Distribution of insect pests and their natural enemies in a barley pile

Belda, C.*#, Riudavets, J.*
IRTA (Institut de Recerca i Tecnologia Agroalimetaris), Entomology, Ctra Cabrils km 2, E-08348 Cabrils (Barcelona), Spain. Email: consuelo.belda@irta.es

* Corresponding author
# Presenting author

DOI: 10.5073/jka.2010.425.143

Abstract

The distribution and abundance of stored product pests and their natural enemies infesting the upper layer of a barley pile was assessed in this study. Sampling was carried out on a monthly basis from February to December 2009. Insects were sampled with a grain trier and pitfall traps. Yellow sticky traps were also used to capture flying insects. Most abundantly captured species were, in order of abundance: *Rhyzopertha dominica*, *Sitophilus granarius*, and *Latheticus oryzae*. Fewer individuals of other species were occasionally captured, such as *Cryptolestes ferrugineus*, *Oryzaephilus surinamensis*, *Lasioderma serricorne* and *Stegobium paniceum*. Concerning Hymenoptera, the species *Anisopteromalus calandrae* and *Cephalonomia waterstoni* were abundantly captured with yellow and pitfall traps, while lower numbers were captured with the grain trier trap. Comparing pitfall and grain trier captures, in the former one, natural enemies were abundantly captured, whilst captures with the grain trier were punctual. The predator *Withius piger* (Pseudoscorpionida: Withiidae) was captured both with grain trier and pitfall traps. Its captures peaked in August-September. The abundance of coleopteran pests varied among the different depths sampled and the time of the year. The highest captures of pests occurred in March and May; the natural enemy *A. calandrae* peaked in April, and *C. waterstoni* was scarcely captured. The three species of natural enemies were occasionally found in the deepest samples, thus, they were able to penetrate around 80-cm deep in the grain searching for their hosts.

Keywords: Grain, Sampling, Biological control, Host finding.

1. Introduction

Pest control of stored products is based on the application of chemical products, fumigants and residual insecticides. However, the maximum residue limits of pesticides allowed in the final food products is becoming more and more restrictive. Therefore, alternatives are needed, and biological control is one possible alternative (Schöller et al., 2006). In previous studies, natural enemies have been found in several stored-product companies manufacturing different food products and in warehouses (Riudavets et al., 2002). Moreover, other studies have focused on how coleopteran pests and natural enemies distribute vertically through a grain bulk (Buchelos and Athanassiou, 1999; Steidle and Schöller, 2002; Steidle et al., 2002). In this study we present the results of sampling a barley pile that had been placed next to a heavily infested 1-year-old barley pile. The main objectives of our study was to search for natural occurring parasitoids, to assess how insects (both pests and natural enemies) colonize a new pile from the very first week, to evaluate which are the first species to arrive and how do they invade and distribute through the pile, i.e. their vertical movement.

2. Material and methods

Trials were carried out in a warehouse of the IRTA (Institut de Recerca i Tecnologia Agroalimetaris) Research Centre, located in Caldes de Montbui, Barcelona, Spain. This warehouse is normally used to store cattle food for winter and sowing machinery. There was an old barley pile in the warehouse that had been stored for one year, since harvesting in summer 2007. The second pile of barley was harvested the summer 2008, and it was placed adjunct to the old barley pile on February 2009. The new pile contained 2 t of barley that had not been treated, as it came from organic crops. It was 180-cm high, 3-m wide and 3-m long. Sampling was conducted on a monthly basis from February 2009 till December 2009. To sample the grain pile for coleopteran pests (Consultores cerealistas S.A., Castelldefels, Barcelona, Spain), a 1.50-m long aluminum grain trier was used (Fig. 1). There are eight elongated holes (each 10-cm long) on the grain trier, with a separation of 2.5 cm between holes. The trier was introduced in the barley pile three times per sampling date, one time on each side of the pile and one in the front side. So, three replicates per month were carried out. Barley was sampled at about 80 cm from the top surface, corresponding with five levels of the grain trier (0, 20, 40, 60 and 80 cm), each with a capacity of 70 g for a total of 350 g of grain. All adults were sieved out, identified and counted. We focused on the grain trier because we wanted to study the vertical distribution of the species present. Other traps were used for sampling the barley pile, this being six pitfall traps (Killgerm S.A., Viladecans, Barcelona, Spain) distributed at two heights (on the surface and 15-cm deep), and three yellow traps (20 x 20 cm, Sanidad Agrícola Econex S.L., Santomera, Murcia, Spain), two located around the pile never higher than 1.5 m, and one hanging 20 cm over the pile. All traps were checked and changed monthly.

Figure 1 Devices used for sampling: grain trier, pitfall trap and yellow sticky trap.

3. Results and discussion

There was a rapid colonization from the older pile to the new pile. In the first month of sampling all species had reached and had distributed among the different depths of the pile. The most abundant coleopteran.species through all the sampling period captured with the grain trier and pitfall traps were *Rhyzopertha dominica* (F.) (Bostrichidae), *Sitophilus granarius* (L.) (Curculionidae), and *Latheticus oryzae* (Waterhouse) (Tenebrionidae) in this order. They were captured with the grain trier in the deepest levels already in the first month of sampling. Fewer individuals of other species were occasionally captured both with grain trier and pitfall traps, such as *Sitophilus oryzae* (L.), *Tribolium confusum* Jacquelin du Val (Tenebrionidae), *Tribolium castaneum* (Herbst), *Cryptolestes ferrugineus* (Stephens) (Laemophloeidae) and *Oryzaephilus surinamensis* (L.) (Silvanidae) (Table 1). Yellow sticky traps also had high captures of coleopteran species.

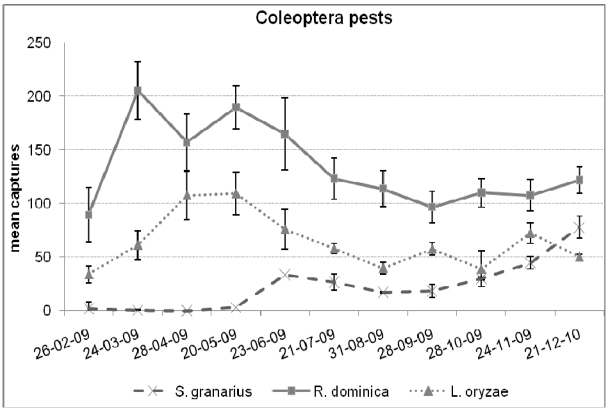

Figure 2 Temporal distribution of Coleoptera pests in one year of sampling with grain trier.

During the sampling period, from February to December 2009, the main coleopteran species captured were relatively abundant (Fig. 2). *Rhyzopertha dominica* had two small peaks in March and May, with its population decreased after that and maintained a relatively constant level. For *L. oryzae*, there was an increase from February to April-May, after that the population decreased until August and stayed fairly constant. *Sitophilus granarius* was, in comparison to the other two species, the last one to increased its population in the new pile. Its population did not increase until June, from where it maintained the levels of captures and slowly increased up to December.

Table 1 Pests and parasitoids captured, abundance levels: 1: abundant, 2: present, 3: occasional.

			Abundance /Trap		
Order	**Family**	**Species**	**Grain trier**	**Pitfall trap**	**Yellow trap**
Coleoptera	Curculionidae	*Sitophilus granarius*	1	1	2
	Bostrichidae	*Rhyzopertha dominica*	1	1	1
	Tenebrionidae	*Latheticus oryzae*	1	1	1
	Laemophloeidae	*Cryptolestes ferrugineus*	3	1	3
	Silvanidae	*Oryzaephilus surinamensis*	3	3	-
	Anobiidae	*Lasioderma serricorne*	-	-	3
Hymenoptera	Pteromalidae	*Anisopteromalus calandrae*	2	1	1
	Bethylidae	*Cephalonomia waterstoni*	3	2	1
Pseudoscorpionida	Withiidae	*Withius piger*	1	1	3

Regarding the natural enemies, the main parasitoids found to infest the barley pile were *Anisopteromalus calandrae* (Howard) (Hymenoptera: Pteromalidae), *Cephalonomia waterstoni* Gahan (Hymenoptera: Bethylidae) and the predator *Withius piger* (Simon) (Pseudoscorpionida: Withiidae) (Table 1). *Anisopteromalus calandrae* is a cosmopolitan parasitoid of coleoptera species that infest stored products (Schöller et al., 2006). Captures of this pteromalid were sporadic; its population had a very small increase in April (Fig. 3). *Cephalonomia waterstoni* is a bethylid parasitoid, very host-specific (Finlayson, 1950a, b), found to parasitize late-instar larvae of *Cryptolestes* species (Rilett, 1949). In our study, captures of this parasitoid happened just in October and November (Fig. 3). *Withius piger* is a natural predator found in rice in Spain (Pascual-Villalobos et al., 2005), but it is the first time to be found on barley in Spain. It was relatively abundant from July to September (Fig. 3). Among all the levels sampled a total of 38 *A. calandrae* were collected, of which three individuals were collected from the deepest sample. Six *C. waterstoni* were captured, only one reached 80-cm deep. Regarding *W. piger,* a total of 131 individuals was collected, and 10 were found in the deepest sample. Hence, there are natural occurring parasitoids present, and all the species sampled are able to penetrate deep in the pile searching for their hosts. Focusing on parasitoids getting captured on yellow traps, *A. calandrae* was abundant from April to August, while *C. waterstoni* was abundant from August to November. Populations seemed to complement each other, as when temperatures got colder *C. waterstoni* replaced *A. calandrae*.

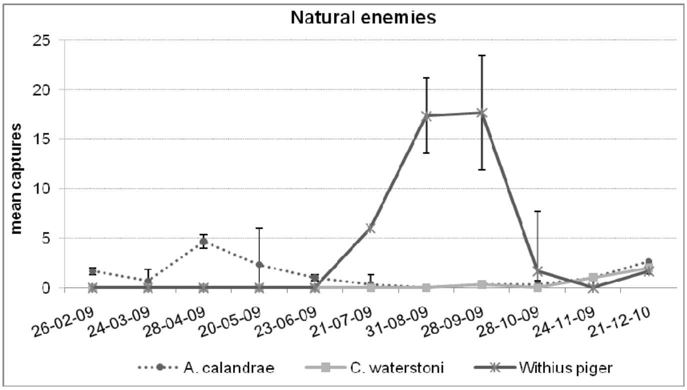

Figure 3 Temporal distribution of natural enemies in one year of sampling with grain trier.

For illustrating the vertical distribution of the main coleopteran pests captured, we present one month representing each season (Fig. 4). For the first month sampled (February 2009) the distribution of *R. dominica* remained in the lower levels of the grain pile, where it's warmer than in the surface and temperature variations are less extreme. *Latheticus oryzae* was more abundantly distributed along the upper levels, though it is a species usually present at high temperatures, as well as *R. dominica*. This might happen because the grain pile has just been placed in the warehouse, so the grain was probably too cool. Also the primary species might have not destroyed the grain at deeper levels enough to allow the entrance of a secondary pest. Other factors affecting the species' distribution was probably their phototactism, mobility or population densities (Hafeez and Chapman, 1966; Buchelos and Athanassiou, 1999). Colonization of *S. granarius* in this first month was low (Fig. 4a).

In April, there was a change in the distribution of insects. The abundance of *R. dominica* increased, and it was also more abundantly distributed in the upper levels. In spring, air temperatures became warmer, and the grain was warming up as well. That may be why insects are found at top grain levels. For *L. oryzae,* captures were probably increasing due to the degradation of grain that *R. dominica* had done at every level and the mild temperatures (Fig. 4b). In July, pests were found at all depths, although there were fewer at the surface, possibly due to the high temperatures. Populations of *R. dominica* were lower, perhaps due to competition with an increasing population of *S. granarius* (Fig. 4c).

In October, more insects were found at the deeper levels, as air temperatures were getting colder. The grain temperature at the surface would be cooler, with the core of the pile being warmer and the insects would probably be attracted to the warmer grain (Flinn and Hagstrum, 1998). With lower temperatures, *S. granarius* got more abundantly distributed, reaching superficial levels, as it is more resistant to colder conditions (Fig. 4d).

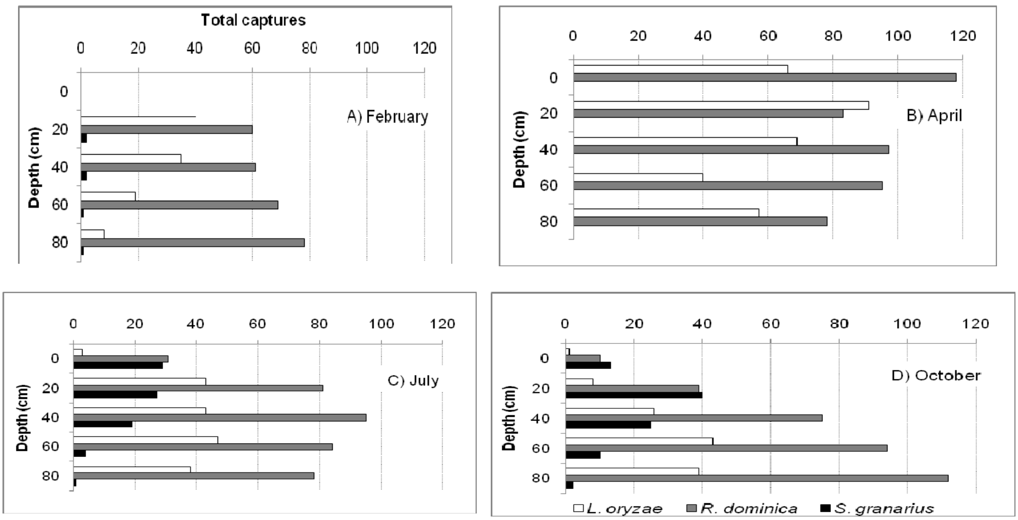

Figure 4 Vertical distribution of the total coleopteran pests captured in the barley pile, sampled with grain trier.

Acknowledgements

Special thanks to Sr. Joaquim Adillón and Sr. Florenci Bayes from “IRTA Torre Marimon” for allowing us to use their facilities. This work was supported by grants from the “Instituto Nacional de Investigación Agraria y Alimentaria: Subprograma Nacional de Recursos y Tecnologías Agrarias en Cooperación con las Comunidades Autónomas” and “INIA RTA 2008-00002-CO2-01 (FEDER)”; and grant number 64 from the “Programa de Becas Predoctorales para la formación de personal investigador” of the “Instituto Nacional de Investigación Agraria y Alimentaria (INIA)”.

References

Buchelos, C.T., Athanassiou, C.G., 1999. Unbaited probe traps and grain trier: a comparison of the two methods for sampling coleopteran in stored barley. Journal of Stored Products Research 35, 397-404.

Finlayson, L.H., 1950a. The biology of *Cephalonomia waterstoni* Gahan (Hym., Bethylidae), a parasite of *Laemophloeus* (Col., Cucujidae). Bulletin of Entomological Research 41, 79-97.

Finlayson, L.H., 1950b. Host preference of *Cephalonomia waterstoni* Gahan, a bethylid parasitoid of *Laemophloeus* species. Behaviour 2, 275-316.

Flinn, P.W., Hagstrum, D.W., 1998. Distribution of *Cryptolestes ferrugineus* (Coleoptera: Cucujidae) in response to temperature gradients in stored wheat. Journal of Stored Products Research 34, 107-112.

Hafeez, M.A.M.A., Chapman, G., 1966. Effects of temperature and high relative humidity on the rate of development and mortality of *Latheticus oryzae* Waterhouse (Coleoptera, Tenebrionidae). Journal of Stored Products Research 1, 235-242.

Pascual-Villalobos, M.J., Baz, A., Del Estal, P., 2005. Occurrence of psocids and natural predators on organic rice in Calasparra (Murcia, Spain). Journal of Stored Products Research 41, 231-235.

Rilett, R.O., 1949. The biology of *Cephalonomia waterstoni* Gahan. Canadian Journal of Research 27, 93-111.

Riudavets, J., Lucas, E., Pons, M.J., 2002. Insects and mites of stored products in the northeast of Spain. Integrated Protection of Stored Products IOBC Bulletin 25, 41-44.

Schöller, M.E., Flinn, P.W., Grieshop, M.J., Zd'árková, E., 2006. Biological control of stored product pests. In: Heaps, J.W. (Ed), Insect Management for Food Storage and Processing Second Edition. American Association of Cereal Chemistry International, St Paul, MN,USA, pp. 67-87.

Steidle, J.L.M., Schöller, M., 2002. Fecundity and ability of the parasitoid *Lariophagus distinguendus* (Hymenoptera: Pteromalidae) to find larvae of the granary weevil *Sitophilus granarius* (Coleoptera: Curculionidae) in bulk grain. Journal of Stored Products Research 38, 43-53.

Steidle, J.L.M., Prozell, S., Schöller M., 2002. Host-finding ability of *Lariophagus distinguendus* (Hymenoptera: Pteromalidae), a potential natural enemy for the biological control of stored product pests. In: Credland, P.F.A., Armitage, D.M., Bell, C.H., Cogan, P.M., Highley, E. (Eds), Proceedings of the Eighth International Working Conference on Stored-Product Protection, 22-26 July 2002, York, UK, CAB International, Wallingford, UK, pp 84-86.