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CLIMATE-LINKED INSECTICIDE RESISTANCE IN SAUDI COCCOIDS (HEMIPTERA: COCCOMORPHA) – A REVIEW

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ABSTRACT

Scale insects and mealybugs remain major constraints in Saudi agroecosystems, particularly the date palm scale *Palmaspis phoenicis* (Ramachandra Rao 1922), the red date scale *Phoenicococcus marlatti* Cockerell 1899, the citrus mealybug *Planococcus citri* (Risso 1813) and the cotton mealybug *Phenacoccus solenopsis* Tinsley 1898. As phloem feeders, these pests cause chlorosis, stunting, fruit deformation and honeydew accumulation that facilitates sooty mold. Sessile females and wax or test like covers hinder spray deposition and penetration, contributing to penetration resistance. Although resistance bioassays from Saudi Arabia are limited, global findings demonstrate reduced susceptibility in *P. solenopsis* to several insecticide classes. Climate warming extends activity windows, weakens natural enemies and may enhance symbiont mediated detoxification. This review consolidates current knowledge on biology, distribution, resistance mechanisms and climate microbiome interactions and proposes a Saudi focused framework for IRAC based rotation, biological control, crawler stage targeting and field validated approaches aligned with Vision 2030.

Key words: Coccoids, *Phenacoccus solenopsis*, *Planococcus citri*, *Palmaspis phoenicis*, *Phoenicococcus marlatti*, insecticide resistance, climate change, Saudi Arabia, microbial symbionts, IPM, One Health, sustainable pest management

Recent reports from Saudi Arabia indicate increasing infestations of scale insects and mealybugs, particularly the date palm scale *Palmaspis phoenicis* (Ramachandra Rao) (Fig. 1), the red date scale *Phoenicococcus marlatti* Cockerell 1899, the citrus mealybug *Planococcus citri* (Risso) and the cotton mealybug *Phenacoccus solenopsis* Tinsley 1898 (Fig. 2), affecting date palm, citrus, vegetables and ornamentals. Although several studies provide pest lists or local observations, no updated synthesis exists that integrates their biology, distribution and the emerging threat of insecticide resistance under warming conditions. Recent records of *P. solenopsis* in Taif and the Eastern Province together with increasing pesticide residues reported in Saudi crops underscore the need for a consolidated and timely review (Alshehri et al., 2022; CABI, 2016; Gullan and Kosztarab, 1997; Balabanidou et al., 2018; Quesada et al., 2018; Ulusoy et al., 2022; Zaid et al., 2002; Katbeh Bader and Al Jboory, 2020; Abdel-Razak, 2024; Saddiq et al., 2014; Saddiq et al., 2015; Ejaz and Shad, 2017; Shankarganesh et al., 2022; Alokail et al., 2023). This review therefore summarizes the present status of major coccoids in Saudi Arabia, evaluates global and regional evidence related to resistance mechanisms

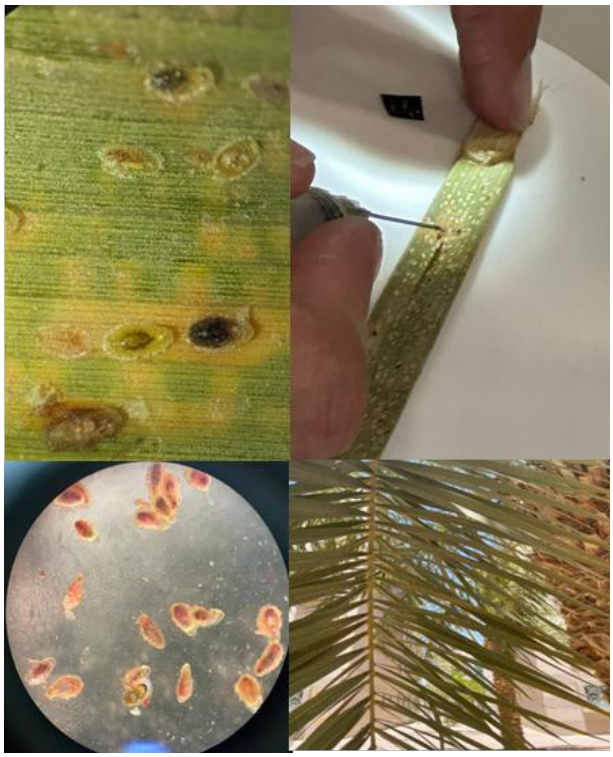

Fig. 1. *Palmaspis phoenicis* infestation (Hafr Al Batin, Saudi Arabia)

Fig. 2. *Phenacoccus solenopsis* infestation-
(Hafr Al Batin, Saudi Arabia)

of relevance to local conditions and synthesizes the influence of climate and microbial symbionts on resistance risk. It also outlines an updated framework for integrated pest management and identifies priority research needs. The scope focuses on studies published during the past decade with emphasis on recent Saudi records, resistance assays and climate related biological interactions.

1. Biology and distribution

More than a dozen coccoid species infests Saudi crops (Alshehri et al., 2022). Date palm, citrus and vegetable systems experience recurring infestations by scale insects and mealybugs whose feeding behavior and protective wax coverings reduce insecticide efficacy (CABI 2016; Gullan and Kosztarab 1997; Balabanidou et al., 2018; Quesada et al., 2018; Ulusoy et al., 2022). This section provides an updated overview of species currently affecting Saudi agriculture.

2. Insecticide resistance: current status and mechanisms

Direct resistance assays from Saudi populations are scarce relative to global datasets, yet international findings demonstrate reduced susceptibility in *P. solenopsis* to organophosphates, carbamates, neonicotinoids, pyrethroids and spirotetramat (Saddiq et al., 2014; Saddiq et al., 2015; Ejaz and Shad, 2017; Shankarganesh et al., 2022). Wax and cuticle modifications reinforce penetration resistance, while elevated detoxification enzymes and behavioral avoidance contribute additional mechanisms (Zhu 2016; Balabanidou et al., 2018; Zalucki and Furlong, 2017). The evidence underscores the need to adapt global insights to Saudi environments and highlights areas lacking Saudi specific data.

3. Climate and symbionts shaping resistance risk

Rising temperatures accelerate development, increase the number of annual generations and alter pest–natural enemy balance, creating conditions favourable for higher resistance potential. Heat driven changes in microbial symbionts may further influence detoxification pathways, potentially compounding resistance risks under Saudi Arabia's prolonged warm seasons.

4. Sustainable management within IPM and One Health

Sustainable control depends on structured rotation of insecticides based on IRAC mode of action groups and on preserving natural enemies. Emphasis is placed on targeting crawler stages when susceptibility is highest, ensuring adequate spray coverage and avoiding sublethal dosing. These approaches support cost effective management suited to Saudi conditions (Sparks and Nauen, 2015; Barzman et al., 2015).

5. Surveillance and research agenda for Saudi Arabia

Based on identified gaps, research priorities include establishing resistance baselines and standardized bioassays across major production regions. Additional needs involve characterizing associated microbiota using 16S rRNA and metagenomics, quantifying detoxification signatures and host gene responses under insecticide and heat stress, testing microbial biopesticides, essential oils and oil/adjuvant combinations and developing field validated control programs targeting crawler windows. A national data hub integrating phenology, residue findings and resistance indicators is also essential.

CONCLUSIONS

Climate-driven resistance in Saudi coccoids is an emerging challenge shaped by warming, high pesticide use, and microbial symbionts. Integrating climate- and symbiont-aware insights into IPM, strengthening surveillance, and investing in diagnostics and field efficacy research will enhance long-term crop protection and agricultural resilience.

CONFLICT OF INTEREST

No conflict of interest.

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