

A review of biology and allergenicity of the house-dust mite *Euroglyphus maynei* (Acari: Pyroglyphidae)

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ABSTRACT

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Euroglyphus maynei is a commonly occurring mite species in house dust throughout the world, but studies of its biology and allergenicity have been relatively scarce because it is difficult to culture, and because species of the genus *Dermatophagoides* have attracted most attention of research workers. *Euroglyphus maynei* has been increasingly recognized as an important source of mite-derived allergens to which patients with house-dust mite allergy are exposed. There is a need for knowledge of its biology and allergenicity, in order to be able to grow it in vitro, and to establish whether or not it produces any unique allergens which do not cross-react with those of *Dermatophagoides* spp. and which may be of clinical significance. This article reviews published and unpublished data on taxonomy and identification, geographical and habitat distribution, seasonal population fluctuations, life-history and the effects of temperature and humidity, culture techniques and allergenicity of *E. maynei*.

INTRODUCTION

Almost all of the knowledge of the biology and allergenicity of house-dust mites and their role in the causation of atopic asthma, rhinitis and dermatitis is based on species of the genus *Dermatophagoides*, in particular *D. pteronyssinus* and *D. farinae*. However, another species, *Euroglyphus maynei*, has been found consistently in dwellings since work on house-dust mite allergy began in earnest in the 1960's. It has a cosmopolitan distribution, and occasionally is the dominant species of the house-dust acarofauna (Burr et al., 1980; Abed-Benamara et al., 1983; Vobrazkova et al., 1986).

Despite its common occurrence, *E. maynei* has been little studied in comparison with *Dermatophagoides* spp. This is due in no small part to the difficulties of maintaining productive cultures in vitro on a long-term basis. This has hindered the isolation and characterization of the major allergens. There is some evidence that *E. maynei* is allergenically important (Mumcough,

1977b) and, in certain localities, may be a major source of house-dust mite-derived allergens to which people with house-dust mite hypersensitivity are exposed (Charpin et al., 1986; Van Hage-Hamsten and Johansson, 1989). Yet it is not certain whether *E. maynei* produces species-specific allergens of clinical significance, although a major allergen appears to cross-react with an equivalent in *D. pteronyssinus* and *D. farinae*. The need for studies which address these problems is growing, because existing commercial preparations and assay systems for diagnosis and immunotherapy are based almost exclusively on allergens derived from, or antibodies raised against, *Dermatophagoides* spp., and because *E. maynei* is being recognized and isolated from house dust more frequently. This raises the hypothetical possibility of mis-diagnosis and inappropriate immunotherapy for patients sensitised primarily to a major species-specific allergen of *E. maynei*.

The purpose of this review is two-fold: to bring together the fragmentary published information on the biology, ecology and allergenicity of *E. maynei* in a single source, and to supplement this information with previously unpublished data.

TAXONOMY AND IDENTIFICATION

Euroglyphus maynei was first described by Cooreman (1950) under the generic epithet *Mealia*, now regarded by authors as a junior synonym of *Dermatophagoides*. Fain (1965) reviewed the Pyroglyphidae and reclassified *Mealia maynei* and a closely related species, *Mealia longior* Trouessart, in a new genus, *Euroglyphus*. Fain also created two new sub-genera for the species; *Euroglyphus* and *Gymnoglyphus*. A further species, *Euroglyphus* (*Gymnoglyphus*) *osu* was described by Fain and Johnston (1973). Fain et al. (1988) recently elevated *Gymnoglyphus* to generic status.

Fain (1967) further reviewed the Pyroglyphidae and created two new subfamilies: the Pyroglyphinae, to contain the genera known at that time — *Euroglyphus*, *Pyroglyphus* and *Bontella* (four additional genera are now included); and the Dermatophagoidinae, to contain the remaining genera in the family. This subfamilial division helps to stress the phylogenetic distance between *Euroglyphus* and *Dermatophagoides*.

Mumcuoglu (1976) provided excellent keys and diagrams for the differentiation of adult and immature stadia of *E. maynei* from those of *D. pteronyssinus* and *D. farinae*. Hart and Fain (1988) included a partial key, with scanning-electron micrographs, to males and females of the Pyroglyphidae, enabling differentiation of *E. maynei* and *E. longior*. Other keys are those by Fain (1965), Wharton (1975), Hughes (1976), Dubinina and Pletnev (1977), Flechtmann (1986), and a pictorial version by Van Bronswijk and Sinha (1971). Penaud et al. (1972) provided a table of characters for differentiating *E. maynei*, *E. longior* and three species of *Dermatophagoides*, and

Arlian (1989) included a tabular key for differentiating *D. pteronyssinus*, *D. farinae* and *E. maynei*. Fain et al. (1989) provided a key for all known species of the family Pyroglyphidae.

GEOGRAPHICAL DISTRIBUTION

Euroglyphus maynei is a cosmopolitan species found in almost all countries where house-dust mite surveys have been carried out (Fig. 1). For a long time it was considered to be absent from continental North America, but a few records do exist, from house dust in Wisconsin (Klein et al., 1986), Ohio (Yoshikawa and Bennett, 1979; Allen et al., 1988), and Atlanta (Smith et al., 1985). It was also believed to be absent from Australia (D. Lee, personal communication, 1987), although Blythe (1976) provided a single record from Melbourne, Voorhorst et al. (1969) found it in an un-named location, and it has recently been found in large numbers in house dust from Western Australia at Perth and Bunbury (Colloff et al., 1991).

From the surveys done to date, *E. maynei* appears to be sparingly distributed in the tropics and rare in continental interiors. Most records are from coastal localities, or areas exposed to maritime climatic influences. An examination of climatic data from sites where it has been found indicates a preference for areas of high mean annual humidity. In Europe it is absent or rare in localities with a mean annual relative humidity of less than 62%, e.g. central Bulgaria (Todorov, 1979) and central Spain (Del Rey Calero and Garcia de Lomas, 1972; Portus and Gomez, 1976). In Iran, Sepasgosarian and Mumcuoglu (1979) found it at only two of seven sites. These were two of three sites where relative humidity exceeded 75% all year. Humidity at the other sites was between 15 and 55% during May and June.

There is some information on the effect of altitude on frequency and abundance of *E. maynei*. In Spain, it was the most frequent species (58%) at Puigcerda, a town with an alpine climate, at an altitude of 1200 m, than it was at Reus (0.2%) or Barcelona (4.4%), towns with maritime climates at altitudes of less than 80 m (Portus and Gomez, 1976). But very few mites (81 in 5 g of dust) were found at Puigcerda, and only six dust samples were taken at each location. In a later paper (Gomez et al., 1981) it was stated that, even though *E. maynei* was the most abundant species in Puigcerda, this was due more to the decreased abundance of *D. pteronyssinus* than to an increased abundance of *E. maynei*. Vervloet et al. (1981) claimed that *E. maynei* was more frequent at high altitudes, although earlier work by this group (Charpin et al., 1972; Penaud et al., 1972) demonstrated the opposite effect. In Israel, Feldman-Muhsam et al. (1985) found *E. maynei* to be far less abundant at the arid inland towns of Beer Sheva (270 m) and Jerusalem (757 m) than at relatively humid, low-altitude sites on the coastal plan.

Table 1 summarizes the details of published surveys containing

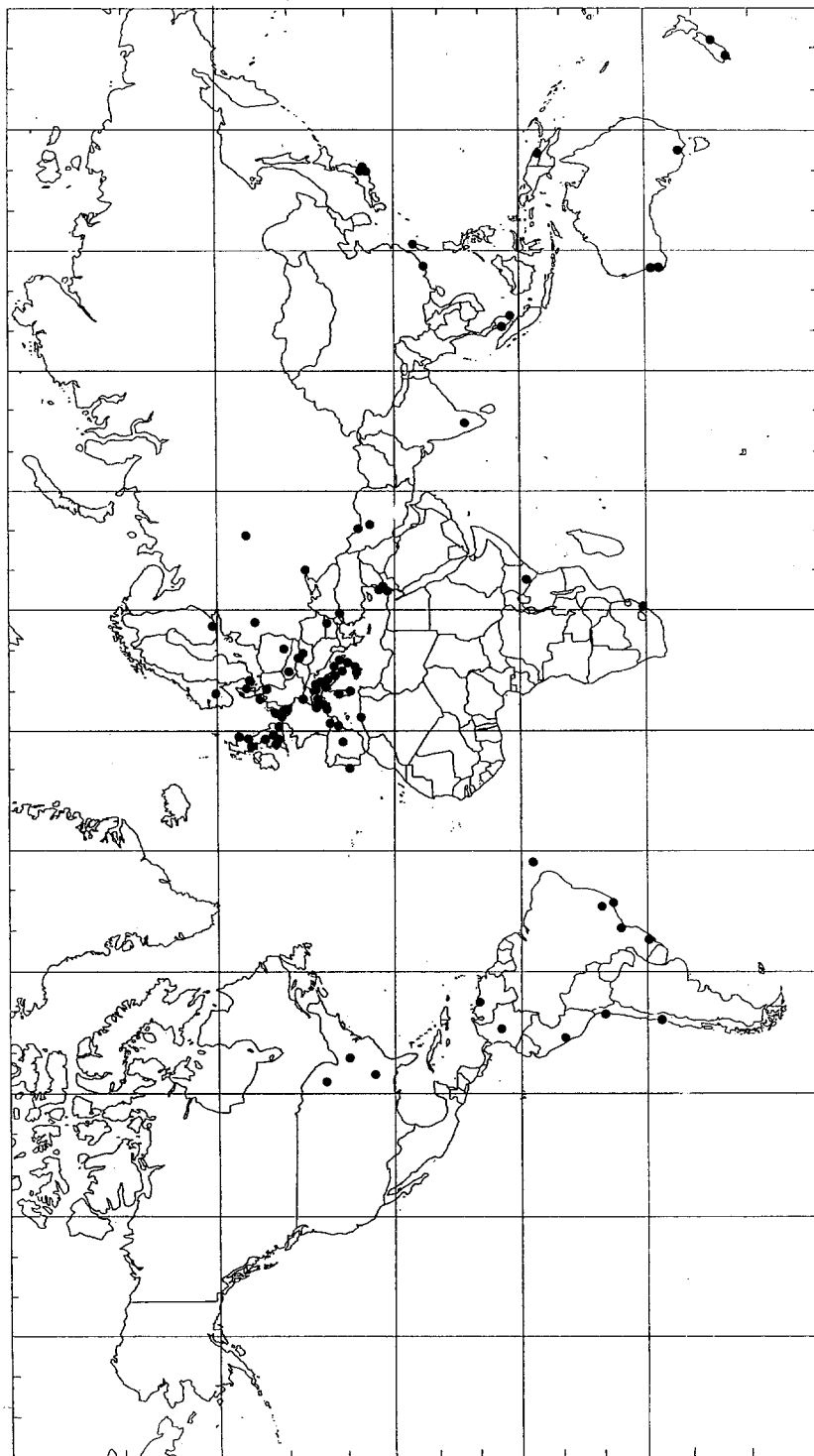


Fig. 1. Map showing the global distribution of *Euroglyphus maynei*, based on published records.

TABLE 1

Published records of *E. maynei*, with country of origin, density, frequency (%F) and percentage of total mite numbers

Country & location	Alt. class ¹	% total mites	Mean no. /100 mg	%F	Reference
Algeria					
Algiers	1	57.0	—	86.0	Abed-Benamara et al., 1983
Australia					
Melbourne	1	0.19	1.16	—	Blythe, 1976
Perth	1	13.9	2.79	50.0	
Bunbury	1	20.5	2.29	100.0	Colloff et al., 1991
Belgium					
Louvain	1	11.0	—	—	Grیدهlet and Lebrun, 1973
Brazil					
Rio Claro	3	0.18	—	2.8	Rosa and Flechtmann, 1979
Belo Horizonte	3-4	1.0	—	—	Moreira, 1975
Bulgaria					
Silistra	1	26.0	—	—	Todorov, 1979
Colombia					
Bogota	6	14.9	—	—	Charlet et al., 1978
Chile					
Iquique	1				
Curico	2	—	—	3.77	Casanueva and Artigas, 1985
China					
Shanghai	1	5.51	—	—	Wen et al., 1988
Czechoslovakia					
Prague	2	—	—	14.3	Samsinak and Vobrazkova, 1985
					Samsinak et al., 1978
Karvina	2	0.7	—	2.0	
Bratislava	1	63.2	1.7	36.7	
		22.2	0.54	18.2	Vobrazkova et al., 1986
Denmark					
Aarhus	1	0.03	—	1.02	Korsgaard, 1982
Copenhagen	1	—	—	1.92	Alani and Haarlov, 1972
Copenhagen	1	—	—	2.38	Haarlov and Alani, 1970
Finland					
Helsinki	1	4.7	1.3	5.4	
Ilomantsi	1	25.9	1.6	50.0	Stenius and Cunningham, 1972
France					
Strasbourg region	1	17.0	—	50.0	Araujo-Fontaine et al., 1973
Montpellier region	1	4.3	—	13.9	Rousset, 1971
Marseilles	1	—	—	15.1	
Briançon	4	—	—	20.4	Charpin et al., 1972 ²
Marseilles region	1	—	—	15.5	
Briançon and Monetier-les-Bains	4	—	—	12.02	Penaud et al., 1972

(continued overleaf)

¹Altitude classes: 1, 0–200 m; 2, 201–500 m; 3, 501–1000 m; 4, 1001–2000 m; 5, 2001–3000 m; 6, 3001–5000 m; 7, > 5001 m.

²Publications of altitude studies with *E. maynei* populations diminished or absent at high altitude.

³Local climatic data included.

TABLE 1 (continued)

Country & location	Alt. class ¹	% of total mites	Mean no. /100 mg	%F	Reference
Marseilles	1	—	—	8.3	Charpin et al., 1971
Marseilles region	1	—	—	11.0	
Briançon region	4	—	—	51.0	Vervloet et al., 1982
Germany					
Hamburg	1	1.2	99.9	—	Keil, 1983
Great Britain					
Birmingham	1	33.0	129.0	76.0	Blythe et al., 1974
Birmingham	1	32.66	103.2	—	Blythe, 1976
Bristol	1	11.1	—	—	Carswell et al., 1982
Cardiff	1	9.0	13.1	26.0	Rao et al., 1975
Cardiff	1	58.2	—	—	Burr et al., 1980
Glasgow & Edinburgh	1	20.2	31.0	—	Sesay and Dobson, 1972
Glasgow	1	11.6	11.3	32.4	Colloff, 1987
Liverpool	1	37.0	—	—	Walshaw and Evans, 1987
London & South Wales	1	15.0	—	40.3	Maunsell et al., 1968
London	1	20.2	21.8	69.7	Gabriel et al., 1982
Newbury	1	—	—	16.7	Eaton et al., 1985
Hong Kong					
Hong Kong	1	16.2	26.0	66.0	Gabriel et al., 1982
Hungary					
Budapest	1	—	—	9.93	Halmai, 1984
India					
Bangalore	3	13.3	100.9	67.1	Ranganath and ChannaBasavanna, 1988
Iran					
Betw. Bandar-e Pahlavi & Sari	1 2	0.1	0.3	5.7	Amoli and Cunnington, 1977 ^{2,3}
Lahidjan	1	7.3	960.0	39.0	
Ramsar	1	13.1	1328.0	93.0	Sepasgosarian and Mumcoglu, 1979 ³
Israel					
Bat Yam	1	4.7	5.6	81.0	Feldman-Muhsam et al., 1985 ^{2,3}
Nes Ziyona	1	5.8	1.8	58.0	
Beer Sheva	2	0.2	0.02	5.0	
Nir David	1	0.6	0.2	17.0	
Jerusalem	3	0.7	0.05	8.0	
Italy					
Putignano	2	—	—	12.2	Noferi et al., 1974
Naples	1	23.0	—	75.7	
Turin	2	2.6	0.19	—	
Gulf of Panzano	1	0.09	0.04	—	Blythe, 1976
Naples	1	9.14	4.02	—	
Japan					
Tokyo	1	3.6	56.0	—	Takaoka et al., 1977
Yokohama	1	6.1	0.14	87.5	Oshima, 1967

Country & location	Alt. class ¹	% total mites	Mean no. /100 mg	%F	Reference
Tokyo	1	0.2	0.2	—	Miyamoto et al., 1968
Tokyo	1	0.05	—	—	Yoshikawa et al., 1982
Saitama Prefecture	2-3	—	1.54	—	Takaoka and Okada, 1984
Kenya					
Nairobi	4	20.15	158.76	—	Blythe, 1976
Netherlands					
Leiden	1	11.2	—	53.0	Spieksma and Spieksma-Boezeman, 1967
New Zealand					
Invercargill	2	1.18	1.01	—	Blythe, 1976
Peru					
Lima	2	—	1.75	50.0	Caceres and Fain, 1974 ²
Papua New Guinea					
Lufa	4	0.08	0.24	7.14	Anderson and Cunningham, 1974
Goroka	4	7.49	11.13	50.0	
Poland					
Katowice	2	2.1	—	—	Horak, 1987
Portugal					
Lisbon	1	—	—	31.7	Pinhao and Gracio, 1978
Singapore					
Singapore	1	0.92	8.18	—	Blythe, 1976
Spain					
Reus	1	0.2	0.76	100.0	Gomez et al., 1981 ^{2,3}
L'Amtella	1	0.1	0.12	16.7	
Puigcerda	4	12.6	5.66	100.0	
Casteltersol	3	0.7	—	—	
Puigcerda	4	58.0	—	—	Portus and Gomez, 1976 ^{2,3} Blasco et al., 1975
Reus	1	0.2	—	—	
Barcelona	1	4.4	—	—	
Barcelona	1	—	—	41.2	
Switzerland					
Basel	1	17.2	—	36.7	Mumcoughlu, 1976
Taiwan					
Taipei	1	0.2	0.02	66.7	Oshima, 1970
Taipei	1	0.6	—	—	Chang and Hsieh, 1989
Tristan da Cunha					
	1	16.0	—	—	Mantle and Pepys, 1974
Turkey					
Istanbul	1	0.09	0.09	—	Blythe, 1976
USA					
Columbus	2	0.1	0.08	7.7	Yoshikawa and Bennett, 1979 Klein et al., 1986
Milwaukee	2	2.73	—	—	
USSR					
Vilnius	1	—	—	3.03	Dubinina et al., 1984
Venezuela					
Caracas	3	7.8	122.0	22.2	Hurtado and Parini, 1987 ³
Yugoslavia					
Pazin	1	7.54	19.47	—	Blythe, 1976

quantitative ecological data on *E. maynei*, including numbers of specimens expressed as a percentage of the total mite numbers found, the mean number per 100 mg of dust, and the percentage frequency of the species. There is enormous variation in these parameters between different localities, part of which is due, doubtless, to differences in sampling, extraction and counting techniques. However, when the data is divided into two groups, that from localities at altitudes between sea level and 100 m, and that from localities at altitudes above 100 m, and is plotted on a histogram (Fig. 2), it is clear there are differences between the two altitude classes in the geometric means of the three parameters. The data was analysed statistically using one-way analysis of variance after using arc-sin transformation of percentage data, followed by $\log_{10} (n+1)$ transformation of this and the data on mean numbers of mites per 100 mg. The mean percentage of *E. maynei* in the total mite population

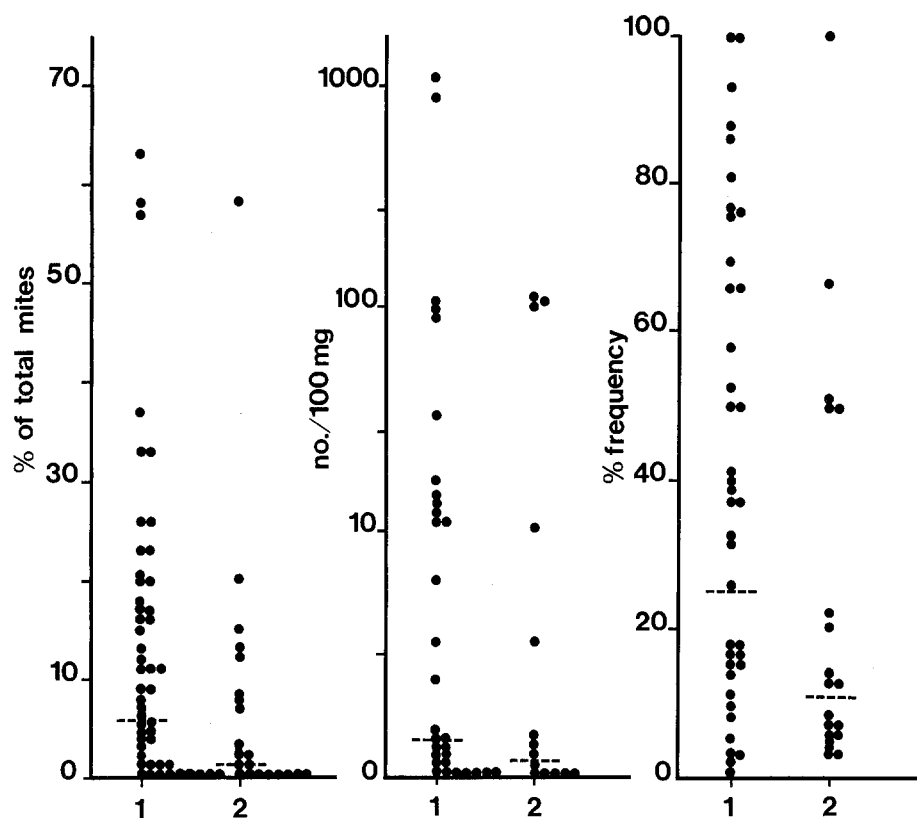


Fig. 2. Histogram plots of ecological data from the published house dust mite surveys detailed in Table 1: ranges and geometric means (---) of numbers of *E. maynei* expressed as a percentage of total mites, numbers of *E. maynei* per 100 mg of dust, and percentage frequency of occurrence. Data was divided into two groups according to the altitude of the locality: group 1, localities below 100 m; group 2, localities above 100 m.

was significantly higher at altitudes below 100 m (5.8%) than above 100 m (1.1%; $P < 0.05$). Similarly, the percentage frequency of *E. maynei* in dust samples was significantly higher below 100 m (26.3%) than above 100 m (12.5%; $P < 0.05$). These differences may reflect the lower humidities that tend to prevail at high altitude. There was no significant difference in mean density of *E. maynei* between sites below 100 m (3.8 per 100 mg dust) and above 100 m (1.5 per 100 mg). Although there are several records of *E. maynei* occurring frequently and abundantly at high-altitude localities, these tend to be ones with relatively high annual rainfall (e.g. Caracas, Bogota and the Papua New Guinea Highlands). The notable exception is Nairobi; the large numbers of *E. maynei* here may be due to high indoor humidity resulting from particular domestic activities and/or overcrowding.

In essence, *E. maynei* is a species that is found mainly in places with cool humid or warm humid climates, and it is rare or absent from places having cool dry and hot dry climates, although this is something of an oversimplification. In some respects, the known global distribution of *E. maynei* reflects the distribution of house-dust mite surveys, predominantly from maritime Europe and thus from sites with cool humid or warm humid climates. If climatic constraints are the only reason for the distribution, it is difficult to see why it has not been recorded from southeast Asia other than Singapore and Malaysia; several able acarologists have carried out surveys in the region. Another notable absence is from west and central Africa, although this does indeed reflect the paucity of studies in these regions.

HABITAT DISTRIBUTION

There are two aspects of habitat distribution to consider: distribution between homes within a particular geographical area; and distribution in different habitats within homes. Blythe et al. (1974) examined the distribution and abundance of pyroglyphid mites at six sites within five houses in Birmingham, England. They found a tendency for a higher mean density of *E. maynei* to be present in mattresses (136 per 100 mg) and bedroom floors (20 per 100 mg) than in living rooms (9 per 100 mg), kitchens (4 per 100 mg) halls/stairs (9 per 100 mg) and landings (8 per 100 mg), and suggested that *E. maynei* was more restricted to mattresses than *D. pteronyssinus*. Charlet et al. (1978) concurred with this view; mean numbers of *E. maynei* in floor dust were about a quarter of those in mattresses. Colloff (1987) also found *E. maynei* more abundant in mattresses than in carpets in 74 homes in Glasgow, Scotland. Sesay and Dobson (1972) found *E. maynei* in 27 of 60 beds studied. It was dominant in four, and the only pyroglyphid species in one. They classified beds according to the health of the occupants and standards of housekeeping — i.e. 'good' and 'bad'. Nineteen *E. maynei*-positive beds were of bronchial asthmatics, 20 of papular urticaria patients, and 21 of healthy con-

trols. Fifteen of the asthmatics' homes were classified as 'good' compared with only eight of the urticaria patients. *Euroglyphus maynei* was particularly common in 'bad' urticaria beds. Sesay and Dobson (1972) found that most *E. maynei* were present in intermediate layers of blankets (mean 63 g^{-1} dust), with the lowest densities in pillows (10 g^{-1}). Carswell et al. (1982) likewise found lower densities in overblankets and pillows than in mattresses and soft toys.

Walshaw and Evans (1987) found *E. maynei* present in 80% of beds and numerically dominant in 48%, representing 37% of the total house-dust mite population in homes of asthmatics in Liverpool, England. It constituted 25% of the population on bedroom floors and 18% on lounge carpets. No correlation was found between density of *E. maynei* and the age of the house or presence of central heating, but there was a positive correlation with the density of *E. maynei* and the relative humidity of the rooms. Similarly, Colloff (1991b) found a higher mean density of mites in homes with signs of damp than in those without, and Burr et al. (1980) found high densities of *E. maynei* in beds of enuretic children, which they attributed to dampness.

A significant correlation between increasing density of *E. maynei* and decreasing social class of the patients was found by Walshaw and Evans (1987), and also between decreasing social class and increasing ionic sodium concentrations (used by them as an index of sweat input) in the beds. They suggested that individuals in lower social classes may perspire more than those with professional, non-manual jobs, and that high 'sodium load' may favour development of large *E. maynei* populations. There are three major flaws to this argument: (1) ionic sodium concentrations are not a reliable measurement of sweat input, as urine, semen and dead epidermal tissue, all of which can also be found in mattress dust, contain appreciable quantities of ionic sodium; (2) no consideration was made of the age of the mattress, older mattresses tending to have well-developed, stable house-dust mite populations, and persons in lower social classes may be less able to afford to replace mattresses as often as those in higher social classes; and (3) persons in higher social classes may be more aware of the beneficial effects of house-dust mite control, and so carry out vacuum-cleaning more frequently than those in lower social classes. To be fair, the authors did state that the relationship between bed dust, ionic sodium, social class and *E. maynei* numbers was not strong, and that other factors may be important.

Colloff (1991b) found that a group of mattresses of patients with atopic dermatitis had a significantly higher frequency of *E. maynei* (74%) than those of healthy non-atopics (48%). The reasons for this difference are not known; it was not due to higher frequency of damp in homes of patients with atopic dermatitis, because there was no significant difference between the two groups.

SEASONAL POPULATION FLUCTUATIONS

Very few publications contain details on seasonal dynamics of *E. maynei*, and it is difficult to make a comparison with data known for *Dermatophagoides* spp. Charlet et al. (1978) found two population maxima, October and April. In floor dust, numbers were too small to show any significant trends (as was the case in the study by Van Bronswijk et al. (1971)), although Charlet et al. (1978) noticed a small increase in immatures, males and females in April. Charlet et al. (1978) did their study in Bogota, Colombia, which has a mild-cool climate and an altitude of 2600 m. The April population peak coincided with that of *D. pteronyssinus*. There was a sharp decline in both species between December and March. This is also the case with European *D. pteronyssinus* populations. Walshaw and Evans (1987) provide some limited information, stating that *E. maynei* numbers were lowest 'in the Autumn' (i.e., August–October). Carswell et al. (1982) indicated an increase in *E. maynei* populations between October and December.

LIFE-HISTORY

Like all other pyroglyphid mites, *E. maynei* has the following developmental stages; egg; prelarva; hexapod larva; active and quiescent protonymph; tritonymph; and adult. Eggs are ellipsoidal, ca. 100–150 μm long and about 50–70 μm in diameter. The process of hatching takes between 1 and 24 h depending on temperature and humidity, followed by an active non-feeding period, after which the larvae become swollen and sessile. At high magnification under a compound microscope, the new protonymphal cuticle is visible beneath the larval integument. Most of the protonymphal period is spent feeding, and the mites are relatively inactive, moving slowly around in the food material. The active stages tend to be far more sluggish in their movements than *D. pteronyssinus*, a facet of their behaviour which can be useful when sorting live specimens from dust samples under a stereobinocular microscope. Before the final moult, the tritonymphs enter a short quiescent phase. After this time they can easily be sexed, as the adult genitalia are visible beneath the tritonymphal cuticle.

Mating behaviour is similar to that of *D. pteronyssinus*. The males of *E. maynei* are able to detect which tritonymphs which will moult into females — possibly due to expulsion of pheromones from the lateral opisthosomal glands of the tritonymphs — and will mount them in advance of the final moult so that copulation can take place shortly afterwards. Mites remain in copula for between 24 and 48 h, although it is not known whether sperm transfer takes place continuously during this period.

Taylor (1975) found female *E. maynei* start laying eggs 3–4 days after copulation has commenced, although Hart and Fain (1988) recorded a mean

pre-reproductive period of almost 14 days (Table 2). Oviposition differs from *D. pteronyssinus*, in that eggs are often laid in small groups of 3–4 rather than singly. Gravid females very rarely contain more than one egg, whereas *D. pteronyssinus* frequently contain two, if not more. Taylor (1975) found the rate of oviposition approximated to one egg per day under all conditions of temperature and humidity, considerably less than *D. pteronyssinus* which can lay up to four eggs per day at optimal conditions, although Hart and Fain (1988) found no difference in reproductive rate of *E. maynei* and *D. pteronyssinus*, Colloff (1991b) suggested that *E. maynei* may be constrained from a high reproductive rate because of considerations of water loss. The eggs of *D. pteronyssinus* and *E. maynei* differ only slightly in volume, but adult female *E. maynei* are considerably smaller than female *D. pteronyssinus*. Based on gravid-female:egg-volume ratios, it was estimated *E. maynei* would lose about 9% of body water per egg laid, compared with only 4% for *D. pteronyssinus*.

TABLE 2

Summary of published data on the bionomics of *Euroglyphus maynei*

Temperature (°C)								Reference
10	15	25	25	25	30	30	40	
Humidity (% RH)								
80	80	60	75	80	75	80	80	
Pre-reproductive period (days)								
–	–	5.1	3.1 13.8	3.4	3.4	3.8	–	Taylor, 1975 Hart and Fain, 1988
Reproductive period								
–	–	6.8	13.8 60.0	8.0	9.2	10.3	4.0	Taylor, 1975 Hart and Fain, 1988
Fecundity (eggs female⁻¹)								
–	–	9.2	14.6 84.0	5.8	8.4	11.7	0.0	Taylor, 1975 Hart and Fain, 1988
Fecundity rate (eggs female⁻¹ day⁻¹)								
–	–	1.4	1.1 1.5	0.7	0.9	1.1	–	Taylor, 1975 Hart and Fain, 1988
			0.4–	0.8				Nannelli et al., 1983
Development time (egg→adult)								
–	115	30	25 33	26	24	21	–	Taylor, 1975 Hart and Fain, 1988
			30– 50–	35 (males) 55 (females)				Nannelli et al., 1983

Female *D. pteronyssinus* produce the bulk of their eggs in the initial phase of oviposition, and the rate of oviposition declines maskedly with the age of the mite. For *E. maynei*, the rate is more constant, and because the risk of mortality increases with age, *D. pteronyssinus* can achieve a greater proportion of potential reproductive output than *E. maynei* during the period when the risk of mortality is lowest. Hart and Fain (1988) found the pre-reproductive period was the only parameter to suggest that *E. maynei* had poorer reproductive potential than *D. pteronyssinus*, but also suggested that males and females of *E. maynei* achieved fewer mating encounters than *D. pteronyssinus* because of their lower mobility. This notion does not fit particularly well with the fact that males of both species seek out and attach to female tritonymphs, wait for them to moult, and then copulate with them. Additional copulation does not affect fertility of female *E. maynei* or the rate of egg production, unlike female *D. pteronyssinus* which require a second mating (Spieksma, 1967).

Sex-ratios

According to Taylor (1975), female *E. maynei* are better able to withstand desiccating conditions than males and juveniles. This supposedly leads to a sex-ratio imbalance at sub-optimal microclimates, with females outnumbering males by more than 3:1 (Spieksma, 1967; Sesay and Dobson, 1972; Blythe et al., 1974) in contrast to the equal sex-ratio, at optimal conditions, after the final moult. However, the validity of the sex-ratio imbalance commented on by these authors remains open to question since it was, in each case, calculated from the numbers of mites extracted from dust samples rather than based on in vitro observations. Walshaw and Evans (1987) commented that the sex-ratio imbalance was more likely due to human error during sorting mites from dust samples; the smaller-sized males were missed more often than the larger females.

EFFECTS OF TEMPERATURE AND HUMIDITY ON MORTALITY AND LONGEVITY

Almost all of the existing information on the temperature/humidity relationships of *E. maynei* is from the work of Taylor (1975), who investigated duration and mortality of each stage at eight combinations of temperature and humidity (Table 2). By calculating the daily rate of multiplication, using the formula of Solomon (1969), he found that populations raised on a diet of skin scales and yeast only showed positive rates of increase at 25°C, 75% RH, and 30°C 80% RH. *Euroglyphus maynei* matured most rapidly and suffered least juvenile mortality at 30°C, 80% RH, and he concluded these represent the optimal microclimate conditions for cultivation of *E. maynei* in vitro. At 10°C, 80% RH, populations declined and eventually died off.

Nearly 55% of *D. pteronyssinus* eggs reached adulthood at 25°C and 80%

RH (Dobson, 1979) whereas no more than 40% of *E. maynei* matured at these conditions (Taylor, 1975). Compared with *D. pteronyssinus*, *E. maynei* has shorter adult longevity, lower fecundity and greater juvenile mortality, at low humidities. Hence, the relative rate of population increase is relatively slow. But Van Bronswijk et al. (1971) presented data that indicated *E. maynei* was better able to withstand desiccating conditions than *D. pteronyssinus*. They found that 95% of specimens of *E. maynei* survived exposure to 33% RH at 25°C for 48 h, compared with only 50% of *D. pteronyssinus*. However, they did not mention which stases they used for these experiments. This is important, because larvae and nymphs are more susceptible to desiccation than adults.

Nannelli et al. (1983) carried out some preliminary observations on duration of stases at 25°C, 75–80% RH. The range of development time of eggs was 5–14 days. Larva, protonymph and tritonymph (including the quiescent phases) lasted 10–17, 5–17 and 6–12 days, respectively. Development from egg to adult took 30–35 days for males and 50–53 days for females.

Taylor (1975) found minimum duration of the egg was 1 day at 30°C, 75 and 80% RH. No eggs survived at 40°C, 80% RH. Mean duration was shorter at 30°C than 25°C, and at 80% RH than 75 or 60% RH. Duration was longest and mortality highest at 60% RH. The larvae lasted 1–3 days at 25–30°C and 4–7 days at 15°C. Longest larval duration was 19 days at 25°C, 60% RH. Larvae developed faster at 75% RH at 25°C than at 60% or 80% RH. At 30°C, 80% RH, larvae developed faster than at 75%. No larvae developed and survived at 10°C or 40°C. Highest mortality was at 30°C, 75% RH and 15°C, 80% RH. Protonymphal duration was not significantly different at 25 and 30°C or 75 and 80% RH, although duration was extended at 60% and 25°C. Tritonymphal duration was faster at 30°C, 80% RH than at 25°C, 80% RH. Mortality of protonymphs was lowest at 25°C, 75% RH, and highest at 15°C, 80% RH. For tritonymphs, there was no significant difference in mortality at 60, 75 or 80% RH at 25°C, or at 70 and 80% RH at 30°C: it varied from 8–40%.

Complete development of *E. maynei* from egg to adult was observed by Taylor (1975) for a total of 100 specimens, of which 54 were males and 46 females, a sex-ratio of 1:1.17. There was no significant difference between the time taken by males and females to reach maturity. Variation in adult female duration at different conditions of microclimate may have a profound effect on fecundity and population increase.

CULTURE

Taylor (1975) used a diet of human beard shavings with adherent skin scales, defatted with acetone, mixed with yeast granules, for culture of *E. maynei*, but was unable to sustain long-term cultures. He also tried a number of other diets, including cottonseed meal which was unsuccessful. Likewise,

Van Bronswijk (1972) was unable to grow *E. maynei* on cottonseed meal. She investigated the suitability of ten foods for population growth of four *Dermatophagoides* spp. and *E. maynei*, and found that human skin scales mixed with yeast, and wheatgerm flakes mixed with yeast powder, gave the best population growth of *E. maynei*.

Nannelli et al. (1983) used a similar diet to that of Taylor (1975), but with the addition of sodium caseinate to the mixture. A different diet consisting of a mixture of six parts commercial rabbit-food pellets, three parts de-bittered dried brewer's yeast, and one part pork fat has been used by these workers for the productive culture of *E. maynei* for over seven years (Castagnoli et al., 1989).

Hart and Le Merdy (1988) found that *D. pteronyssinus* and *D. farinae* grew best on dried yeast, but *E. maynei* did best on beard shavings and second-best on insect meal. Good population growth was achieved with a mixture of dried liver, wheatgerm and dried yeast, which was also, purportedly, the least allergenic culture medium. Food particle size was also found to be an important factor in population growth; larger particles result in better growth than fine ones.

In the present author's laboratory, *E. maynei*, harvested at regular intervals from several mattresses known to be rich in the species, are kept in the mattress dust, with no added food substrate, at room temperature and 80% RH. This system achieves slow but stable population growth, but is adequate only if relatively small numbers of mites are required for study. One disadvantage is the need to regularly 'cull' *D. pteronyssinus* to prevent them becoming numerically dominant.

ALLERGENICITY

Studies on the allergenicity of *E. maynei* have been confined mostly to skin-prick testing or radioallergosorbent serum testing (RAST) for *E. maynei*-specific IgE antibody, using crude extracts of whole mite cultures. Voorhorst et al. (1969) first reported that extracts of *E. maynei* produced qualitatively and quantitatively identical skin-prick test reactions to those caused by extracts of *D. pteronyssinus* and house dust in patients with atopy from Leiden, The Netherlands. In 30 patients with atopy, they found a highly significant positive correlation between the intensity of reactions to three dilutions of *D. pteronyssinus* extract and those to the same dilutions of extracts of *E. maynei*. On the basis of these data they concluded that *E. maynei* and *D. pteronyssinus* contained the same allergen, although it would have been more accurate to conclude that they contained partially cross-reacting allergens.

Mumcuoglu (1977a, b) found that, of nine species of house-dust and stored-products mites, *E. maynei* extracts elicited the most frequent and the most severe scratch test reactions on the backs of 115 patients with allergic asthma and/or rhinitis from Basel, Switzerland. A total of 58 patients had

positive skin reactions to one or more extracts of the nine mite species (50.4%), of which 49 (84.5% of skin-test-positive patients) reacted to extracts of *E. maynei*. It was found that there was some cross-reactivity between the mite species, but only between *D. pteronyssinus*, *D. farinae* and *E. maynei*. Using the Schultz-Dale test of smooth-muscle reaction of guinea pigs, Mumcuoglu (1977c) found that *E. maynei* extracts evoked positive responses only in those animals that had been sensitised with *D. pteronyssinus* extract, and not those sensitised with extracts of the stored-products mites *Tyrophagus putrescentiae*, *Chortoglyphus arcuatus* and *Lepidoglyphus destructor*.

The possibility of a common cross-reactivity between *E. maynei* and *D. pteronyssinus* was further reinforced by the finding that *D. pteronyssinus*, which was the numerically dominant species in 71% of homes and was present in 89% of homes, gave positive skin tests in 75% of the patients, whilst *E. maynei*, which caused 85% of positive skin tests, was numerically dominant in only 17% of homes and was present in 37% (Mumcuoglu, 1977b). The fact that seven patients reacted to *E. maynei* extract only, and two to *D. farinae* only, suggested that species-specific allergens were present, but on the basis of frequency of reactivity they would not be considered major allergens. Although *E. maynei* produced more positive reactions graded + + + (7 of 49; 14.3%) than *D. pteronyssinus* (5 of 43; 11.6%) and *D. farinae* (5 of 47; 10.6%), the differences were not statistically significant. The high frequency of skin-test positivity found by Mumcuoglu (1977b) was in marked contrast to the findings of Nannelli et al. (1983). In Italy, of approximately 15 000 patients with atopy who were skin prick-tested with extracts of *E. maynei*, only 0.64% had positive reactions.

Charpin et al. (1986), in a comparative study of intradermal skin reactions to *E. maynei* extract in Marseilles and Briançon, France, found that of 22 patients positive to *D. pteronyssinus* at Marseilles, 21 were also positive to *E. maynei*. Of seven positives at Briançon, three were also positive to *E. maynei*. In spite of the higher frequency of *E. maynei* in house dust at Briançon (51% of homes), positive skin reactions were not found more often than at Marseilles, where the frequency of *E. maynei* in homes was only 11%. No patients appeared to have been positive to *E. maynei* only.

Fain et al. (1988) included a diagram illustrating the frequency of skin-test positivity to *E. maynei* extracts, both alone and when mixed with extracts of *D. farinae* and *D. pteronyssinus*, in 158 patients, of whom 48 were positive for house-dust mite. Of these, 4/48 (8.3%) were positive to *E. maynei*, 2/48 (4.2%) to *D. farinae* only, and 2/48 (4.2%) to *E. maynei* and *D. pteronyssinus*, which indicated that two patients were sensitive to *E. maynei* extracts only. Le Merdy et al. (1988), using crossed-radioimmuno-electrophoresis (CRIE) of extracts of *E. maynei*, *D. pteronyssinus* and *D. farinae*, together with measurement of specific IgE against these species, found 3/27 patients were positive to *E. maynei* only, but with weak titres (0.6, 1.5 and 0.35 Inter-

national Units (IU) ml^{-1}). Both these studies further support the existence in *E. maynei* of major cross-reacting and minor species-specific allergens.

During development of a radioimmunosassay for *Der p* I-equivalent (i.e. pyroglyphid-derived allergen with common epitopes to *Der p* I; Platts-Mills et al., 1986) it was found that extracts of *E. maynei* incubated with affinity-purified rabbit anti-*Der p* I sera inhibited > 90% of *Der p* I binding activity. This, and quantification of *Der p* I equivalent in *E. maynei*-dominant dust samples, indicated that *E. maynei* produces an allergen which cross-reacts with *Der p* I.

Van Hage-Hamsten and Johansson (1989) investigated the cross-reactivity of extracts of *E. maynei* with those of *Acarus siro*, *Lepidoglyphus destructor* and *D. pteronyssinus* using sera from farmers from Gotland, Sweden, and found positive reactions to *E. maynei* in 4.5% of the sera that were mite-positive by RAST, compared with 5.2% for *D. pteronyssinus*. A significant correlation was found between *E. maynei*- and *D. pteronyssinus*-specific RAST scores, but not between RAST scores of either of these and scores for *L. destructor*-positive sera. However, there were a substantial number of farmers with IgE against *E. maynei* only (7.8%), which suggested that *E. maynei* possessed its own unique allergens. This was confirmed by RAST inhibition studies: *D. pteronyssinus* extract failed to inhibit *E. maynei*-positive sera from binding to paper discs coated with *E. maynei* extract.

Fain et al. (1988) included diagrams of protein profiles of *E. maynei* and *D. pteronyssinus* separated by isoelectric focussing. There were no major differences detectable between extracts of the two species.

Recently, Pharmacia (Uppsala, Sweden) have begun to market an IgE RAST assay using paper discs coated with *E. maynei* extract. This suggests the beginnings of recognition by the immunodiagnostics industry of the potential importance of *E. maynei* as a source of allergens. Similar recognition is required by house-dust-mite allergologists in order to motivate more research to determine exactly how clinically important are the allergens of *E. maynei*.

CONCLUDING REMARKS

There are clearly large gaps in our knowledge of the biology and allergenicity of *E. maynei*. In several studies of the species, there is too little information to make unequivocal statements, a phenomenon compounded by contradictory data such as that on reproductive rates. It seems unlikely that the study of the ecology and population dynamics of *E. maynei* will ever receive quite the same attention from researchers as *Dermatophagoides* spp. have, and many problems are likely to remain unresolved for some time. The future of research on allergenicity of *E. maynei* is more promising: at a recent WHO-sponsored meeting on house-dust-mite allergy (Anonymous, 1988) this topic

was highlighted as a research priority, and there are several teams worldwide currently involved in such investigations.

REFERENCES

- Abed-Benamara, M., Fain, A. and Abed, L., 1983. Note préliminaire sur la faune acarologique des poussières de matelas d'Alger. *Acarologia*, 24: 79–83.
- Alani, M.D. and Haarlov, N., 1972. The house-dust mite: a possible source of allergen in the environment of patients with atopic dermatitis. *J. Nat. Med. Assoc.*, 64: 302–305.
- Allen, B.S., Arlian, L.G., Bernstein, L., Friedman, S., Grant, A., Lieberman, P., Lopez, M., Metzger, J., Schatz, M., Spector, S. and Wassemann, S., 1988. Prevalence of dust mites in the homes of asthmatics in several U.S. geographical regions. *J. Allergy Clin. Immunol.*, 81: 270 (Abstr.).
- Amoli, K. and Cunningham, A.M., 1977. House dust mites in Iran. *Clin. Allergy*, 7: 93–101.
- Anderson, H.R. and Cunningham, A.M., 1974. House dust mites in the highlands of Papua New Guinea. *Papua New Guinea Med. J.*, 17: 304–308.
- Anonymous, 1988. Dust mite allergens and asthma: a worldwide problem. *Bull. WHO*, 66(6): 769–780.
- Araujo-Fontaine, A., Wagner, M. and Kramer, M., 1973. Contribution à l'étude des acariciens de la poussière domestique en Alsace. Relations avec les conditions d'habitat. *C.R. Seances Soc. Biol.*, 167: 371–378.
- Arlian, L.G., 1989. Biology and ecology of house dust mites, *Dermatophagoides* spp. and *Euroglyphus* spp. *Immunol. Allergy Clin. N. Am.*, 9(2): 339–356.
- Blasco, C., Gallego, J. and Portus, M., 1975. Estudio de la acarofauna del polvo doméstico de Barcelona y poblaciones circundantes. *Allergol. Immunopathol.*, 3: 403–418.
- Blythe, M.E., 1976. Some aspects of the ecological study of house dust mites. *Br. J. Dis. Chest*, 70: 3–31.
- Blythe, M.E., Williams, J.D. and Morrison-Smith, J., 1974. Distribution of pyroglyphid mites in Birmingham with particular reference to *Euroglyphus maynei*. *Clin. Allergy*, 4: 25–33.
- Burr, M.L., Dean, B.V., Merrett, T.G., Neale, E., St Leger, A.S. and Verrier-Jones, E.R., 1980. Effects of anti-mite measures on children with mite-sensitive asthma: a controlled trial. *Thorax*, 35: 506–512.
- Caceres, I. and Fain, A., 1979. Notes sur la faune acarologique des poussières de maisons du Perou. In: E. Piffi (Editor), *Proc. 4th Int. Congress of Acarology*, Saalfelden, Austria, 1974. Akadémiai Kiadó, Budapest, pp. 259–261.
- Carswell, F., Robinson, D.W., Oliver, J., Clark, J., Robinson, P. and Wadsworth, J., 1982. House dust mites in Bristol. *Clin. Allergy*, 12: 533–545.
- Casanueva, M.E. and Artigas, J.N., 1985. Distribucion geografica y estacional de los ácaros del polvo de habitacion en Chile (Arthropoda, Acari). *Gayana Zool.*, 49: 3–75.
- Castagnoli, M., Liguori, M. and Nannelli, R., 1989. A methodology for rearing *Euroglyphus* (*E.*) *maynei* (Coor.) (Acarina: Pyroglyphidae) in laboratory. *Redia*, 72: 127–131.
- Chang, Y.-C. and Hsieh, K.-H., 1989. The study of house-dust mites in Taiwan. *Ann. Allergy*, 62: 101–106.
- Charlet, L.D., Mulla, M.S. and Sanchez-Medina, M., 1978. Domestic Acari of Colombia: Population trends of house dust mites (Acari: Pyroglyphidae) in homes in Bogota, Colombia. *Int. J. Acarol.*, 4: 23–31.
- Charpin, J., Penaud, A., Nourrit, J., Autran, P. and Razzouk, H., 1971. Allergie aux poussières domestiques et *Dermatophagoides*. *Rev. Fr. Allergol.*, 11: 315–328.
- Charpin, J., Autran, P., Penaud, A., Nourrit, J. and Razzouk, H., 1972. Un parasite de la poussière domestique: le *Dermatophagoides*. Rôle dans l'allergie respiratoire. *Nouv. Presse Méd.*, 1: 859–862.

- Charpin, J., Penaud, A., Charpin, D., Faraj, F., Thibaudon, M., Vervloet, D. and Razzouk, H., 1986. *Euroglyphus maynei*: étude comparative des réactions cutanées à Marseille et à Briançon. Rev. Fr. Allergol., 26: 117–119.
- Colloff, M.J., 1987. Mites from house dust in Glasgow. Med. Vet. Entomol., 1: 163–168.
- Colloff, M.J., 1991a. Population studies on the house dust mite *Euroglyphus maynei* (Cooreman, 1950) (Pyroglyphidae). In: R.H. Schuster and P.W. Murphy (Editors), The Acari: Reproduction, Development and Life-History Strategies. Chapman & Hall, London, pp. 497–506.
- Colloff, M.J., 1991b. A comparison between house dust mite populations in homes of patients with atopic dermatitis and healthy non-atopics. In: F. Dusbabek and V. Bukva (Editors), Modern Acarology, Vol. I. SPB Academic, The Hague, & Academia, Prague (in press).
- Colloff, M.J., Stewart, G.A. and Thompson, P., 1991. House dust acarofauna and *Der p I* equivalent in Australia: the relative importance of *Dermatophagoides pteronyssinus* and *Euroglyphus maynei*. Clin. Exp. Allergy, 21: 225–230.
- Cooreman, J., 1950. Sur un acarien nouveau, préjudiciable aux matières alimentaires entreposées: *Mealia maynei* n. sp. Bull. Annu. Soc. Entomol. Belg., 86: 164–168.
- Del Rey Calero, J. and García de Lomas, J., 1972. Alergia respiratoria provocada por los ácaros sensibilizantes del polvo doméstico. Rev. Clin. Española, 126: 215–222.
- Dobson, R.M., 1979. Some effects of microclimate on the longevity and development of *Dermatophagoides pteronyssinus* (Trouessart). Acarologia, 21: 482–486.
- Dubinina, E.V. and Pletnev, B.D., 1977. Methods of Observation and Determination of Allergenic Mites in Domestic Dust. USSR Academy of Sciences, USSR, Leningrad, 52 pp. (in Russian).
- Dubinina, E.V., Vaitsekauskaitė, R.L., Baigorinaite, A. and Razgauskas, A.F., 1984. The fauna of house dust mites in the homes of bronchial asthma patients in the Lithuanian SSR. Med. Parazitol. Parazit. Bolezni, 5: 63–67 (In Russian).
- Eaton, K.K., Downing, F.S., Griffiths, D.A., Hockland, S. and Lynch, S., 1985. Housedust mites (*D. pteronyssinus*) in pets' beds and their relation to dust allergy. Clin. Allergy, 15: 151–154.
- Fain, A., 1965. Les acariens nidicoles et detriticoles de la famille Pyroglyphidae Cunliffe (Sarcoptiformes). Rev. Zool. Bot. Afr., 52: 257–286.
- Fain, A., 1967. Deux nouvelles espèces Dermatophagoidinae rattachement de cette sous-famille aux Pyroglyphidae (Sarcoptiformes). Acarologia, 9: 870–881.
- Fain, A. and Johnston, D.E., 1973. *Euroglyphus* (*Gymnooglyphus*) *osu* new species from barn floor in U.S.A. (Acarina: Pyroglyphidae, Sarcoptiformes). Bull. Annu. Soc. Roy. Entomol. Belg., 109: 131–134.
- Fain, A., Guérin, B. and Hart, B.J., 1988. Acariens et Allergies. Allerbio, Varennes-en-Argonne, France, 179 pp.
- Feldman-Muhsam, B., Mumcough, Y. and Osterovitch, T., 1985. A survey of house dust mites (Acari: Pyroglyphidae and Cheyletidae) in Israel. J. Med. Entomol., 22: 663–669.
- Flechtmann, C.H.W., 1986. Ácaros em Produtos Armazenados e na Poeira Domiciliar. Fundação de Estudos Agrários Luiz de Queiroz, Piracicaba, Brazil, 97 pp.
- Gabriel, M., Cunningham, A.M., Allan, W.G.L., Pickering, C.A.C. and Wraith, D.G., 1982. Mite allergy in Hong Kong. Clin. Allergy, 12: 157–171.
- Gomez, M.S., Portus, M. and Gallego, J., 1981. Factores que influyen en la composición de la fauna de ácaros del polvo doméstico. IV. Altitud. Allergol. Immunopathol., 9: 123–130.
- Grیدهlet, D. and Lebrun, P., 1974. Contribution à l'étude écologique des acariens des poussières de maisons. Acarologia, 15: 461–467.
- Haarlov, N. and Alani, M., 1970. House-Dust Mites (*Dermatophagoides pteronyssinus* (Trt.), *D. farinae* Hughes, *Euroglyphus maynei* (Cooreman) Fain) in Denmark. Entomol. Scand., 1: 301–306.

- Halmai, Z., 1984. Changes in the composition of house-dust mite fauna in Hungary. *Parasitol. Hung.*, 17: 59–70.
- Hart, B.J. and Fain, A., 1988. Morphological and biological studies of medically important house-dust mites. *Acarologia*, 29: 285–295.
- Hart, B.J. and Le Merdy, L., 1988. Human dander-free house dust mite extracts. In: A.L. de Weck and A. Todt (Editors), *Mite Allergy — A Worldwide Problem*. UCB Institute of Allergy, Brussels, pp. 47–50.
- Horak, B., 1987. Preliminary study on the concentration and species composition of bacteria, fungi and mites in samples of house dust from Silesia (Poland). *Allergol. Immunopathol.*, 15: 161–166.
- Hughes, A.M., 1976. *Mites of Stored Food and Houses*. HMSO, London, 400 pp.
- Hurtado, I. and Parini, M., 1987. House dust mites in Caracas, Venezuela. *Ann. Allergy*, 59: 128–130.
- Keil, H., 1983. Ökofaunistische Untersuchungen der Hausstaubmilben in Hamburg. *Entomol. Mitt. Zool. Mus. Hamburg*, 7: 343–386.
- Klein, B.S., Rodgers, L.A., Patrican, L.A., Burgdorfer, W., Schell, W.L., Kochel, R.L., Marchette, N.J., McPherson, J.T., Nelson, D.B., Yolken, R.H., Wortmann, D. and Davis, J.P., 1986. Kawasaki syndrome: a controlled study of an outbreak in Wisconsin. *Am. J. Epidemiol.*, 124: 306–316.
- Korsgaard, J., 1982. Preventive Measures in House-Dust Allergy. *Am. Rev. Resp. Dis.*, 125: 80–84.
- Le Merdy, L., Guerin, B. and Hart, B., 1988. Cross-reacting antigens and allergens of mites from house dust. In: A.L. de Weck and A. Todt (Editors), *Mite Allergy — A World-Wide Problem*. UCB Institute of Allergy, Brussels, pp. 42–45.
- Mantle, J. and Pepys, J., 1974. Asthma amongst Tristan da Cunha Islanders. *Clin. Allergy*, 4: 161–170.
- Maunsell, K., Wraith, D.G. and Cunningham, A.M., 1968. Mites and house-dust allergy in bronchial asthma. *Lancet*, ii: 1267–1270.
- Miyamoto, T., Oshima, S., Ishizaki, T. and Sato, S., 1968. Allergenic identity between the common floor mite (*Dermatophagoides farinae* Hughes, 1961) and house dust as a causative agent in bronchial asthma. *J. Allergy*, 42: 14–28.
- Moreira, N.S., 1975. *Acarinos Pyroglyphidae e outros Sarcoptiformes em amostras de pó domiciliar em Belo Horizonte, Minas Gerais*. MS Thesis, Federal University of Minas Gerais, 80 pp.
- Mumcuoglu, Y., 1976. House dust mites in Switzerland I. Distribution and taxonomy. *J. Med. Entomol.*, 13: 361–373.
- Mumcuoglu, Y., 1977a. House dust mites in Switzerland II. Culture and control. *Int. J. Acarol.*, 3: 19–25.
- Mumcuoglu, Y., 1977b. House dust mites in Switzerland III. Allergenic properties of the mites. *Acta Allergol.*, 32: 339–349.
- Mumcuoglu, Y., 1977c. Immunologische untersuchungen von hausstaub und hausstaubmilben. I. Schultz-Dale test. *Allergie und Immunol.*, 23: 107–110.
- Nannelli, R., Liguori, M. and Castagnoli, M., 1983. Osservazioni preliminari sulla biologia di *Euroglyphus (E.) maynei* (Coor.) (Acarina: Pyroglyphidae) e sua distribuzione in Italia. *Redia*, 66: 3–10.
- Noferi, A., Serino, W., Sacerdoti, G. and Blythe, M.E., 1974. Survey on concentration and type of house dust mites (HDM) in dusts of specifically sensitised people in Naples. Preliminary data. *Fol. Allergol. Immunol. Clin.*, 21: 466–469.
- Oshima, S., 1967. Studies on the genus *Dermatophagoides* (Psoroptidae: Acarina) as floor-mites with special reference to medical importance, *Jpn. J. Sanit. Zool.*, 18: 213–216.

- Oshima, S., 1970. Studies on the mite fauna of the house-dust of Japan and Taiwan with special reference to house-dust allergy. *Jpn. J. Sanit. Zool.*, 21: 3–7.
- Penaud, A., Nourrit, J., Autran, P., Timon-David, P. and Nicoli, R.-M., 1972. Données actuelles sur les Acariens Pyroglyphides des poussières de maison. *Ann. Parasitol (Paris)*, 47: 631–662.
- Pinhao, R.C. and Gracio, A.J.S., 1978. House dust mites in Lisbon — a short notice. *An. Inst. Hig. Med. Trop.*, 5: no. 1/4.
- Platts-Mills, T.A.E., Heyman, P.W., Chapman, M.D., Hayden, M.L. and Wilkins, S.R., 1986. Cross-reacting and species-specific determinants on a major allergen from *Dermatophagoides pteronyssinus* and *D. farinae*: Development of a radioimmunoassay for antigen P1 equivalent in house dust and dust mite extracts. *J. Allergy Clin. Immunol.*, 78: 398–407.
- Portus, M. and Gomez, M.S., 1976. Variaciones cuali y cuantitativas de la fauna de ácaros del polvo doméstico en diversas localidades catalanas. *Circ. Farm.*, 34: 547–551.
- Ranganath, H.R. and ChannaBasavanna, G.P., 1988. House dust mites from Bangalore, India — A quantitative analysis. In: A.L. de Weck and A. Todt (Editors), *Mite Allergy — A World-wide Problem*. UCB Institute of Allergy, Brussels, pp. 21–22.
- Rao, V.R.M., Dean, B.V., Seaton, A., and Williams, D.A., 1975. A comparison of mite populations in mattress dust from hospital and from private houses in Cardiff, Wales. *Clin. Allergy*, 5: 209–215.
- Rosa, A.E. and Flechtmann, C.W.H., 1979. Mites in house dust from Brazil. *Int. J. Acarol.*, 5: 195–198.
- Rousset, G., 1971. Contribution à l'étude systématique et écologie des acariens impliqués dans l'allergie respiratoire à la poussière de maison. Thesis, Faculty of Medicine, University of Montpellier, 105 pp.
- Samsinak, K. and Vobrazkova, E., 1985. Mites from the city pavement. *Zentralbl. Bakteriologie Mikrobiol. Hyg.*, 1B (Hyg.), 181: 132–138.
- Samsinak, K., Palicka, P., Vobrazkova, E., Malis, L. and Zitek, K., 1978. Findings of *Sarcoptes scabiei* (Linnaeus, 1758) in the beds of patients with scabies (Sarcoptiformes: Sarcoptidae). *Int. J. Acarol.*, 4: 33–37.
- Sepasgosarian, H. and Mumcoughlu, Y., 1979. Faunistische und Ökologische studien der haustaubmilben in Iran. *Int. J. Acarol.*, 5: 131–137.
- Sesay, H.R. and Dobson, R.M., 1972. Studies on the mite fauna of house dust in Scotland with special reference to that of bedding. *Acarologia*, 14: 384–392.
- Smith, T.F., Kelly, L.B., Heyman, P.W., Wilkins, S.R. and Platts-Mills, T.A.E., 1985. Natural exposure and serum antibodies to house dust mite of mite-allergic children with asthma in Atlanta. *J. Allergy Clin. Immunol.*, 76: 782–788.
- Solomon, M.E., 1969. *Population Dynamics*. Edward Arnold, London, 60 pp.
- Spieksma, F.Th.M., 1967. The house dust mite *Dermatophagoides pteronyssinus* (Trouessart, 1897) producer of the house-dust allergen (Acari: Psoroptidae). Doctoral Thesis, State University of Leiden, 65 pp.
- Spieksma, F.Th.M. and Spieksma-Boezeman, M.I.A., 1967. The mite fauna of house dust with particular reference to the house dust mite *Dermatophagoides pteronyssinus* (Trouessart, 1897) (Psoroptidae: Sarcoptiformes). *Acarologia*, 9: 226–241.
- Stenius, B. and Cunningham, A.M., 1972. House dust mites and respiratory allergy: A qualitative survey of species occurring in Finnish house dust. *Scand. J. Resp. Dis.*, 53: 338–348.
- Takaoka, M. and Okada, S., 1984. Ecological studies on mites in Saitama Prefecture Japan. Seasonal occurrence of the pyroglyphid mites in house dusts in 1981 to 1982. *Jpn. J. Sanit. Zool.*, 35: 129–137. (in Japanese).
- Takaoka, M., Ishii, A., Kabasawa, Y. and Ouchi, T., 1977. Mite fauna in house dusts collected from the residence of asthmatic children. *Jpn. J. Sanit. Zool.*, 28: 237–244.

- Taylor, R.N., 1975. Contribution to the biology and ecology of house dust mites. Doctoral Thesis, University of Glasgow, 98 pp.
- Todorov, D.A., 1979. Mites of the family Pyroglyphidae (Sarcoptiformes) in house dust and methods for their isolation. *Acta Zool. Bulg.*, 13: 64–71 (in Bulgarian).
- Van Bronswijk, J.E.M.H., 1972. Food preference of pyroglyphid house dust mites (Acari). *Neth. J. Zool.*, 22: 335–340.
- Van Bronswijk, J.E.M.H. and Sinha, R.N., 1971. Pyroglyphid mites (Acari) and house dust allergy. *J. Allergy*, 47: 31–52.
- Van Bronswijk, J.E.M.H., Schoonen, J.M.C.P., Berlie, M.A.I. and Lukoschus, F.S., 1971. On the abundance of *Dermatophagoides pteronyssinus* (Trouessart, 1897) (Pyroglyphidae: Acarina) in house dust. *Res. Popul. Ecol.*, 13: 67–79.
- Van Hage-Hamsten, M. and Johansson, S.G.O., 1989. Clinical significance and allergenic cross-reactivity of *Euroglyphus maynei* and other non-pyroglyphid and pyroglyphid mites. *J. Allergy Clin. Immunol.*, 83: 581–589.
- Vervloet, D., Penaud, A., Razzouk, H., Senft, M., Arnaud, A., Boutin, C. and Charpin, J., 1982. Altitude and house dust mites. *J. Allergy Clin. Immunol.*, 69: 290–296.
- Vobrazkova, E., Kasiakova, A. and Samsinak, K., 1986. Analysis of dust samples from the clinical environment of children with eczemas. *Angew. Parasitol.*, 27: 53–55.
- Voorhorst, R., Spieksma, F.Th.M. and Varekamp, N., 1969. House Dust Atopy and the House Dust Mite. *Dermatophagoides pteronyssinus* (Trouessart, 1897). Stafleu's Scientific, Leiden, 159 pp.
- Walshaw, M.J. and Evans, C.C., 1987. The effect of seasonal and domestic factors on the distribution of *Euroglyphus maynei* in the homes of *Dermatophagoides pteronyssinus* allergic patients. *Clin. Allergy*, 17: 7–14.
- Wen, T., Hong, S., Shen, S., Cal, L., Xu, W., Wang, H., Liao, M., Zhuang, Y. and Liu, J., 1988. Preliminary survey of mite allergy in China. In: A.L. de Weck and A. Todt (Editors), *Mite Allergy — A Worldwide Problem*. UCB Institute of Allergy, Brussels, pp. 23–24.
- Wharton, G.W., 1976. House dust mites. *J. Med. Entomol.*, 12: 577–621.
- Yoshikawa, M. and Bennett, P.H., 1979. House dust mites in Columbus, Ohio. *Ohio J. Sci.*, 79: 280–282.
- Yoshikawa, M., Hanaoka, K. and Yamada, Y., 1982. Seasonal changes of mite fauna and population in four concrete apartment houses. *Annu. Rep. Tokyo Metro. Res. Lab. Public. Health*, 33: 299–306.