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Citizen scientist lepidopterists exposed to potential carcinogens

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ABSTRACT

Lepidopterists use substantial volumes of solvents, such as chloroform, 1,1,2,2-tetrachloroethane and xylene, in their traps when collecting faunistic and phenological data. A majority of them are citizen scientists and thus in part not identified by occupational healthcare as being at risk due to solvent handling. We surveyed the extent of solvent use, the frequency and extent of potential exposure and the safety precautions taken in trapping and catch handling by Finnish lepidopterists.

Chloroform and 1,1,2,2-tetrachloroethane were the most frequently used anaesthetics. Potential for exposure prevailed during trap maintenance and exploration and catch sorting. Adequate protection against vapours or spills was worn by 17% during trap exploration. Subjects completed a median of 100 trap explorations per season. Dermal or mucosal spills were recorded at a median rate of one spill per ten (chloroform) to 20 (1,1,2,2-tetrachloroethane and xylene) trap explorations. Median annual cumulative durations of 8 and 20 h of exposure to chloroform and 1,1,2,2-tetrachloroethane at levels above odour detection threshold were reported. Subjective adverse findings possibly related solvents had been noticed by 24 (9.8%) lepidopterists. All the events had been mild to moderate.

No factor predicting unsafe procedures or adverse reactions was recorded despite thorough statistical testing.

1. Introduction

Anaesthetics or killing agents are practically essential tools in entomological field research. Volatile organic compounds have been and remain frequently used for this purpose. This is in large part due to their easy handling as liquids at ambient temperature combined with high volatility and insecticidal properties.

Long time series of local faunistic and phenological studies are important in collecting data on the effects of environmental changes, such as global warming. For this purpose bait and light traps are frequently used, and large volumes of solvents are used in sample collection. For more than 50 years, chloroform and 1,1,2,2-tetrachloroethane have been the compounds most frequently applied into killing jars explored with several day intervals, whilst ethyl acetate has mainly been used in traps explored and maintained daily (Jalas, 1975; Schauff, 2001). By the end of the 20th century the access to chloroform and 1,1,2,2-tetrachloroethane became only available for research use. Since then substituting agents have been sought for. Among those, ammonia solution has been used to some extent in daily maintained traps. Xylene, in its turn, has evoked interest for use in less frequently explored traps, assumingly because of its affordable price and easy availability as a mixture of dimethylbenzene isomers.

Volatile organic compounds are a well-known health hazard when used as solvents at home or in workplaces. A long-term exposure to solvents may cause neurological defects, such as chronic solvent encephalopathy. Along decennia solvent-based products, especially paints, have in large part been replaced with water-based products (Wieslander et al., 1994), and a decline in incidence of chronic solvent encephalopathy has been documented (Triebig and Hallermann, 2001). However, these glycol containing compounds possess reproductive toxicity (Gray et al., 1996). Furthermore, haloalkanes such as chloroform and 1,1,2,2-tetrachloroethane have been classified as possibly carcinogenic to humans by IARC (group 2B), the liver and, with regard to chloroform, the kidney being the suspected target organs (IARC, 1999, 2014). Significant measures have been undertaken to reduce the exposure to these agents, including legislation as well as search for

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substituents and use of personal protection. Nevertheless, subacute poisonings with target-organ toxicity appear infrequently, such as an epidemic in Fujian province in China, where 18 workers handling tetrachloroethane-containing glue presented with gastrointestinal symptoms and substantially increased hepatic enzymes in circulation (Zheng et al., 2012).

There is a risk of exposure to the solvents used as killing agents in entomological field research. This applies especially to moth trapping, which mainly is utilised in Scandinavia, Russia, the Baltics and on the British Isles as well as in North America. Typically the anaesthetic in a trap is dosed in a polyethylene vial and allowed to vaporise into the killing jar. Thus, any time the jar is opened the field worker is at a risk of exposure to solvent fumes and there is a potential of dermal solvent spills. Although the single exposures are of short duration, the hundreds to thousands annual repeats lead to a potentially significant cumulative exposure. In addition to the trap maintenance and catch collection task, further, mainly inhalational, exposure may occur upon catch exploration and sorting, which may take hours in continuum.

The toxicity of the haloalkanes is recognized among both professional and amateur entomologists, and these compounds are used with research permission only. However, no survey has been conducted to record the practices and use of personal protective equipment upon handling the solvents. There are no data publically available on the solvent exposure among lepidopterists or other hobbyists, such as scale model builders, potentially at risk. Since xylene has only recently gained popularity and its availability is not controlled, the amount used and number of entomologists using it can hardly be estimated. Furthermore, the attitudes towards handling killing agents may vary substantially.

Whichever volatile organic compound is considered, not much is known about the duration or level of exposure among entomologists. However, the volumes typically used in the light and bait traps of active lepidopterists are not insignificant. A professional or an active amateur lepidopterist may pour dozens of litres of xylene or chloroform or many litres of 1,1,2,2-tetrachloroethane into the poison containers in the killing jars over a catching season. Exposure to these volatile organic compounds then potentially reoccurs upon collecting and sorting the catch. The exposure may thus occur via inhalation and through the skin.

We conducted this study to find out the attitudes towards and the estimated exposure to organic solvents among Finnish lepidopterists in order to identify factors associated with subjective symptoms secondary to exposure to volatile organic compounds.

2. Methods

2.1. Target group

A self-administered interview form was sent to members of Lepidopterological Society of Finland (Suomen Perhostutkijain Seura) per the contact details in the membership directory. Among the 1130 subjects in the target group, 608 lepidopterists were approached by e-mail contacts and 522 by surface-mailed letters. The request was to fill in the questionnaire if the recipient used killing agents in moth traps of any type. A description of file was composed to describe the handling of personal data as set out in the local legislation.

2.2. Questionnaire

The questionnaire comprised 97 items in 23 self-standing questions. The demographic variables included gender, age and region of residence. The moth-trapping history was asked for entire trapping duration as single figure in years and for duration of using various poisons, mainly organic solvents, using a 2-based logarithmic scale. Volume of each solvent used during the latest catching season was enquired in litres using a 2-based logarithmic scale. The means of personal protection in handling and maintaining the traps as well as in handling and sorting the catch were enquired. Furthermore, the trap maintenance and catch collection repeats in total and potential exposure situations per killing agent were asked, as were the observed spills on skin or mucosal surface and sensing the smell of an anaesthetic upon sorting the catch.

The attitude towards solvents was tested asking how the subjects react upon spills, if they freeze their catch at all or in kitchen or dedicated sample freezers, where they handle the open killing jars and where they sort the catch.

Finally the subject was asked if he or she had ever experienced untoward symptoms due to solvent handling over a four-point intensity and seriousness scale: 1. never, 2. mild treated at home, 3. mild to moderate symptoms with physician contacted, 4. serious event treated in hospital. At the end, a subjective assessment of the adequacy of personal practices in terms of safety was to be graded over a three-step scale: 1. sufficient in preventing health hazard, 2. mostly adequate for purpose, 3. inadequate.

2.3. Statistics

Continuous variables are presented using mean, standard deviation, median, minimum and maximum values. Categorical variables are presented using frequencies and percentages. The associations between categorical variables were analysed using chi-square test. The differences in non-normally distributed variables between two groups were tested with Mann–Whitney U-test. Age and the duration of trapping between the classes of subjective assessment of adequacy of protection were compared using 1-way analysis of variance. Non-normally distributed variables were analysed using Kruskal–Wallis test, and further pairwise comparisons were done with Mann–Whitney U-test using Bonferroni adjustment for p-values. All p-values were calculated with two-sided tests and p-values lower than 0.05 were considered statistically significant. Statistical analyses were performed with SAS System for Windows, version 9.4 (SAS Institute Inc., Cary, NC).

3. Results

3.1. Demographics

Out of the 1130 contacted members of Lepidopterological Society of Finland, 311 responded. These included one explicit refusal, two technical barrier issues, 33 announcements of no solvent exposure and 44 censored interviews due to no trapping or no use of solvents. Thus, altogether 231 interviews qualified for analysis. Four responders were female and 227 were male. The median age was 52.5 (range 13–88; mean 53, SD 13) years. Twenty responders were professional and 210 were hobbyist entomologists. The geographic distribution of responders compared with population distribution in Finland.

3.2. Trap structure and phases of potential exposure

In the most commonly used moth traps (Fig. 1), a lure (a bait or light source) was located above or within a funnel, which, in its turn, penetrated and was attached to the lid of a plastic killing jar. The floor of the killing jar was most typically covered by a sheet of softening foam plastic and pieces of egg carton on it. The killing agent was stored in liquid form in a polyethylene vial (50–250 mL) and was allowed to volatilise and to escape into the jar atmosphere through a punched hole in the upper part of the vial, often via a