

Chemical Profiling of Dual-Gland Scent Secretions in Heteropteran Bugs

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ABSTRACT

Heteropteran bugs rely on specialized scent glands for defense and communication. Adults possess metathoracic scent glands (MTGs), whereas nymphs feature abdominal dorsal glands (ADGs), both producing diverse volatile chemicals. This study analyzes the chemical composition of secretions from both glands using GC-MS. MTG secretions were dominated by long-chain aldehydes and acids associated with defense, while ADGs produced short-chain aldehydes and alcohols linked to alarm signaling. Comparative profiling showed clear differentiation in chemical signatures, indicating functional specialization across life stages. This dual-gland system contributes significantly to the ecological success of Heteroptera.

Keywords: Heteroptera, metathoracic scent gland, abdominal dorsal gland, GC-MS, defensive secretions, alarm pheromones, chemical ecology, volatile compounds.

INTRODUCTION

Chemical communication is central to the behavioral ecology of Heteroptera. Their unique scent glands—metathoracic scent glands (MTGs) in adults and abdominal dorsal glands (ADGs) in nymphs—produce volatile compounds essential for predator deterrence, alarm signaling, aggregation, and species recognition (Aldrich, 1988; Staddon, 1979). MTGs typically release persistent, potent chemicals such as long-chain aldehydes and organic acids (Blum, 1981; Aldrich & Zhang, 2016). Conversely, ADGs produce highly volatile compounds with rapid dispersal, aiding communication within nymph groups (Lockwood *et al.*, 1990; Gunawardena & Bandara, 1999). Despite numerous studies on defensive secretions, few have compared the two gland systems simultaneously (Hoshino *et al.*, 2015).

This study uses gas chromatography-mass spectrometry (GC-MS) to compare chemical profiles of abdominal and metathoracic scent gland

secretions in heteropteran bugs, highlighting their functional and ecological roles (Millar & Haynes, 1998).

MATERIALS AND METHODS

Adults and nymphs of Pentatomidae, Coreidae, and Reduviidae were collected from crop fields using sweep nets. Specimens were maintained in ventilated plastic containers and fed host plants until use. MTGs: Adults were anesthetized on ice; glands were dissected and punctured to collect exuding fluid. ADGs: Nymphs were gently compressed to collect secretions through abdominal pores. Collected samples were dissolved in n-hexane (1:20 dilution).

GC-MS Analysis: GC column: DB-5MS, Injector: 250°C, Oven: 40°C to 260°C at 10°C/min, Carrier gas: Helium, Mass range: 40–500 m/z. Compounds were identified via NIST library matching and comparison with published heteropteran profiles (Jones *et al.*, 2001; Borges *et al.*, 2006). Peak area percentages were calculated for each compound. PCA was performed to visualize chemical differences between the gland types.

RESULTS AND DISCUSSION

MTG secretions of adults included long-chain aldehydes, acids, ketones, and esters (Aldrich, 1988; Blum, 1981). Long-chain aldehydes such as (E)-2-decenal produced strong odors and were associated with effective defense responses (Aldrich & Zhang, 2016; Noge *et al.*, 2008). ADG secretions in nymphs were dominated by short-chain volatiles (Lockwood *et al.*, 1990; Gunawardena & Bandara, 1999). The high volatility of these short-chain aldehydes allows rapid dispersal, ideal for communication among nymphs (Urban, 2010; Brennan *et al.*, 2012).

Chemical Composition of MTG Secretions

MTG secretions of adults included long-chain aldehydes, acids, ketones, and esters. Major components are listed below (Table 1).

Long-chain aldehydes such as (E)-2-decenal produced strong odors and were associated with effective defense responses.

Chemical Composition of ADG Secretions

ADG secretions in nymphs were dominated by short-chain volatiles.

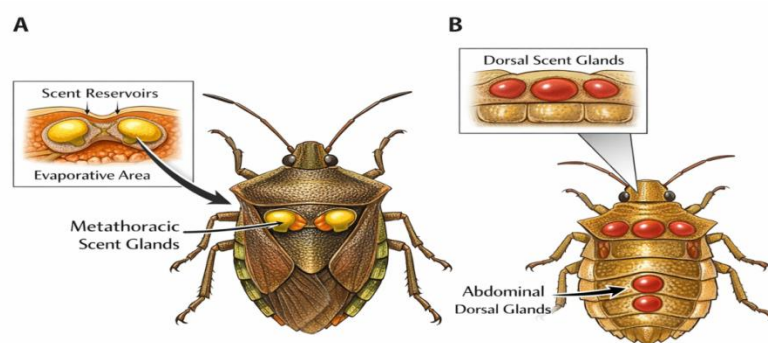


Figure 1. Schematic diagram of anatomical locations of MTGs and ADGs in a typical heteropteran bug.

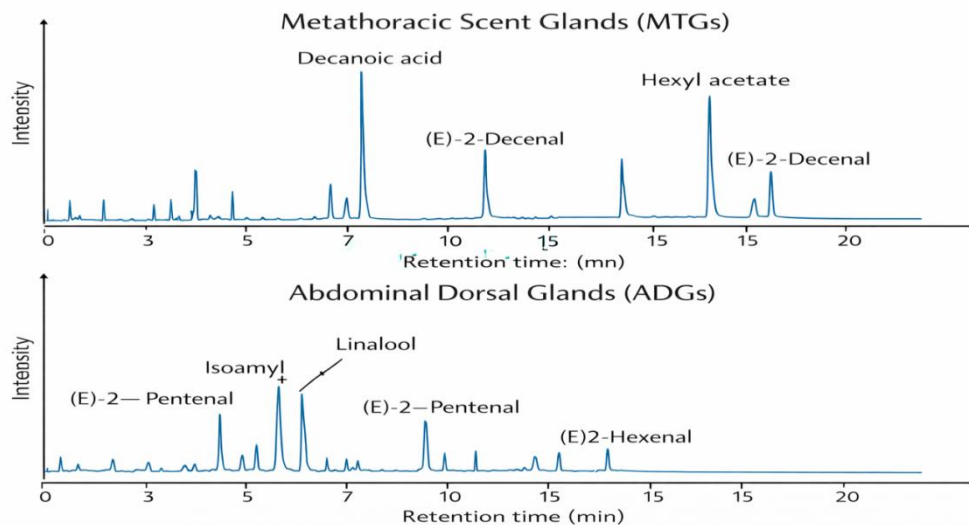
Table 1. Major compounds identified in metathoracic scent gland (MTG) secretions

Compound	Chemical Class	Relative Abundance (%)	Known Function
(E)-2-Decenal	Aldehyde	28.4	Predator deterrent
(E)-2-Hexenal	Aldehyde	17.3	Irritant/defense
Decanoic acid	Fatty acid	15.9	Cytotoxic defense
Hexyl acetate	Ester	12.5	Odor masking
3-Hexanone	Ketone	8.1	Repellent

Table 2. Major compounds identified in abdominal dorsal gland (ADG) secretions

Compound	Chemical Class	Relative Abundance (%)	Known Function
(E)-2-Hexenal	Aldehyde	31.2	Alarm signaling
(E)-2-Pentenal	Aldehyde	22.4	Aggregation cue
Isoamyl alcohol	Alcohol	14.8	Alarm/communication
Linalool	Terpenoid	10.6	Semiochemical
(E)-2-Butenal	Aldehyde	8.3	Rapid signaling

The high volatility of these short-chain aldehydes allows rapid dispersal, ideal for communication among nymphs.

**Figure 2.** Representative GC-MS chromatograms comparing MTG and ADG secretions.

(MTG shows more long-chain compounds; ADG shows sharper peaks for low molecular-weight volatiles.)

Table 3. Comparison of characteristics of MTG vs. ADG secretions

Feature	MTGs (Adults)	ADGs (Nymphs)
Dominant Compounds	Long-chain aldehydes, acids	Short-chain aldehydes, alcohols
Volatility	Moderate	High
Persistence	Long-lasting	Short-lived
Biological Role	Defence	Alarm signaling
Chemical Diversity	High	Moderate

Chemical divergence highlights adaptive specialization: adults require strong, lasting defense, while nymphs primarily communicate danger (Hoshino *et al.*, 2015; Farine, 1987). The separation of glandular functions across ontogeny is evolutionarily advantageous. Adults face predators requiring strong repellents, while nymphs rely on group cohesion and rapid response (Aldrich, 1988; Urban, 2010). Dual-gland specialization increases survival across life stages and demonstrates chemical adaptation in Heteroptera (Koul, 2008; Hoshino *et al.*, 2015)

CONCLUSION

Chemical profiling of heteropteran scent glands shows clear differentiation between metathoracic (adult) and abdominal (nymphal) systems. MTGs produce persistent defensive chemicals, whereas ADGs generate rapidly dispersing alarm pheromones. The dual-gland system provides versatile ecological functions and plays a critical role in survival and communication. This comparative study enhances understanding of chemical ecology in true

bugs and highlights the importance of volatile semi chemicals in insect behaviour (Brennan *et al.*, 2012).

Conflict of Interest: The authors declare no conflict of interest in relation to this research.

Data Availability Statement: Not applicable.

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