

Assessing the effects of coumaphos in beeswax on honey bee brood

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Introduction

Coumaphos is a lipophilic acaricide used to control *Varroa* spp. mites in managed honey bee (*Apis mellifera*) colonies. Its lipophilic properties promote long-term accumulation in beeswax, with residues of up to 159 mg kg⁻¹ reported in brood combs following treatment¹. In Switzerland and the EU, coumaphos containing products are no longer authorized for beekeeping, due to mite resistance and persistent accumulation in beeswax. However, its use remains permitted under restrictions in the USA and parts of Asia and South America. Our understanding whether persistent residues of coumaphos alter brood development via direct prolonged exposure remains limited. Here, we investigated if field-realistic coumaphos residues in brood comb affect brood development, emergence success, and adult body mass over one complete brood cycle.

Material and Methods

Natural beeswax was spiked with coumaphos nominal concentrations of 25, 50, or 100 mg kg⁻¹ and used to prepare wax foundation sheets. Brood combs were naturally drawn by the honey bee colonies on foundation sheets spiked with coumaphos or not (controls), and subsequently used for brood exposure assays. Four honey bee colonies were used, with four replicates per treatment. Honey bee queens were confined to coumaphos treated and untreated combs for 48 h to synchronize oviposition. The full brood development cycle (i.e., egg to adult emergence) was monitored using transparent acetate sheets and digital images² at day 0, 8, 18, and 21 post-oviposition (Fig. 1). At day 18, sealed brood was transferred to a 35 °C climate chamber to determine emergence success and the mass of newly emerged worker bees (N = 50; per colony and treatment) was assessed using a scale. Coumaphos residues in wax were quantified by GC-MS/MS after emergence to verify exposure levels during brood development³.

Results

Following one brood-rearing cycle, coumaphos residues decreased in the foundation and accumulated in the cell walls, resulting in an approximately 1.8-fold reduction in effective brood exposure through the foundation (Tab. 1). At the nominal concentration of 100 mg kg⁻¹ wax, mean larval survival decreased to 79%, compared with 86–94% in the control and lower-concentration treatments; however, this difference was not statistically significant (p > 0.05). Mean overall emergence was reduced to 64%, compared with 70–75% in the control and lower-concentration treatments, but this difference was also not statistically significant (p > 0.05; Fig. 2). No treatment-related effects were observed on the body mass of emerged bees, which ranged from 110.8 to 115.2 mg across treatments (Fig. 3).

Discussion

Coumaphos residues were redistributed from the foundation to the cell walls after one brood-rearing cycle, resulting in an approximately 1.8-fold reduction in effective brood exposure and suggesting a potential filtering effect. However, residues can leach from beeswax into larval food (jelly) and may affect brood development.⁴ At 100 mg kg⁻¹ wax, larval survival and adult emergence showed numerical reductions, but these effects were not statistically significant (p > 0.05). No treatment-related effects were observed on the body mass of emerged bees. Overall, coumaphos redistribution within wax may reduce brood exposure over time, while the tested concentrations showed no significant effects on brood survival, emergence or adult body mass.

Conclusion

Coumaphos exposure at 25–100 mg kg⁻¹ beeswax did not significantly affect brood survival, adult emergence, or adult body mass. The reduction and redistribution of residues after one brood cycle suggest that beeswax may limit brood exposure over time. Nevertheless, further research is needed to assess potential sublethal effects of chronic coumaphos exposure on brood development and newly emerged bees.

References: ¹Kast et al. (2020) *Apidologie* 51(1):112; ²Jeker et al. (2012) *Journal of Apiculture Research* 51(1):63-73; ³Kast et al. (2023) *Environ. Toxicol. Chem.* 42(8):1816; ⁴Kast & Kilchenmann (2022) *Chemosphere* 287:132214

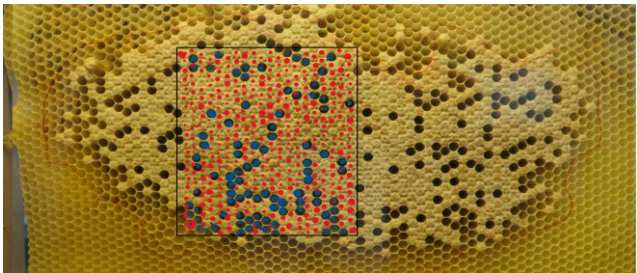


Fig. 1 Evaluation of brood development by using acetate sheets and digital image (red and blue dots on selected brood cells) at day 0, 8, 18, and 21 post-oviposition.

Nominal Coumaphos concentration in beeswax foundation [mg kg ⁻¹]	Analysed mean coumaphos concentration in beeswax foundation [mg kg ⁻¹]	Analysed mean coumaphos concentration in beeswax foundation after brood emergence [mg kg ⁻¹]	Coumaphos reduction factor in beeswax foundation after one brood cycle
25	20.8	12.3	1.7
50	44.8	26.1	1.7
100	96.4	47.8	2.0
Mean:			1.8

Tab 1: Coumaphos concentration in foundation sheets before and after brood exposure and the calculated reduction factor of coumaphos in beeswax of foundation after one brood cycle.

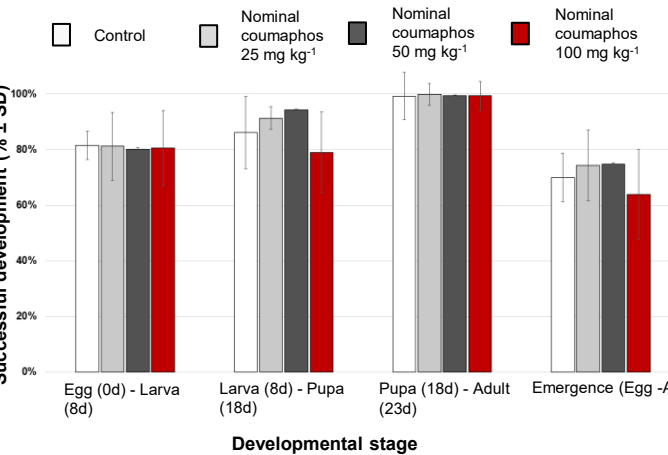


Fig. 2: Brood development success rate in wax combs with coumaphos (25 mg, 50 mg or 100 mg kg⁻¹ wax foundation) and without coumaphos (control). Emergence rate at 100 mg coumaphos kg⁻¹ wax was not significantly different to lower coumaphos concentrations or in control.

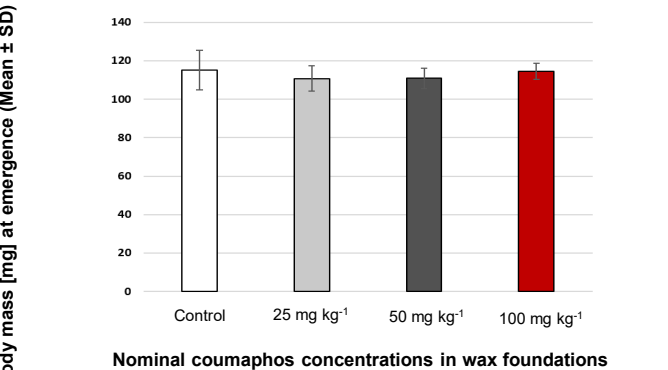


Fig. 3: Body mass of emerged adult bees (mg) after brood development in wax combs with and without coumaphos residues.