Available online at www.sciencedirect.com
SCIENCE DIRECT®
Journal of Stored Products Research 41 (2005) 145–161
Journal of STORED PRODUCTS RESEARCH
www.elsevier.com/locate/jspr

# Progress towards a lure to attract three stored product weevils, *Sitophilus zeamais* Motschulsky, *S. oryzae* (L.) and *S. granarius* (L.) (Coleoptera: Curculionidae)

M.E. Wakefield*, G.P. Bryning, J. Chambers

*Central Science Laboratory, Sand Hutton, York, YO41 1LZ, UK*

Accepted 15 January 2004

**Abstract**

The behavioural responses of *Sitophilus granarius*, *S. oryzae* and *S. zeamais* to synthetic 4S,5R-sitophinone alone and in combination with volatiles from kibbled carob have been investigated with a view to the development of a single lure to attract all three species. *Sitophilus zeamais* and *S. oryzae* were shown to respond to 4S,5R-sitophinone at amounts as low as 0.025 ng. *Sitophilus granarius* gave a significant response to 50 ng 4S,5R-sitophinone. Volatiles from kibbled carob were also shown to attract all three species. This is the first time that attraction of *S. zeamais* and *S. oryzae* to carob volatiles has been demonstrated. Fresh lures containing 4S,5R-sitophinone and carob volatiles attracted significantly more insects in pitfall bioassays for all three species than when either component was used alone. However, after 6 weeks a significant increase in response compared to the control was found only for *S. oryzae* and *S. zeamais*. The effect of insect age on response to the pheromone and carob volatiles was also studied for all three species. The response to carob volatiles decreased with increasing insect age for all three species. A significant response to 4S,5R-sitophinone was found only for 1–2-day-old adults of *S. oryzae* and *S. zeamais* but for all ages tested of *S. granarius*. The effect of the combination of pheromone and carob volatiles also decreased with increasing insect age.


*Keywords:* *Sitophilus granarius*; *Sitophilus zeamais*; *Sitophilus oryzae*; Sitophinone; Attractant; Lure

## 1. Introduction

The maize, rice and grain weevils, respectively *Sitophilus zeamais* Motschulsky, *Sitophilus oryzae* (L.) and *Sitophilus granarius* (L.), are important primary pests of stored products. All are

*Corresponding author. Tel.: +41-1904-462579.
*E-mail address:* m.wakefield@csl.gov.uk (M.E. Wakefield).

0022-474X/$ - see front matter 
doi:10.1016/j.jspr.2004.01.001

distributed widely, *S. granarius* particularly in cooler parts of the world and the other two species especially in tropical and sub-tropical areas. Early detection of infestations avoids serious damage to the product and subsequent economic loss. Traps help detect low level infestations and the incorporation of lures, either pheromone or food based, can significantly improve trap performance. Ideally, any trapping strategy for the detection of these species would therefore include a lure and to maximise operational flexibility and cost effectiveness, it would be advantageous if it were to attract all three species.

All three *Sitophilus* species have a male-produced aggregation pheromone. Walgenbach et al. (1987a) identified the aggregation pheromone of *S. zeamais* and *S. oryzae* as (4S,5R)-5-hydroxy-4-methyl-3-heptanone, commonly known as 4S,5R-sitophinone (Walgenbach and Burkholder, 1986). The aggregation pheromone of *S. granarius* was identified as 1-ethylpropyl (2S,3R)-2-methyl-3-hydroxypentanoate (Phillips et al., 1987, 1989), commonly known as 2S,3R-sitophilate. Previous authors have shown that *S. granarius* is also attracted to 4S,5R-sitophinone, but neither *S. oryzae* nor *S. zeamais* is attracted to 2S,3R-sitophilate (Walgenbach et al., 1983; Phillips et al., 1985, 1989). From the existing evidence the most likely candidate for a pheromone based multi-species lure is therefore 4S,5R-sitophinone.

Several authors have found that the addition of a food-based material to a pheromone will often enhance its effect. For example, Walgenbach et al. (1987b) reported synergism occurred between cracked wheat and 4S,5R-sitophinone when used in cardboard traps to detect *S. zeamais*. Phillips et al. (1993), in studies using *S. oryzae,* found that a combination of three grain volatiles, valeraldehyde, maltol and vanillin, and *R**, *S**-sitophinone was more attractive than either the pheromone or the grain volatile mixture alone. Trematerra and Girgenti (1989) reported a synergistic effect with 4S,5R-sitophinone and either rice kernels or cracked corn in traps. Likhayo and Hodges (2000) found a significant increase in catch of *S. zeamais* in refuge and flight traps baited with sitophinone and cracked wheat compared to either component alone. This combination also caught the most *S. oryzae* in both trap types. However, this increase was not significantly different from the same concentration of sitophinone alone, and Hodges et al. (1998) found that the addition of synthetic maize volatiles to flight or crevice traps did not improve the catch of *S. zeamais*.

Kibbled pods of the carob tree [*Ceratonia siliqua* (L.)], or their extracts, are known to be attractive to a number of stored-product insect pest species (O'Donnell et al., 1983; Stubbs et al., 1985; Obeng-Ofori, 1993; Roberts et al., 1993; Wakefield and Cogan, 1993) and therefore have the potential to attract all three *Sitophilus* species. Volatiles from kibbled carob pods can be collected by aeration and held in a solvent carrier. The effect of combining carob volatiles with 4S,5R-sitophinone to devise a lure for all three weevil species has been investigated and is reported here.

Several physiological factors can affect the response of stored-product beetles to pheromone, for example age, sex, mating status, culture density and pre-exposure to the pheromone. The effects of these have been demonstrated for stored-product beetles in both electroantennogram and behavioural studies (Boughton and Fadamiro, 1996; Dowdy et al., 1993; Fadamiro and Wyatt, 1996; Obeng-Ofori and Coaker, 1990; Pierce et al., 1983; White, 1989). If pheromones and food attractants are to be used as lures in practical situations for monitoring and detection then it is important that all factors that may influence trap catch are considered (Walgenbach and Burkholder, 1986).