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An Australian Experience of Using Work Practices to Establish an Exposure Model for Shearers

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This is an example of a national regulatory approach in estimating worker exposure to pesticide residues in wool. © 2001 British Occupational Hygiene Society. Published by Elsevier Science Ltd. All rights reserved

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INTRODUCTION

Sheep ectoparasiticides are widely used in Australia. Occupational exposure to residues of these pesticides in wool is of concern. The National Occupational Health and Safety Commission (NOHSC) has developed the following approach in order to conduct a risk assessment for workers re-handling treated sheep or wool. Workers considered in the risk assessment include wool handlers (e.g. roustabouts, wool classers and wool pressers) and sheep handlers (e.g. shearers and farmers involved in husbandry activities).

This approach has been developed after wide consultation with woolgrowers and the agrochemical industry. Assumptions incorporated in the risk assessment methodology were based on the work practices in the wool industry (Anon, 1999).

The risk assessment takes into account the **exposure** and the **hazard** associated with the chemical. NOHSC has defined an exposure model to estimate the maximum level of exposure to chemical residues when handling treated sheep or wool fleece. While this model is similar to approaches of other regulators (USA, Canada, Europe) to establish exposure during re-entry of treated crop fields, it is innovative in that it estimates worker exposure to treated animals.

ESTABLISHMENT OF AN EXPOSURE MODEL

Work practices among wool and sheep handlers were comprehensively reviewed (Anon, 1999). It was determined that because of the type of contact and duration of exposure, shearers comprised the group most exposed to chemical residues in wool. The present model reflects shearers' exposure.

The level of exposure resulting from pesticide use depends on factors such as work practices, residue levels on the sheep/fleece and percutaneous absorption properties of the chemical. The percutaneous absorption of the chemical is also influenced by the chemical relationship with the wool wax (or more accurately the wool yolk) and is described below.

Raw (greasy) wool is composed of fibre and yolk. The yolk is a dispersion of wool wax, suint (solid sweat including minerals), proteinaceous skin flakes, moisture and dirt. Most of the moisture in the wool/yolk composite is bound to the proteinaceous material (keratin), which makes up the fibre (personal communication, Dr Russell, CSIRO, Australia).

Chemical residues in wool are considered to be associated with the wool yolk on the surface of the fibre with a preference for either the wax (lipophilic chemicals) or the moisture of the wool yolk (hydrophilic chemicals). Both lipophilic and hydrophilic chemicals are either 'dissolved' in the wool yolk or present as particles, depending upon their solubility characteristics and their concentrations (personal communication, Dr Russell, CSIRO, Australia).

The interactions between wool yolk, the chemical and human skin have been previously reviewed in 1989 by the Australian Working Party on Pesticide Residues in Wool. For example, lanolin is known to soften the stratum corneum but not to penetrate into the dermis. This means that lipophilic pesticides contained in wool wax are expected to remain on the surface of the skin while hydrophilic pesticides are likely to penetrate. However, other factors such as

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increased body temperature during exercise, sweat and the reservoir properties of the stratum corneum may affect the rate of penetration of the chemicals into the skin. It is considered that there is potential for all the wool wax to penetrate into the skin and that 100% of pesticides contained in wool wax can reach the systemic circulation (Working Party on Pesticide Residues in Wool, 1989).

Previous studies have demonstrated that human skin is more selective than rat skin, so percutaneous absorption factors derived from rat skin studies may be overestimations (Russell and Nunn, 1991; Moody and Nadeau, 1994). While wool wax may prevent chemicals from entering into the skin, perspiration was found to increase skin penetration (Russell and Nunn, 1991). It is suggested that the vehicle used in percutaneous studies be in a lipid formulation similar to wool wax lipids (e.g. lanolin) and mixed with artificial perspiration.

Amount transferred to shearer/handler

Worker exposure to chemical residues is considered to occur by contact with wool and transfer from wool yolk to skin. Because of the relationship of the chemical with wool yolk, as a worst case scenario, 100% of residues bound to the wool yolk are considered available for transfer to skin.

In this model, residues are considered to be distributed uniformly along the wool fibre (from tip to base). It is recognised that oxidation of chemicals and wool wax may occur at the top of the fleece, but equally there is evidence that significant levels of residues may remain at the tip of the fibre (Johnson *et al.*, 1995a,b, 1996). In any case, as shearers will be in contact with the total fleece, this assumption does not affect the risk assessment. Any scientific evidence against this assumption, which is relevant to the chemical being assessed, will need to be provided.

The chemical exposure (E) is estimated by using:

(a) Residue data (R) in g/kg wool, at time of shearing

Residues decrease with time after application. Residue data generated from field trials as per the *Guidelines for Conducting Residue Trials* (developed by the Australian National Registration Authority) are preferred rather than estimates. Residue estimates may be provided using recently developed models on residue dissipation for sheep ectoparasiticides (Campbell *et al.*, 1998).

(b) 13% Wool wax/yolk in total wool

All residues are considered to be contained in wool wax/yolk. The wax content in wool depends on the wool quality: it is around 13% in Australia (McLennan, 1998).

(c) Wool wax exposure

Exposure to wool wax has been estimated to be 23 g per day per shearer, based:

- on body surface (front half of body: 9000 cm^2; based on the whole body surface value (18 000 cm^2; World Health Organisation, 1982) and
- on the maximum amount of wool wax estimated to adhere to the skin (2.5 mg/cm^2).

This value of 23 g was generated by the Australian Working Party on Pesticide Residues in Wool (1989). It is considered to be an overestimation (personal communication, Dr Russell, CSIRO, Australia). However, it is presently used as a default value because of the absence of data.

(d) Shearer/worker weight: 70 kg

Pesticide exposure (in g/kg body weight per day):

$$E = \frac{\underset{\text{(g/kg wool)}}{R} \times \underset{\text{(wool wax in kg)}}{0.023}}{\underset{\text{(\% wax in wool)}}{0.13} \times \underset{\text{(shearer weight in kg)}}{70}}$$

Residue distribution in wool and impact upon exposure

Due to the application method, pesticide residues may not be distributed uniformly on the animal. Worker exposure data which demonstrate that shearers or other workers may only be in contact with some parts of the sheep can be provided for consideration. The above equation can then be modified by decreasing the amount of wool wax per shearer.

RISK ASSESSMENT

The shearing season in each area of Australia lasts approximately 3–6 months; however, itinerant shearers may shear for 6–9 months/yr. Shearers may also be involved in husbandry activities (i.e. Crutching which consists in removing wool around the genitals) between shearing seasons. Therefore, it is considered that these workers will be exposed on a long-term basis to chemical residues in wool.

Margins of exposure (MOE) are calculated with the most appropriate no observable effect levels (NOEL) that determine the level of risk to workers repeatedly exposed to pesticide residues. MOE are calculated using NOEL established from dermal or chronic oral studies. When an oral NOEL is used, a dermal absorption factor needs to be taken into account in the calculation of the MOE (Anon, 1999).

CONCLUSIONS

The present model has required a comprehensive understanding of work practices in the wool industry and wide consultation with stakeholders. It is flexible in that data challenging the various assumptions such as the level of chemical absorption through skin can be provided to refine the assessment.

This model has considered the significant role of the wool wax/yolk as a vector in chemical absorption.

Similar considerations should be taken into account when establishing exposure models for agricultural chemicals. The roles of the formulation of agricultural products should be incorporated in exposure models for a better outcome for agricultural workers.

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