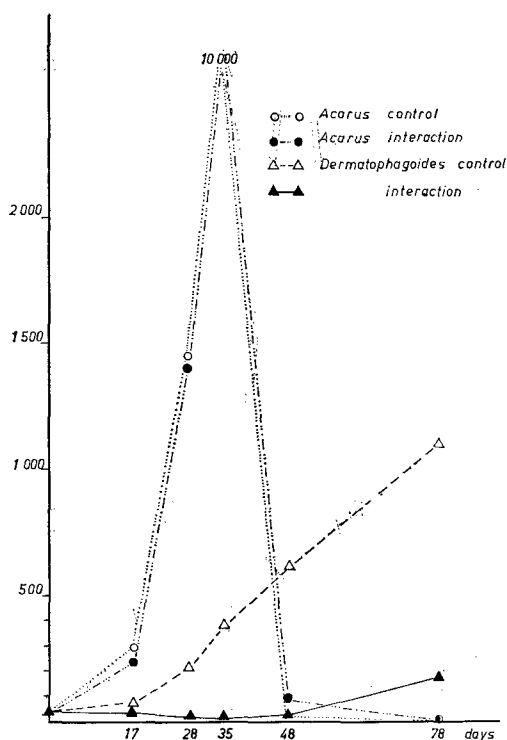


Fig. 4. Interaction between *Acarus* and *Dermatophagoides* on 0.15 g skin scales-yeast powder mixture at 25°C and 75% R. H.

5. Interaction of Mites

Mite species living in the same niche and allowed to feed on the same ingredients may be regarded as competitors. Interaction tests between *Acarus* and *Dermatophagoides* showed no effect on *Acarus*, but a very strong suppressing effect on the *Dermatophagoides* population (Fig. 4). *Acarus* built up a large population within a short time, but diminished shortly afterwards. Following the reduction of the number of *Acarus*, *Dermatophagoides* started to increase its numbers. In interaction cultures started with 250 specimens of *Dermatophagoides* and 25 of *Acarus*, a strong regression of the pyroglyphid population occurred also within 5 weeks.

Interaction tests between *Glycyphagus* and *Dermatophagoides* showed no remarkable effect on *Glycyphagus*; the regression of the population development of *Dermatophagoides* was noticeable, but not so strong as in the case of *Acarus*. Many hypopes (the teromorphic deuteronymphs) of *Glycyphagus* were formed.

Results of interaction tests of the 3 sarcoptiform species *Dermatophagoides*, *Acarus* and *Glycyphagus* are shown in Fig. 5. A comparison with the controls showed only a slight effect on *Acarus* and *Glycyphagus*, but a strong regression of *Dermatophagoides* population by the vivacious species. The 2 species caused the same regression as *Acarus* alone.

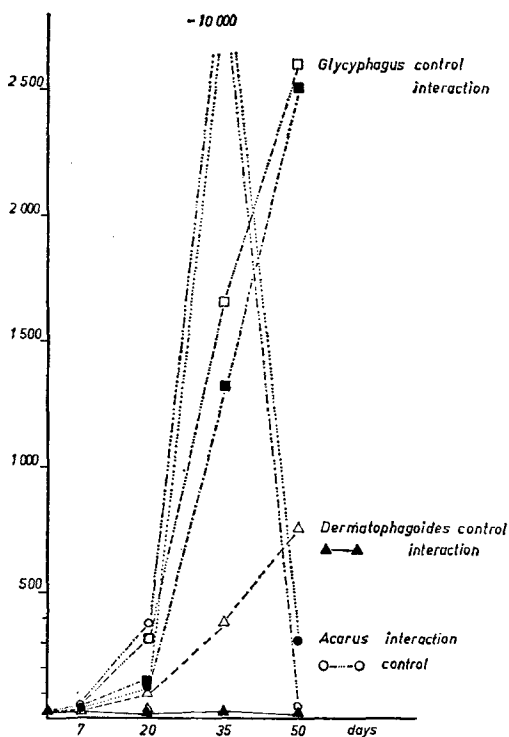


Fig. 5. Interaction between *Acarus*, *Glycyphagus* and *Dermatophagoides* on 0.15 g skin scales-yeast mixture at 25°C and 75% R. H.

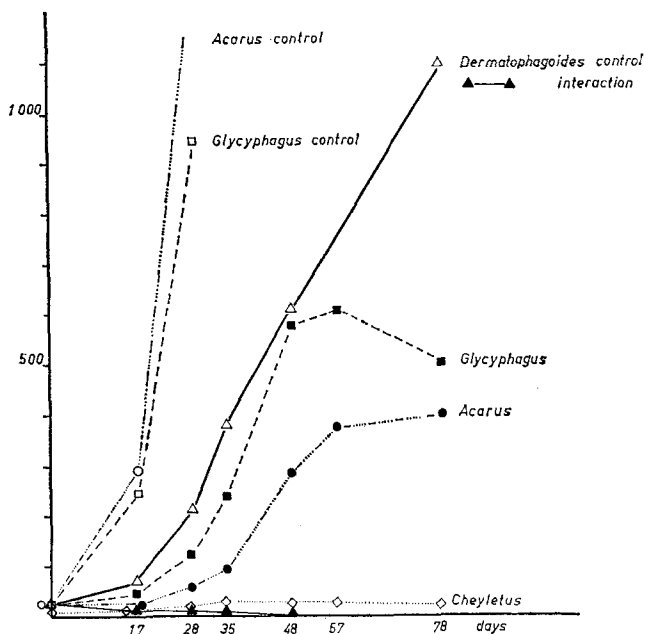


Fig. 6. Interaction between *Cheyletus*, *Acarus*, *Glycyphagus* and *Dermatophagoides* on 0.15 g skin scales-yeast mixture at 25°C and 75% R. H. Experiment started with 5 individuals of the predator and 25 of each of the prey species.

To compare with natural conditions, interaction tests were started with 25 specimens of *Dermatophagoides*, *Acarus* and *Glycyphagus* each, and 5 specimens of *Cheyletus*. One of the results of similar tests is shown in Fig. 6. The predator *Cheyletus* prevented mass development of *Acarus* and *Glycyphagus* and exterminated *Dermatophagoides*. *Glycyphagus* showed only a weak tendency to form hypopes.

6. Behavior

The fairly drought-resistant species *Dermatophagoides* did not quickly escape from dry, hot or strong light conditions. Its only defence against excessive dry conditions was crowding. Usually locomotion was slow but excessive light or heat sped it up, though no strong influence on the direction of movement was found. The mite hides beneath its food, preferably in cracks. Dorsal thigmotaxy seemed to be necessary for good development. Reproduction did not occur on finely powdered food or on food quantities too small to hide underneath. This has already been stated by SPIEK-SMA (1967). Mechanical disturbance by sand particles or mites of vivacious species resulted in uncontrolled movements or complete immobility.

The highly drought-susceptible species *Acarus* and *Glycyphagus* tried to escape quickly from excessive heat, light or dryness. A high locomotory activity was observed. Hiding under its food was not necessary for development. In unfavorable conditions *Glycyphagus* formed hypopes which are very mobile and drought resistant. A slight disturbance did not markedly affect on reproduction.

The predator *Cheyletus* was very mobile. It preferred high humidities and got away from excessive light and heat. This mite wandered around a lot and always tried to escape from culture vessels. Only when prey was present and hunting started, it hid itself under the food particles.

7. Susceptibility to Insecticides

The most common insecticides for house-pest control are D. D. T. and Lindane. Preliminary tests with 0.1 and 1.0% acetone solutions of these insecticides were applied for 24 hours to the ceilings of the cages containing approximately 20 mites (Table 3). The acetone controls had 100% survival except for 90% survival of *Cheyletus*. The 2 insecticides have only a little effect on *Dermatophagoides*, while *Acarus* and *Glycyphagus* are very susceptible.

8. Effect of Partial Elimination by Man

In the ecological system called house dust which is frequently disturbed and partially eliminated by cleaning, the presisting species will have a very large reproduction rate like *Acarus*, or a hiding habit like *Dermatophagoides*. In the past 50 years cleaning methods changed from sweeping and mopping to vacuum cleaning. In this regard the different behavior of the mites may be important.

House dust samples from 6 lodgings without vacuum cleaning have been analysed. In 3 second and higher floors *Dermatophagoides* was abundant : 98%, 95% and 90% of the total mite fauna, respectively ; the same occurred on a dry main floor (86%).

Table 3. Survival percentages after 24-hour contact with insecticides of some house dust mites at 25°C and 75% R. H.

Insecticide	Conc. %	Mite			
		<i>Cheyletus</i>	<i>Dermatophagoides</i>	<i>Acarus</i>	<i>Glycyphagus</i>
Lindane	0.1	10	70		92
Lindane	1.0	0	84		17
D. D. T.	0.1	76	100	0	12
C. D. T.	1.0	80	51	0	0

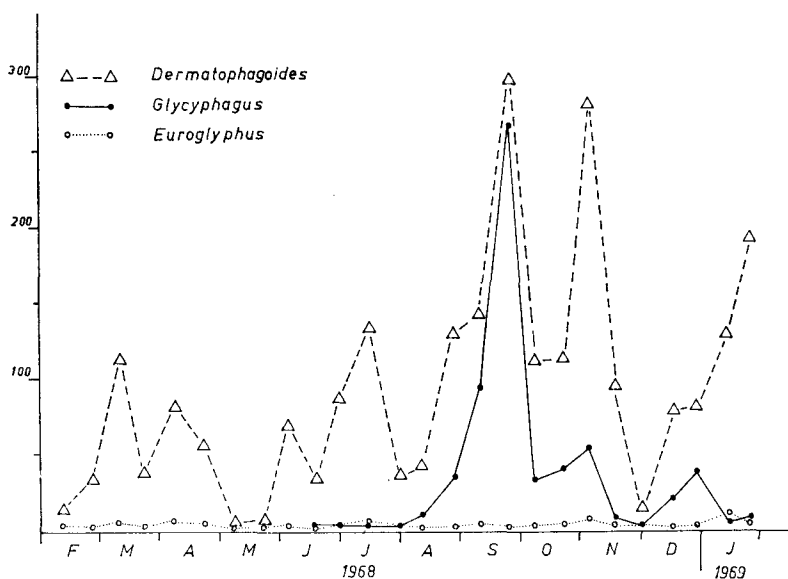


Fig. 7. Numbers of *Dermatophagoides*, *Euroglyphus* and *Glycyphagus* in 1 gram dust in a temporarily poor-cleaned main floor.

On the wetter main floor of 2 older houses the mite fauna consisted of only 61% and 38% of *Dermatophagoides*. This is markedly lower than in the carefully cleaned cottages of Fig. 1.

On the main floor of the 150-year-old house, cleaning was done every fortnight with a vacuum cleaner to provide sufficient material for the study. Fig. 7 shows the results of this test on the influence of the vacuum cleaner, for the most abundant species, *Dermatophagoides* and *Glycyphagus*. There is a strong increase in *Glycyphagus* population after diminishing the frequency of cleanings. Population development stopped at the beginning of the heating period.

CONCLUSION

Mites inhabiting the house dust differ in adaptation to humidities. Pyroglyphidae have optimal conditions between 70% and 80% R. H., its survival at low humidities is

possible, but high humidities are detrimental. *Acarus* and *Glycyphagus* have optimal conditions between 75% and 95% R. H. They can live at high humidities but are very susceptible to dryness, even when exposed to it for a short time. The predator *Cheyletus* is eurybiont but its optimum lies at 90% R. H.

In competition under conditions suitable for all the species, *Dermatophagoides* is suppressed and sometimes exterminated. This species can survive only in small numbers in hiding places. In lower humidities not suitable for *Acarus* and *Glycyphagus*, mass development of *Dermatophagoides* may occur. Very dry conditions are not suitable for any species of mite.

There is no doubt that humidity conditions on the floor of a room undergo seasonal changes and they are dependent on constructional characteristics of the house. They also changed largely during the last century. On the main floor the microclimate of the habitat of the mites is influenced by coldness from the soil. In the heating season the relative humidity on the floor is largely reduced, especially when there are heated rooms underneath this floor. Thus it is not surprising to find large mite populations on main floors and only small ones on higher floors, in addition to the seasonal changes: an increase in numbers in summer and fall and a decrease in the heating season. Man prefers humidities of 50%-60% R. H. in his lodgings. In older constructions and ways of heating (coal and wood) the tenants did not succeed in obtaining optimal humidities. Walls and floors retained moisture up to conditions that favored mold growth. These conditions are favorable for *Acarus*, *Glycyphagus* and *Tyrophagus*, but not for *Dermatophagoides*. It is obvious that previous investigators observed a different composition of the house dust fauna in which *Dermatophagoides* was not numerous. Nowadays we have fairly optimal humidity conditions for mites, though we complain that the ground floors are insufficiently heat-insulated. These conditions particularly fit for *Dermatophagoides*, which can develop abundantly without competition with steno-humid mites. On more elevated floors, especially those in the houses with central heating, the air seems too dry and therefore we try to increase the humidity by vaporizing water. These rooms are fairly unfitted for mites.

The use of insecticides clearly favors *Dermatophagoides* over *Acarus* and *Glycyphagus*.

Cleaning methods changed considerably during the last century. Sweeping and mopping do not remove as much mites and their food as vacuum cleaning does. With vacuum cleaning only mites in cracks and crevices have a chance for survival. By mopping the moisture conditions improved for *Acarus*, *Glycyphagus* and *Tyrophagus*. The different behavior of the mites results also in a negative selection by elimination of relatively large numbers of the predator *Cheyletus* by the vacuum cleaner. Thus it will not be surprising to find the highest numbers of *Dermatophagoides* in rooms which are being cleaned very regularly.

SUMMARY

The dominance of the Pyroglyphidae in house dust has been influenced by a number of factors. The humidity in houses dropped recently to such an extent that only Pyroglyphidae can survive. When temperature and relative humidity are favorable for *Acarus siro* and *Glycyphagus destructor* as well as *Dermatophagoides pteronyssinus*, *Dermatophagoides* diminished in numbers by competition. Introduction of the predator *Cheyletus eruditus* into this mixed breeds causes the extermination of *Dermatophagoides*. The vacuum cleaner trapped mites, but *Dermatophagoides* was protected by its habit to hide in cracks and crevices. The use of insecticides has a more killing effect on *Acarus* and *Glycyphagus* than on *Dermatophagoides*.

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家屋内の塵埃中に見られるダニ *Dermatophagoides* の個体数について

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家屋の塵埃に生息するダニ類の中では *Dermatophagoides pteronyssinus* をはじめとする Pyroglyphidae の数種の個体数が最も多い。この科のダニの豊富さにはいくつかの要因が関与している。まず湿度であるが、最近の家屋では湿度が以前よりずっと低くなっており、このような低湿度でふつう生存できるのは Pyroglyphidae だけである。温度や湿度が他の種 (*Acarus*, *Glycyphagus*) にも好適な範囲にある条件下では種間競争の結果 *Dermatophagoides* の個体数は減る。この3種の混合個体群の中へさらに捕食者 *Cheyletus* を導入すると *Dermatophagoides* の個体群は絶滅してしまう。本種はまた割れめやすき間などに入り込む習性を持っており、そのため電気掃除機による集塵の際にあまり捕えられない。さらに殺虫剤に対しても他種に比べて強いという特質を持っている。