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ScienceDirect
Applied Soil Ecology 35 (2007) 546–552
Applied Soil Ecology
www.elsevier.com/locate/apsoil

Reproduction of the dung beetle (*Copris tripartitus*) in the dung of cattle treated with cis-cypermethrin and chlorpyrifos

Hea Son Bang [a,*], Joon-Ho Lee [b], Young Eun Na [a], Richard Wall [c]

[a] *National Institute of Agricultural Science and Technology, RDA, Suwon 441-100, Republic of Korea*
[b] *School of Agricultural Biotechnology, Seoul National University, Suwon 441-744, Republic of Korea*
[c] *School of Biological Sciences, The University of Bristol, Woodland, Bristol, BS8 1UG, UK*

Received 12 June 2006; received in revised form 19 September 2006; accepted 22 September 2006

Abstract

Fresh dung was collected from untreated cattle and cattle dosed with a spray-on formulation of high cis-cypermethrin and chlorpyrifos (2.1 g/cow), on days 1, 3, 5 and 7 post-treatment. The survival and reproduction of the dung beetle *Copris tripartitus* Waterhouse, when given this dung was assessed. Residues of high cis-cypermethrin and chlorpyrifos in dung collected 1 day after treatment were sufficient to inhibit oviposition by female *C. tripartitus*. However, there was no significant effect on egg-laying in dung collected at days 3, 5 or 7 days post-treatment. In a second generation of *C. tripartitus*, derived from beetles fed the dung from treated animals, residues in dung collected both 1 and 3 days after treatment were sufficient to inhibit oviposition, and residues in dung collected 1 day after treatment inhibited dung consumption by newly emerged adults of *C. tripartitus*. It is concluded that dung voided by cattle treated with a spray-on formulation of high cis-cypermethrin and chlorpyrifos have toxic lethal effects for 1 day post-treatment and sub-lethal toxic effects on ovarian condition and brood-ball production in dung voided at 1 and 3 days post-treatment. The potential ecotoxic effects of these compounds are discussed in terms of dung beetle activity and strategies for parasite control of cattle in the Korean environment.

Keywords: Dung beetles; Antiparasiticide; Reproduction; Synthetic pyrethroid

1. Introduction

Dung beetles are of considerable ecological and economical importance, especially in tropical and subtropical regions, because of their role in the decomposition of animal excrement, the recycling of nutrients and the resulting enhancement in the productivity of grassland ecosystems (Bornemissaza, 1976).

In Korea, there are about 90 species of dung beetle belonging to 5 subfamilies and 11 genera (Kim, 1994). Species of the genus *Copris*, such as *Copris tripartitus*, play a particularly important role in dung dispersal in the Korean peninsula and Jeju Island because they are responsible for the removal of large volumes of pastureland dung for their food and offspring (Paik, 1976). Adults of *C. tripartitus* are paracoprids, which bury dung beneath or around dung pats. It is a brood-caring, univoltine species; a new generation of adults emerge each autumn and after a period of feeding, the young adults overwinter below ground. They emerge in spring and begin egg-laying in early summer. *C. tripartitus* has a breeding season from June to August and most of the brood-balls are made in early summer

* Corresponding author. Present address: School of Biological Sciences, The University of Bristol, Woodland, Bristol, BS8 1UG, UK. Tel.: +44 117 928 9182 (UK)/+82 31 290 0236 (Republic of Korea); fax: +44 117 928 9182 (UK)/+82 31 290 0206 (Republic of Korea).
E-mail address: verdurehsl@hanmail.net (H.S. Bang).

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doi:10.1016/j.apsoil.2006.09.010

(Bang et al., 2000, 2001). In the field, juvenile development is rapid and is generally completed in less than 2 months (Bang et al., 2000, 2001). Under laboratory condition, the beetles survive for more than 2 years and will undergo at least two breeding seasons.

In Korea, changes in livestock and pasture management over the last three decades are thought to have resulted in a general decline in dung beetle abundance and a reduction in the diversity of dung beetle communities, especially in mainland areas (Bang et al., 2001). The widespread use of insecticides, herbicides, fungicides and veterinary parasiticides in particular, may also have played a role in the decline of these beetle populations.

Studies on the effects of veterinary parasiticides on beneficial dung-frequenting insects, in particular dung beetles, have focused primarily on the use of macrocyclic lactones, such as ivermectin, doramectin, eprinomectin and moxidectin (Wall and Strong, 1987; Wardhaugh and Mahon, 1991; Strong, 1992; Krüger and Scholtz, 1997). Macrocyclic lactones are highly effective in the control of internal and external parasites of a wide variety of livestock, including cattle (Benz and Cox, 1989; Drummond et al., 1998) but a number of studies have shown that residues of some of these compounds are excreted unmetabolized in cattle dung where they continue to exert a detrimental effect on non-target beneficial insects, particularly dung beetles and cyclorrhaphous Diptera (Floate et al., 2005). A wide variety of other insecticides, such as organophosphates and pyrethroids, are also used as topical pour-on formulations, plunge-dips or sprays, as systemic formulations applied orally or as spot-ons, or as slow-release formulations in eartags to control ticks, lice, biting and nuisance flies. These compounds are rapidly metabolized by hydrolysis and oxidation to polar metabolites which are eventually eliminated through urine and faeces, but may also have their toxic properties (Elliot et al., 1978). Studies in Brazil, Australia and South Africa (Bianchin et al., 1992, 1998; Wardhaugh et al., 1998; Krüger et al., 1999) have shown that pyrethroids in the dung of treated animals following systemic treatment can be lethal to dung breeding beetles. However, there is no information on the effect of these compounds on non-target dung insects following treatment with topical, non-systemic formulations.

The pyrethroid high cis-cypermethrin and the organophosphate chlorpyrifos are two of the most widely used livestock insecticides in Korea, mainly applied topically during summer, to control ticks and nuisance flies on farms. The objective of the present study, therefore, was to determine whether there were any adverse effects of spray-on treatments of these compounds when administered to cattle, on the reproduction and dung consumption of *C. tripartitus*.

2. Materials and methods

2.1. Treatment of cattle and dung collection

Dung was collected from a group of 25 steers (200–450 kg body mass) held at the Seo-San experimental farm, 150 km south-west of Suwon, Korea (37°30′N, 127°00′E; 250 m above sea level). None of these animals had been treated with antiparasitic drugs for at least 3 months before the trials. Half of the cattle, selected at random, served as untreated controls and the rest were treated with a spray-on formulation of high cis-cypermethrin and chlorpyrifos (Cymex®, Samyang Pharma-Chem. Co., Ltd., Korea) at the manufacturer's recommended dose of 2.1 g/steer.

Dung was collected from treated and untreated animals 1, 3, 5 and 7 days after treatment. Collections occurred in the early morning to minimize colonization by dung-feeding insects. Collected dung was mixed thoroughly for each group and stored at −70 °C. When required, aliquots of dung were thawed at room temperature over a period of 24 h prior to use and then re-mixed.

2.2. Beetle laboratory colony

The beetles used in this study were derived from a laboratory colony of *C. tripartitus*, which was established with beetles collected from a field population on Jeju Island, Korea. In all experiments, beetles were held under a 14-h light:10-h dark cycle and a temperature of 22–26 °C. Under such conditions the durations of different developmental stages are: egg 8 days, larval stages 31 days, pre-pupal and pupal stage 18 days, oviposition activity 180 days. Voucher specimens of the *C. tripartitus* used in this study have been placed in the NIAST Insect Collection.

2.3. Assay methodology

2.3.1. Effects of treated dung on reproductive output

To determine the effects of the dung voided by treated animals on brood-ball production and adult emergence, 50 pairs of sexually mature F_1 beetles were divided into five groups of 10. Each group was allocated at random to 1 of 5 dung types: untreated dung, or dung voided by treated cattle 1, 3, 5 or 7 days post-treatment.