CHEMICAL COMMUNICATION IN CUCUJID GRAIN BEETLES¹⁻³

A.C. OEHLSCHLAGER⁴, A.M. PIERCE⁴, H.D. PIERCE, JR.,⁴ and J.H. BORDEN⁵

⁴Department of Chemistry
⁵Centre for Pest Management
Department of Biological Sciences
Simon Fraser University
Burnaby, British Columbia, Canada V5A 1S6

(Received November 22, 1987; accepted March 15, 1988)

Abstract—Males of five sympatric species of economically damaging cucujid grain beetles, Cryptolestes ferrugineus (Stephens), C. pusillus (Schönhen), C. turcicus (Grouvelle), Oryzaephilus mercator (Fauvel), and O. surinamensis (L.), produce macrolide aggregation pheromones especially in the presence of food. Work leading to the isolation, identification, and establishment of biological activity of these semiochemicals is reviewed. The trivial name “cucujolide” is proposed and used to identify these compounds that are characteristic of the Cucujidae. The two Oryzaephilus share species share a common cucujolide pheromone, while Cryptolestes species use cucujolides that are either enantiomeric, unique to the genus, or released in trace quantities by Oryzaephilus spp. and not used as pheromones by the latter species. The major mechanisms for species specificity in chemical communication are: (1) presence of a unique pheromone (C. ferrugineus and C. pusillus); (2) use of pheromones that are inactive alone but synergize response to cucujolides unique to a species (C. pusillus, C. turcicus, and O. surinamensis); (3) response to only one enantiomer of a pheromone (C. ferrugineus, O. surinamensis, and O. mercator); and (4) synergism between enantiomers of a pheromone (C. turcicus). The only species for which cross-attraction was evident was O. mercator to O. surinamensis. Both sexes of Oryzaephilus

¹Coleoptera: Cucujidae.
³Research supported by the Natural Sciences and Engineering Research Council of Canada, Strategic Grant No. G1039 and Operating Grants Nos. A3881 and A3706.
spp. produce (R)-1-octen-3-ol, which highly synergizes response to the cucujolide pheromones. Similar synergism occurs between hexanal, octanal, and nonanal and the cucujolide pheromones of *Oryzaephilus* spp. The males of a sixth cucujid species, *Cathartus quadricollis* (Guér) produce a different aggregation pheromone, (3R,6E)-7-methyl-6-nonen-3-yl acetate. Trapping of *Cryptolestes* and *Oryzaephilus* spp. in cardboard traps baited with pheromones is efficient in environments mimicking food-storage areas. Pheromone-baited plastic probe traps are the most efficient at capturing these species in infested grain.

**Key Words**—Grain beetles, Coleoptera, Cucujidae, *Cathartus quadricollis*, *Cryptolestes ferrugineus*, *C. pusillus*, *C. turcicus*, *Oryzaephilus mercator*, *O. surinamensis*, macrolide aggregation pheromone.

Hormones and pheromones are potent regulators of insect growth, development, reproduction, and behavior. Many new, safe, and specific approaches to insect control are based on manipulation of insect populations using these regulators. Knowledge of the chemical communication systems of economically important, grain-infesting insects (Levinson and Levinson, 1979; Burkholder, 1981, 1982) contributes to the development of semiochemical-based control programs. In the present article, we review the isolation, identification, and biological activity of the pheromones of six species of grain beetles in the family Cucujidae, for which we have unraveled much of the chemical communication systems.

**IMPORTANCE OF CUCUJID GRAIN BEETLES**

The species of beetles investigated are important stored-product pests of worldwide distribution. In the United States, the sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.), ranked first in importance as a pest of stored products and processed food and second as a program on raw grain (Mueller, 1982). The sawtoothed grain beetle cannot penetrate dry intact kernels and, when found in grain, is usually an indication of a prior infestation. The merchant grain beetle, *O. mercator* (Fauvel) is more affected by low ambient temperatures (Howe, 1956). It is an established household pest in North America, especially on cereal products and processed food (Loschiavo and Smith, 1970; Loschiavo and Sabourin, 1972). The rusty grain beetle, *Cryptolestes ferrugineus* (Stephens), is a severe pest of stored wheat throughout the world (Reid, 1942; Howe and Lefkovitch, 1957; Banks, 1979). In Canada, the beetles infest wheat during storage (Loschiavo, 1975) and transportation (Monro, 1969; Loschiavo, 1974). Pockets of damp grain subject to heating are attractive to these insects (Smith, 1983). Infested wheat suffers loss of germinating ability (Campbell and Sinha, 1976). The flour mill grain beetle, *Cryptolestes turcicus* (Grouvelle), is a secondary feeder on broken and milled grain (Howe, 1956; Olsen et al., 1987). The flat grain beetle, *Cryptolestes pusillus* (Schönherr), is a seri-