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ORIGINAL PAPER

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Susceptibility of head lice (*Pediculus humanus capitis*) to pediculicides in Australia

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Abstract Infestation with head lice, *Pediculus humanus capitis,* is a worldwide problem, especially among primary (elementary) school children. Although studies in many different countries indicate lower levels of susceptibility to certain insecticides than expected (''resistance''), there is no empirical data from Australia. Data on the susceptibility of head lice to malathion, pyrethrums and permethrin were collected from four schools in Brisbane and one school in northern Queensland. Since no completely susceptible strain of head lice was available and head lice are difficult to keep in culture, a completely susceptible strain of body lice, *Pediculus humanus humanus*, was used for reference. All five groups of head lice were less susceptible to malathion, pyrethrums and permethrin than were lice from the reference strain. Moreover, the degree of susceptibility to these insecticides varied substantially among schools. Thus, a pediculicide that controlled lice at one school in Brisbane would not necessarily control head lice at another school in the same city. These preliminary data indicate that detailed information on the susceptibility of the different populations of head lice in Queensland to the different insecticides available is needed to maximize the chance of effective control of these increasingly common parasites.

Introduction

Goldsmid (1990) reported the first evidence of the failure of pediculicides to control head lice (*Pediculus humanus capitis)* in Australia. This evidence was from Tasmania in southern Australia. While anecdotal reports suggest that certain pediculicides fail to control certain populations of head lice and that the prevalence of resistance to pediculicides in head lice is increasing in Australia and elsewhere, there have been only a handful of papers with empirical data on the susceptibility of head lice, and none from Australia. Doubtless, this is due to the difficulty of working with live head lice. Head lice are difficult to maintain in culture and have short lives when removed from the host. We report the first empirical data on the susceptibility of head lice to pediculicides in Australia.

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Materials and methods

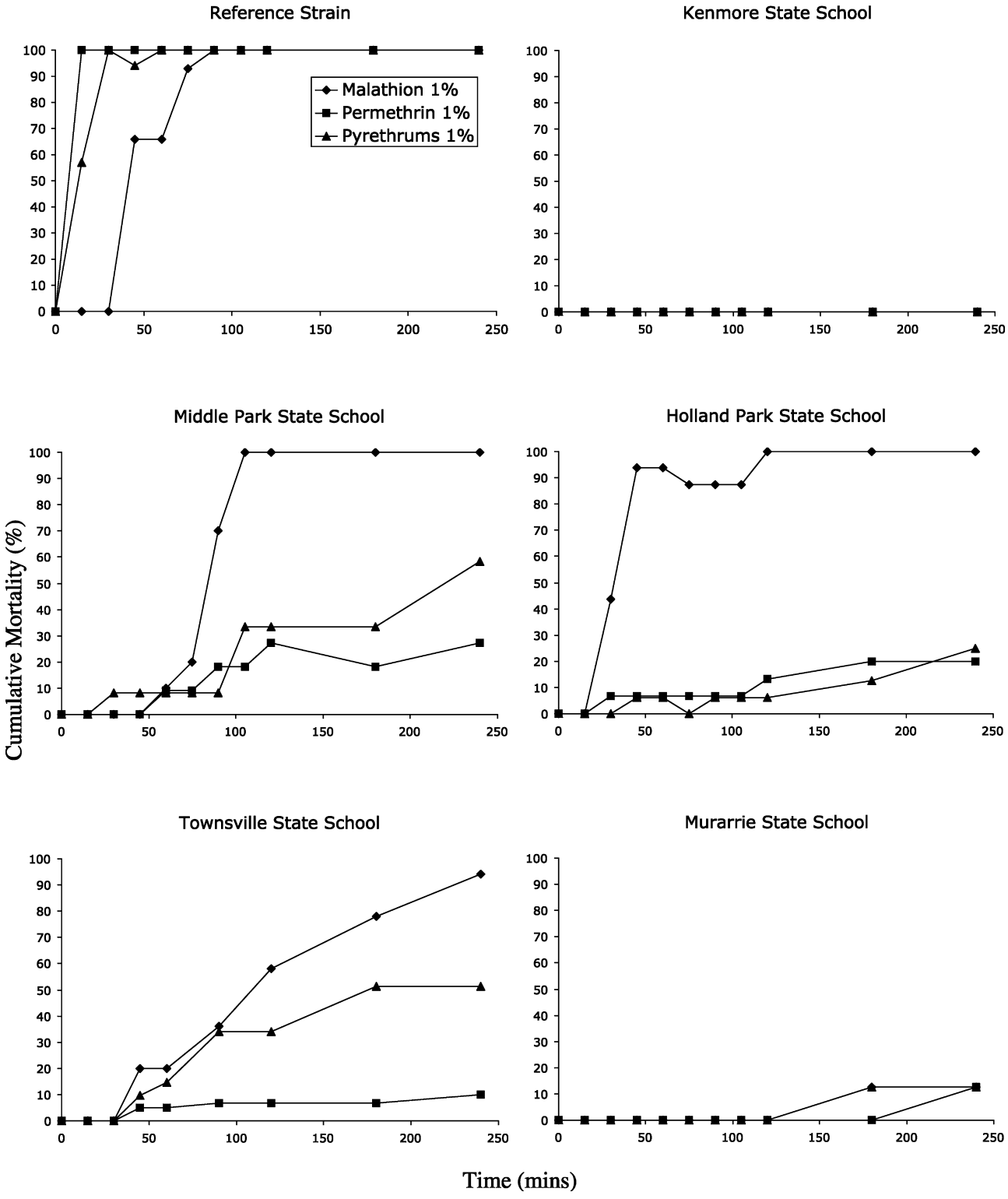
We used the World Health Organisation (WHO)-style filter-paper kill-assay to measure the susceptibility of head lice to malathion (organophosphate), pyrethrums (natural pyrethroids) and permethrin (synthetic pyrethroid). Since no insecticide-susceptible strain of head lice is available, a colony of body lice, *Pediculus humanus humanus*, which is completely susceptible to insecticides, was used for reference. This colony was founded from the colony of Culpepper (1948), and was kindly supplied to us by Dr. K. Mumcuoglu (Department of Parasitology, Hebrew University, Hadassah Medical School, Jerusalem, Israel). Body lice were maintained in the laboratory by feeding daily on rabbits (Mumcuoglu et al. 1995). In between feeds, the lice were kept at 30–32°C and 70–80% relative humidity. Head lice were collected by dry-combing from the hair of one to ten children from four primary (elementary) schools in Brisbane, Queensland, and a primary school in northern Queensland (Townsville State School). Since only small numbers of lice were collected, these were pooled for the kill-assays.

Technical grade malathion, pyrethrums (50% concentration) and permethrin was kindly donated by Biotech Industries, Brisbane, Australia. The WHO-style filter-paper kill-assay was used to

Fig. 1 Percent cumulative mortality of the reference strain (laboratory colony of completely insecticide-susceptible body lice) and head lice from five schools in Queensland, Australia. Malathion is represented by a *diamond*, permethrin by a *square* and pyrethrums by a *triangle*. At Kenmore State School there was zero mortality for all three insecticides 240 min after first exposure. For Murrarrie State School the mortality at 180 min was 13% for both malathion and pyrethrums and 0% for permethrin; at 240 min, all pediculicides had caused a cumulative mortality of 13%. These data are not obvious from the figure

measure the mortality of lice. These insecticides were prepared as 1% volume/volume solutions in silicone fluid (a solvent for crystalline insecticides like permethrin and pyrethrums) (Dow Corning 556). Each solution was mixed 1:1 with acetone to facilitate impregnation of filter papers (Whatman no. 4). The filter papers were evenly spread with 1 ml of the mixture, and then left to dry in a fume hood so that the acetone could evaporate. Filter papers were then stored in aluminium foil at 4°C until use. Control papers (no insecticides) were treated with silicone fluid and acetone only.

Adult lice and third-stage nymphs were tested in batches of ten or more insects. Mortality was recorded every 15 min for up to 24 h after first-exposure. Groups of ten lice from the reference strain were placed on filter papers treated with silicone fluid and acetone only. Mortality was defined as the inability of a louse to right itself when rolled onto its back.



Results and discussion

The reference strain of body lice, as expected, was highly susceptible to permethrin at a concentration of 1% with almost immediate responses, i.e. seizures. In most tests, 100% mortality was recorded at the first reading (15 min). Responses to pyrethrums were slower than to permethrin and malathion but there was at least 50% mortality after 1 h and 100% mortality after 3 h. In most tests with malathion there was 100% mortality after 1 h. No difference in mortality was evident from papers that were fresh and those that were up to 3 months old (stored at 4°C).

The susceptibility to malathion, pyrethrums and permethrin of the head lice tested varied substantially among schools (Fig. 1). For example, the lice from Kenmore State School and Murarrie State School were not susceptible to malathion (0% and 13% mortality after 240 min), yet 94–100% of lice from the other schools were dead after 240 min exposure.

These preliminary data indicate that particular insecticides are likely to be more effective in some school than others. This is consistent with anecdotes that certain pediculicides control lice at one school, but not at other schools in Brisbane. Detailed information about the degree of susceptibility of different populations of head lice in Queensland to the available insecticides is needed to maximize the chances of effective control.

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