

ORIGINAL ARTICLE

Occupational allergy to fruit flies (*Drosophila melanogaster*) in laboratory workers

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ABSTRACT

Objectives *Drosophila melanogaster* (the 'fruit fly') is commonly used in genetic research, but there is only one report of IgE-associated allergy in exposed workers. 4 newly identified cases prompted us to examine the extent of this problem in a university laboratory. Our aim in this study is to determine the prevalence and determinants of sensitisation to fruit flies in a population of exposed workers.

Methods In a cross-sectional study, we surveyed 286 employees working in a department carrying out research involving *D. melanogaster*. Sensitisation was assessed by specific IgE measurement in serum and examined in relation to symptoms and to estimated exposure to fruit flies.

Results The overall prevalence of specific sensitisation was 6% with a clear relationship to increasing frequency/intensity of exposure (p trend < 0.001). Work-related eye/nose, chest or skin symptoms were reported by substantial proportions of participants but for most of these there was no evidence of specific sensitisation to fruit fly. The overall prevalence of any work-related symptoms and sensitisation was 2.4%, rising to 7.1% in those working in high exposure groups.

Conclusions We were able to demonstrate, for the first time, a clear exposure–response relationship between fruit fly exposure and specific sensitisation. Facilities housing fruit flies should carefully consider methods to reduce exposure levels in the workplace.

BACKGROUND

Drosophila melanogaster (the 'fruit fly') has been widely used in genetic research for several decades.¹ In the UK, it is estimated that among the several hundred individuals who carry out research work with insects, the annual incidence of occupational asthma is 0.24% and of occupational rhinitis 2.1%;² the proportion of these who work specifically with fruit flies is unknown.

Occupational allergy to various insects has been described^{3–8} but only one report refers to fruit flies. In a small survey of 22 exposed workers, 7 (32%) reported work-related respiratory symptoms, all but one of whom had evidence of specific IgE sensitisation.⁹ The fruit fly extract was immunologically cross-reactive with the cultivation room dust, suggesting that the latter contained constituents of fruit flies, posing a potential source of inhalable fruit fly allergen in the work environment. There was no cross-reactivity between fruit flies and either house dust mite or any of the nutrient

What this paper adds

- ▶ Insects (including *Drosophila melanogaster*) are widely used for research, and within the UK it has been estimated that the annual incidence of occupational asthma and rhinitis to insects is 0.24% and 2.1%, respectively.
- ▶ Little is known about occupational allergy to *Drosophila*. One small study of exposed workers reported that a third of workers had work-related symptoms with evidence of specific sensitisation.
- ▶ We report a far larger cross-sectional survey of workers exposed to fruit flies (n=286) with, an overall prevalence of *Drosophila* sensitisation of 6%, but 15% in those in the highest exposure category.
- ▶ We were able to demonstrate a clear dose–response relationship between estimated fruit fly exposure and sensitisation and, admittedly with very small numbers, a trend for a similar relationship for work-related chest or eye/nose symptoms in the presence of specific sensitisation.
- ▶ Facilities housing fruit flies should carefully consider engineering controls and the use of personal protective equipment to reduce personal exposure, such as those in place for laboratory mice and other species.

constituents such as corn meal, yeast, agar, brown sugar and nipagin.⁹

We became interested in this topic after the identification, in our clinic, of four cases of occupational allergy in workers who were working with fruit flies. Each had measurable levels of serum-specific IgE antibodies to an extract of whole fruit fly as well as upper respiratory tract symptoms; two had asthma, in each case attributed to fruit fly.

The aim of this work was to determine the prevalence and determinants of sensitisation to fruit flies in a larger population of exposed workers.

METHODS

In April 2000, we visited a large academic institute (in which three of our index cases worked and included in this survey) and carried out a confidential, cross-sectional survey of employees working

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within a department carrying out research involving fruit flies; participants either worked directly with fruit flies or worked in or near rooms where such research was being undertaken. The flies were held, in a stock room and an open laboratory, in glass containers stoppered with cotton wool. The laboratory was generally old with poor ventilation.

Of an eligible 1346 persons in the study population, a total of 286 attended (21.4%) the study. On the day of the survey, each participant completed a questionnaire enquiring into the nature of their current and past work with particular reference to the duration, frequency and intensity of work with fruit flies. For each, prior to completion of the survey, we asked participants to categorise their exposure into one of the following four groups:

- ▶ *Frequent high intensity*: participants working principally in areas where fruit flies were kept (alive or dead) and whose work involved direct contact with flies ('transferring', 'pushing' or 'scoring' flies), food preparation in the fly area or cleaning debris from glassware. This work was performed for periods of over an hour most days of the week and for more than half the weeks of the year. The response rate for this group was 72/226 (32%).
- ▶ *Infrequent high intensity*: participants who worked less frequently—for fewer than half the weeks of the year—in areas where fruit flies were kept. The work performed when in these environments, however, included direct contact with flies (as above), food preparation in the fly area or cleaning debris from glassware. The response rate for this group was 19/63 (30%).
- ▶ *Frequent low intensity*: participants who were not working principally in a designated fly area, but worked in the close vicinity of such workspaces on most working days of the year. The response rate for this group was 48/68 (71%).
- ▶ *Infrequent low intensity*: participants who were not knowingly exposed to fruit flies in their daily work, but who worked in the same department where fruit flies were kept (alive or dead) and may have come across them inadvertently. The response rate for this group was 147/989 (15%).

Similarly, participants were asked to select a category of exposure to fly food dust and cotton wool as above.

Through the same questionnaire, we also asked about the presence and relationship to work of any current chest, eye/nose or skin symptoms consistent with an airborne protein allergy.

Following completion of the questionnaire, all participants were invited to undergo skin prick tests with common aeroallergen extracts (mixed grass pollen, house dust mite and cat fur, Allergopharma, Germany). We classified participants as atopic if, to one or more of the common aeroallergen extracts, they had a skin weal with a mean diameter of ≥ 3 mm greater than that to a negative, saline control.

Serum samples were collected from participants, and specific IgE to whole fruit fly extract was determined using an in-house radioallergosorbent assay (RAST). *Drosophila*, collected from the workplace, were extracted in 0.01 mol/L ammonium carbonate overnight at 4°C; the extracts were centrifuged at 500 g at 4°C for 10 min and the supernatant dialysed against distilled water, lyophilised and stored at -20°C until used. Briefly, 3 mg of the allergen was coupled to 300 mg of cyanogen bromide-activated filter paper discs according to the method of Ceska.¹⁰ For the assay, serum (50 μ L) was added to an allergen-coupled disc. Following incubation at room temperature for 16 hours, the disc was washed and ¹²⁵I-anti-human IgE (50 μ L) added. After a further 16 hours, the disc was washed again and the bound I¹²⁵ anti-human IgE quantified using a gamma

scintillation counter. The amount of allergen-specific IgE was expressed as the percentage of the total counts that remained bound to the disc (percentage binding). Participants with a specific serum IgE binding of $\geq 2\%$ were considered sensitised to *Drosophila*.

Comparisons of demographic factors and skin prick test reactions between exposure groups were made using the Kruskal-Wallis test for continuous variables and the χ^2 (or Fisher's exact) test for categorical variables. The χ^2 test for trend was used to test the association of fruit fly sensitivity or work-related symptoms against categories of fruit fly exposure. Associations between immunological responses and work-related symptoms were tested using the χ^2 (or Fisher's exact) test. STATA V13 (College Station, Texas, USA) and EpiInfo were used for all analyses.

Ethical approval was obtained from the Cambridge Local Ethics Committee—LREC 00/24. All participants provided written, informed consent.

RESULTS

A total of 286 workers completed the questionnaire, of whom 277 (95%) underwent skin prick testing and 247 (86%) venepuncture. The overall response rate for the study was 21%.

Characteristics of survey participants, categorised by exposure group, are shown in [table 1](#). Almost a third (32%) worked either directly with fruit flies or in their maintenance; a smaller proportion (17%) worked closely to, or in the vicinity of, other fruit fly workers ('frequent low' exposure) but half (51%) were not knowingly exposed to fruit flies, but worked in the same department where research was carried out. There were few important differences between the groups except that workers in the low exposure groups were more likely to report urticaria ($p < 0.05$). A total of 124 (45%) of the participants who were skin tested were atopic, a proportion that was constant across the exposure groups; the prevalences of positive skin tests to extracts of house dust mite and house fly were similarly distributed. Gender did not affect the distribution of findings by exposure.

Among those who provided a blood sample, the overall prevalence of sensitisation to fruit fly was 6%, rising to 15.4% in those working in the highest exposure group ([table 1](#)). There was a clear relationship between specific sensitisation and increasing frequency/intensity of exposure to fruit flies (p trend < 0.001). The prevalence of specific sensitisation was almost 10 times higher in the highest than lowest exposure group (15.4% vs 1.6%).

Work-related eye/nose (26%), chest (14%) or skin symptoms (16%) were reported by substantial proportions of participants but for most of these there was no individual evidence of specific sensitisation to fruit fly ([table 1](#)); and no significant exposure-response relationship between their prevalence and exposure categories ([table 1](#)).

The overall prevalence of any work-related symptom in the presence of *Drosophila* sensitisation was 2.4%, rising to 7.1% in those working in the highest exposure group ([table 1](#)). Sensitised participants with work-related chest or eye/nose (but not skin) symptoms were almost all working in the highest exposure category ([table 1](#)). Participants who reported work-related chest symptoms were more likely to be sensitised than those without chest symptoms (12.5% vs 5.1%, $p = 0.103$), but this was not the case with either work-related skin or eye/nose symptoms.

An exploration of potential alternative causes of work-related symptoms failed to demonstrate any relationship between their

Table 1 Participant characteristics and specific sensitisation/symptoms by estimated exposure to *Drosophila*

	Exposure group				p Value
	High and frequent n=72 (25%)	High but infrequent n=19 (7%)	Low and frequent n=48 (17%)	Low and infrequent n=147 (51%)	
Age, years: median (range)	31 (19–61)	28 (22–48)	33 (22–64)	32 (21–64)	0.149
Male; n (%)	33 (46)	11 (58)	21 (43.8)	55 (37.4)	0.292
Duration of employment, years: median (range)	2.2 (0.1–22.3)	2.4 (0.2–26.3)	3.0 (0.1–31.7)	2.5 (0.02–38.7)	0.581
Prior asthma; n (%)	10 (14)	2 (11)	10 (21)	20 (14)	0.659
Prior hayfever; n (%)	16 (22)	5 (28)	14 (30)	38 (26)	0.822
Atopy; n (%)	30 (44)	8 (42)	23 (50)	63 (44)	0.888
+SPT HDM; n (%)	24 (35)	6 (32)	12 (26)	36 (25)	0.452
+SPT house fly; n (%)	11 (16)	3 (16)	7 (15)	14 (10)	0.507
Venepuncture; n (%)	65 (90)	17 (89)	40 (83)	125 (85)	0.961
<i>Drosophila</i> specific IgE; n (%)*	10 (15)	1 (6)	2 (5)	2 (2)	<0.001
Work-related symptoms					
Any work-related symptoms	26 (36)	9 (47)	20 (42)	48 (33)	0.472
Chest; n (%)	12 (17)	2 (11)	5 (10)	20 (14)	0.601
Eye/nose; n (%)	22 (31)	6 (32)	16 (33)	31 (21)	0.114
Skin; n (%)	9 (13)	3 (16)	7 (15)	26 (18)	0.322
	High and frequent n=72	High but infrequent/low and frequent/low and infrequent n=214			
Work-related symptoms with specific IgE to <i>Drosophila</i>					
Any work-related symptoms	5 (7)	2 (1)			0.014
Chest; n (%)	3 (4)	1 (0.5)			0.052
Eye/nose; n (%)	4 (6)	1 (0.5)			0.017
Skin; n (%)	1 (1)	2 (1)			1.000

HDM, house dust mite; SPT, skin prick test.

*Of those with blood sample (n=247).

Table 2 Work-related symptoms by estimated cotton-wool exposure among fruit fly exposed participants

Symptoms	Estimated exposure to cotton wool				p Value
	High and frequent n=59 (21%)	High and infrequent n=20 (7%)	Low and frequent n=33 (12%)	Low and infrequent n=172 (61%)	
Any work-related symptoms	24 (40.7)	6 (30.0)	13 (39.4)	60 (35.1)	0.51
Chest	11 (18.6)	1 (5.0)	5 (15.1)	22 (12.8)	0.38
Eye/nose	20 (33.9)	5 (25.0)	5 (15.5)	45 (26.2)	0.29
Skin	8 (13.6)	2 (10.0)	7 (21.2)	28 (16.4)	0.57

prevalence and an estimate of exposure to cotton wool (table 2) or to dust produced during fruit fly food preparation (data not shown).

DISCUSSION

From this comparatively large, cross-sectional survey of staff at an academic institute, we report specific *Drosophila* sensitisation among workers exposed to fruit flies with an overall prevalence of sensitisation of 6%, but 15% in those in the highest exposure category. We were able to demonstrate a clear dose–response relationship between estimated fruit fly exposure and sensitisation and, admittedly with very small numbers, a trend for a similar relationship for work-related chest or eye/nose symptoms in the presence of specific sensitisation.

To the best of our knowledge, there has only been one other survey of respiratory allergy to laboratory fruit flies;⁹ there, among 22 exposed workers, 10 had evidence of specific sensitisation to *Drosophila melanogaster* as demonstrated by skin prick testing and the identification of specific IgE antibodies. Seven (32%) had work-related respiratory symptoms, six of them with specific sensitisation; all seven reported nasal symptoms, four additional chest and three eye symptoms. The prevalences of sensitisation and of work-related symptoms in our survey were lower, which may reflect lower exposures over a decade later than the earlier survey. Curiously, we found a far higher prevalence of work-related symptoms that could not readily be attributed to fruit fly sensitisation and bore no relationship with estimates of exposure to either fruit fly or cotton wool fibres. One likely explanation is that the symptoms in our survey were identified through a self-completed questionnaire whereas those from the earlier study were established from face-to-face interviews ‘until an unequivocal temporal relation ... could be confirmed or excluded’. Alternative explanations include the possibility of an allergic response to associated antigens including, perhaps, those from parasitic mites which sporadically infest fruit fly cultures; or a response to endotoxin, which may be present in fruit fly laboratories. Aerosolised endotoxin triggers nasal and other symptoms in technicians and research scientists during experimental animal work, even in those workers who are not sensitised to laboratory animals.¹¹ Another explanation may be due to sick-building syndrome where non-specific symptoms may be due to old facilities, which are hard to clean thoroughly, and may well provoke non-specific symptoms.

Allergic reactions to a variety of insects including locusts, crickets, houseflies, blowflies and screwworms have been well

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documented in laboratory animal workers and entomologists.¹² The prevalence of either asthma or upper respiratory symptoms in entomologists was reported in six studies and ranged between 3 and 30%.¹² Very little information is available regarding the allergens produced by these insects and whether there are any similarities between them.

A significant limitation of this survey is its low participation rates, particularly in those whose work involved direct contact with flies. While we cannot be sure, we have no reason to believe that any bias in recruitment with respect to sensitisation would correlate with the four categories of exposure intensity/frequency. Indeed, it is possible that our estimate of the prevalence of sensitisation among those with the highest exposure might underestimate the true figure, if workers who suspected that they had allergic symptoms did not participate through concerns regarding their employment.

This study indicates that workers exposed to laboratory fruit flies are at risk of specific sensitisation and work-related symptoms; the risk—particularly of sensitisation—appears to be related directly to the level of exposure. Facilities housing fruit flies should carefully consider methods to contain exposure in the workplace, such as those in place for laboratory mice and other species. These methods include engineering controls, careful attention to tasks that involve direct exposure and the use of personal protective equipment. Regular health surveillance of exposed personnel should be considered. Employees who report work-related symptoms should be invited to undergo testing for specific sensitisation; those whose symptoms are attributed to a specific allergy should be advised to control further exposure at work.

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Contributors MJ interpreted data, wrote the manuscript and involved in the conception and design of the study. SB acquired data, involved with the design of

the study and critically reviewed the manuscript. SM interpreted the data. JW acquired the data. AH acquired the data and involved with the design of the study. PB involved with the design of the study and critically reviewed the manuscript. PC conceived and designed the study and critically reviewed the manuscript.

Competing interests None declared.

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REFERENCES

- 1 Matthews KA, Kaufman TC, Gelbart WM. Research resources for *Drosophila*: the expanding universe. *Nat Rev Genet* 2005;6:179–93.
- 2 Draper A, Newman Taylor A, Cullinan P. Estimating the incidence of occupational asthma and rhinitis from laboratory animal allergens in the UK, 1999–2000. *Occup Environ Med* 2003;60:604–5.
- 3 Wahl R, Fraedrich J. Occupational allergy to the housefly (*Musca domestica*). *Allergy* 1997;52:236–8.
- 4 Tee RD, Gordon DJ, Lacey J, et al. Occupational allergy to the common house fly (*Musca domestica*): use of immunologic response to identify atmospheric allergen. *J Allergy Clin Immunol* 1985;76:826–31.
- 5 Tee RD, Gordon DJ, Hawkins ER, et al. Occupational allergy to locusts: an investigation of the sources of the allergen. *J Allergy Clin Immunol* 1988;81:517–25.
- 6 Harris-Roberts J, Fishwick D, Tate P, et al. Respiratory symptoms in insect breeders. *Occup Med (Lond)* 2011;61:370–3.
- 7 Suarathana E, Shen A, Henneberger PK, et al. Post-hire asthma among insect-rearing workers. *J Occup Environ Med* 2012;54:310–17.
- 8 Focke M, Hemmer W, Wöhrl S, et al. Specific sensitization to the common housefly (*Musca domestica*) not related to insect panallergy. *Allergy* 2003;58:448–51.
- 9 Spiekma FT, Vooren PH, Kramps JA, et al. Respiratory allergy to laboratory fruit flies (*Drosophila melanogaster*). *J Allergy Clin Immunol* 1986;77(1 Pt 1):108–13.
- 10 Ceska M, Eriksson R, Varga JM. Radioimmunosorbent assay of allergens. *J Allergy Clin Immunol* 1972;49:1–9.
- 11 Pacheco KA, McCammon C, Liu AH, et al. Airborne endotoxin predicts symptoms in non-mouse-sensitized technicians and research scientists exposed to laboratory mice. *Am J Respir Crit Care Med* 2003;167:983–90.
- 12 Stanhope J, Carver S, Weinstein P. The risky business of being an entomologist: a systematic review. *Environ Res* 2015;140:619–33.



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