Year 5: Engineering a Novel IoT Trapping System With a Multiple Linear Regression Model Towards Eco-Friendly, High-Efficacy, Low-Cost Honey Bee Pest Treatment and Management

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Honeybees are irreplaceable, performing 80% of global crop pollination. However, commercial US hives have been dying at alarming rates (~50% annually). Scientific literature identifies small hive beetles (SHBs) as significant, destructive honeybee pests. In the first three years of this research, a novel blend of volatiles based on beer's chemical composition was developed. The blend is an attractant-bait placed within in-hive SHB traps. A comparative trial against coumaphos (only EPA-approved in-hive pesticide) also demonstrated the blend ($0.005/treatment cycle) is 4754 times cheaper than coumaphos ($23.77/treatment cycle) while equally effective. Coumaphos presents organismal/environmental toxicity; the blend poses no consequences. Currently, treatments are laborious, time-intensive, and cannot monitor infestation levels continuously. To correct this, the current research developed a novel tool, BeetleGuardAI, comprised of (1) 3D-printed SHB traps embedded with electronics (2) a multiple linear regression (MLR) model, and (3) the previously developed beer-blend. BeetleGuardAI costs $13.31/hive (one-time installation). The IoT trap records SHB capture with 99.5% in-vitro accuracy and 99.2% field accuracy. The MLR model predicts future infestation levels based on any hive strength index (ranging 1-5) and initial SHB trap count. It was trained/tested on 4,000+ data from previous years and explains 94% of variance (R^2) with insignificant error (MAE–0.82). After continuing to integrate BeetleGuardAI into an iOS app, beekeepers/farmers can instantly predict future SHB infestations and incorporate personalized pest management plans. Collectively, the data suggest that BeetleGuardAI is an eco-friendly, non-toxic, and low-cost replacement for coumaphos and other pesticides.