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Insect pests and management of stored hard wheat in central southern Italy

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Abstract

In Italy, hard wheat (*Triticum durum* Desf.) is one of the most important staple foods. After harvesting and threshing, the wheat is usually taken to storage facilities in which it can be damaged by several species of moulds and pests, primarily several insect species. In this regard, results of studies carried out on stored insect pests of hard wheat in cereal crop areas of central southern Italy (Molise, Apulia and Basilicata regions) were reported. Surveys were conducted analyzing samples of stored wheat taken from both traditional warehouses of small farms and from different types of commercial storage facilities, such as flat structures, concrete silos and metal bins. The results obtained showed various levels of infestation with differences in insect species and populations. A total of about 25 species of insect pests representing five orders were found, predominantly Coleoptera. *Cryptolestes ferrugineus* (Steph.), *Oryzaephilus surinamensis* (L.), *Plodia interpunctella* (Hb.), *Rhyzopertha dominica* (F.), *Sitophilus oryzae* (L.) and *Tribolium castaneum* (Herbst) were the most frequently detected species. In our paper, these results are discussed in view of the commercial importance of hard wheat in the crop areas under study and the various insect pest management techniques adopted in the storage facilities of central southern Italy.

Key words: Insect management, hard wheat, central southern Italy.

Introduction

In Italy, hard wheat (*Triticum durum* Desf.) is one of the primary crop production enterprises. In the period between 2000 and 2004, its production was estimated to vary from 3,624,200 tons in 2001 to 5,545,600 tons in 2004, according to the Central Statistics Institute (ISTAT, 2006). Nevertheless, non-processed cereals are traditionally a negative component in the Italian agro-food trade balance (Istituto Nazionale di Economia Agraria, INEA, 2000). Hard wheat represents about 15 % of non-processed cereal imports which mainly come from the United States, France, Canada and Greece.

In this context, Italian wheat production varies according to the crop areas in the different regions (ISTAT, 2006). One of the main areas of hard wheat cultivation is located in the central southern part of the Country, in particular the Molise, Apulia and Basilicata regions. In 2004, the yield obtained in these regions amounted to more than 40 % of the national harvest; Apulia, in particular, ranked first among all the Italian regions for the cultivation of hard wheat with 23 % of the national produce.

After harvesting and threshing, storage of

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wheat is carried out predominantly in commercial facilities instead of on-farm traditional warehouses. The most common storage facilities are concrete warehouses (flat structures), concrete silos and metal bins.

Because of hot summertime climate conditions, central southern Italy is at high risk for stored wheat insect pests, which can cause significant damage and reduction in grain value. This is true especially for the traditional storage facilities often characterized by poor hygienic conditions and that generally lack control measures against stored product pests (Trematerra and Sciarretta, 1998; Trematerra, 2002). In this case, however, after almost 1 or 2 months, harvested wheat is usually taken to commercial warehouses where it is stored for a longer period of time.

In the majority of commercial facilities, several procedures to manage pests are used. Those that minimize pest invasion into storage structures include cleaning bins and equipment prior to harvesting and after bin emptying, applying “empty-bin” insecticides to the inside of the structures, sealing structures, cleaning up grain spills and removing weeds close to the structures. Additional management techniques include storing dry wheat (< 13 % moisture content), since moisture can encourage the growth of mould and insects, and in some cases aerating stored grain with fans to cool the wheat and slow insect growth, and close monitoring of grain temperature. Only a few bins, generally those used to store organic produce, are supplied with modified atmospheres and low temperatures.

This investigation presents the results of species composition surveys of fauna pests living in hard wheat that is stored in traditional and commercial facilities of the Molise, Apulia and Basilicata regions in central southern Italy.

Materials and methods

Surveys in traditional storage facilities were carried out in the last 10 years (Trematerra and Sciarretta, 1998). The warehouses consisted of concrete flat structures, most of which were small

and located near the farms.

In regards to the commercial facilities, 40 warehouses were visited in 2004 and 2005: 22 in Apulia, 11 in Molise and 7 in Basilicata. Of these, 21 were metal bins, 15 concrete flat structures, and 4 were concrete silos.

A conventional survey method was used, which consisted in taking sufficiently large samples of stored wheat before the commodities were treated. In metal bins and concrete silos, the samples were taken from several locations of the grain mass surface, whereas in flat warehouses the wheat was sampled from the bulk surface near the corners and walls.

The samples were first analyzed in the laboratory by sieving the grain and examining the insects using a stereoscopic microscope (first analysis). After recording the presence of the pests, the samples were placed in jars at 28 ± 1 °C and 70 % relative humidity (r.h.) to allow the development of immature stages. After an incubation period of 60 days the samples were analyzed once again (second analysis).

Results

The results of the surveys conducted on insects found in traditional and commercial hard wheat warehouses are reported in Table 1. A total of about 25 species of insect pests representing five orders were found, predominantly Coleoptera. The majority of species collected were primary and secondary phytophagous pests typically associated with stored products. The fauna list obtained in the two different cases shows that a greater number of species was found in traditional warehouses rather than commercial granaries.

In traditional facilities, 24 taxa of insect pests were identified. Those species which were found regularly formed a rather small group, whereas a number of insects only occurred sporadically. The most common internal grain feeders found were *Sitophilus granarius* (L.), *S. oryzae* (L.) and *Rhyzopertha dominica* (F.), with negligible data regarding *S. zeamais* Motschulsky and *Sitotroga*

cerealella (Olivier).

Aside from the external grain feeding insects, the most frequently found species were *Tribolium castaneum* (Herbst), *Oryzaephilus surinamensis* (L.), *Cryptolestes ferrugineus* (Steph.) and *Latheticus oryzae* Waterhouse. Other external feeder insects were *Ephestia elutella* (Hb.), *E. kuehniella* (Z.), *Plodia interpunctella* (Hb.), *Tenebroides mauritanicus* (L.), *Tribolium confusum* du Val and *Trogoderma granarium* Everts.

Some insects also feed on mould mycelium, such as the Trogiidae specimens, *Alphitobius diaperinus* (Panzer) and *Typhaea stercorea* (L.). Other species develop and damage cereals

exclusively in field; these include *Aelia rostrata* Boheman and *Eurygaster austriaca* (Schrank). Finally, other insects collected are predators or parasitoids of phytophagous pests, such as *Carcinops pumilio* (Erichson), the Carabidae and Calcidoidea specimens.

Considering the samples taken in commercial warehouses, the total number of insect pests found was 11 (Table 1). Only in 5 metal bins no insect pests were collected, 1 located in Molise, 3 in Apulia and 1 in Basilicata.

The differences in the occurrence of pests among the respective basic types of storage facilities in the three Italian regions are shown in Tables 2 and 3. In many cases, the second

Table 1. Insect species found in hard wheat warehouses of the Molise, Apulia and Basilicata regions.

Order	Species	Traditional Warehouse	Commercial Warehouse
Psocoptera	<i>Trogium</i> spp.	**	**
Rhynchota	<i>Aelia rostrata</i> Boheman	*	
	<i>Eurygaster austriaca</i> (Schrank)	*	
Lepidoptera	<i>Ephestia elutella</i> (Hb.)	*	
	<i>Ephestia kuehniella</i> (Z.)	*	
	<i>Plodia interpunctella</i> (Hb.)	*	**
	<i>Sitotroga cerealella</i> (Olivier)	*	
Coleoptera	<i>Alphitobius diaperinus</i> (Panzer)		*
	<i>Carcinops pumilio</i> (Erichson)	*	
	<i>Cryptolestes ferrugineus</i> (Steph.)	**	****
	<i>Latheticus oryzae</i> Waterhouse	**	*
	<i>Oryzaephilus surinamensis</i> (L.)	***	****
	<i>Rhyzopertha dominica</i> (F.)	**	***
	<i>Sitophilus granarius</i> (L.)	***	*
	<i>Sitophilus oryzae</i> (L.)	**	***
	<i>Sitophilus zeamais</i> Motschulsky	*	
	<i>Stegobium paniceum</i> (L.)	*	
	<i>Tenebroides mauritanicus</i> (L.)	*	
	<i>Tribolium castaneum</i> (Herbst)	***	****
	<i>Tribolium confusum</i> du Val	*	*
	<i>Trogoderma granarium</i> Everts	*	
	<i>Typhaea stercorea</i> (L.)	*	
	Carabidae	*	
	Staphilinidae	*	
Hymenoptera	Calcidoidea	*	

= 10 % of samples; * 11-25 % of samples; *** 26-50 % of samples; **** > 50 % of samples.

analyses of samples allowed the detection of a larger number of pests. The most common species were *O. surinamensis* (30 samples), *T. castaneum* (25 samples) and *C. ferrugineus* (21 samples), followed by *R. dominica* (18 samples), *S. oryzae* (13 samples), and by the unclassified samples of Trogidae (11) and *P. interpunctella* (7). In a few warehouses, *S. granarius* (4 samples), *A. diaperinus* (3 samples) and *T. confusum* (3 samples) were found, whereas *L. oryzae* was identified in a single sample.

The insect fauna found in the commercial warehouses did not seem to be considerably affected by the type of storage facilities or by their geographic location. Nevertheless, our data indicate that in flat storehouses the internal feeding pests were found more frequently than in concrete silos and metal bins. This is true especially for the two *Sitophilus* species, *S. oryzae* and *S. granarius*, the latter detected only in samples taken from flat structures.

Table 2. Insect species found in the commercial storage facilities of the Molise, Apulia and Basilicata regions (metal bins).

Species	Sample	Metal bin															
		Ma	Mb	Mc	Md	Aa	Ab	Ac	Ad	Ae	Af	Ag	Ah	Ai	Ba	Bb	Bc
<i>Alphitobius diaperinus</i>							x										
<i>Cryptolestes ferrugineus</i>		xo				xo	xo	xo	xo	xo	xo				xo		
<i>Latheticus oryzae</i>									x								
<i>Oryzaephilus surinamensis</i>			x	x	x	o	xo	o		o	o	o	o	xo	xo		xo
<i>Plodia interpunctella</i>						o	o	o									
<i>Rhyzopertha dominica</i>			x			x	x	x	x			x	x	x	x	x	x
<i>Sitophilus oryzae</i>											o		xo		xo	x	
<i>Tribolium castaneum</i>				x	x	o	xo	xo	xo	o	xo	xo					xo
<i>Tribolium confusum</i>						x										x	
<i>Trogium spp.</i>		xo				xo	xo	xo	o	xo	xo	xo					

Ma - Md: samples from Molise; Aa - Ai: samples from Apulia; Ba - Bc: samples from Basilicata

x = found in the first analysis; o = found in the second analysis

Table 3. Insect species found in the commercial storage facilities of the Molise, Apulia and Basilicata regions (concrete silos and flat warehouses).

Species	Sample	Concrete Silo					Flat Warehouse												
		Aj	Ak	Al	Am	Me	Mf	Mg	Mh	Mi	Mj	An	Ao	Ap	Aq	Ar	As	Bd	Be
<i>Alphitobius diaperinus</i>										o									x
<i>Cryptolestes ferrugineus</i>		xo	o				x	xo	xo		xo	xo	xo	xo		x	x	xo	
<i>Latheticus oryzae</i>																			
<i>Oryzaephilus surinamensis</i>		xo	xo	xo		o	o	xo	xo	xo	xo		o	xo	xo	xo	xo	xo	xo
<i>Plodia interpunctella</i>								x	x	x						x			
<i>Rhyzopertha dominica</i>			x			xo	xo				o	xo	xo					xo	
<i>Sitophilus granarius</i>									o		xo			o		x			
<i>Sitophilus oryzae</i>			x	x					xo		xo	x	x	xo			x		xo
<i>Tribolium castaneum</i>			xo	xo	x	xo	o	xo	xo		xo	xo		xo	xo	xo	x	xo	xo
<i>Tribolium confusum</i>																		xo	
<i>Trogium spp.</i>			xo								xo					x			

Me - Mj: samples from Molise; Aj - As: samples from Apulia; Bd - Bf: samples from Basilicata.

x = found in the first analysis; o = found in the second analysis.

Discussion

In Italy, harvested hard wheat is largely sold to semolina-mills that supply pasta factories. Pasta production is one of the most important sectors of the Italian food industry, with a turnover of € 3,170 million gained in 2004 (INEA, 2005). In this context, many of the more important Italian pasta factories are traditionally located in the central southern part of the Country which is a major production area of hard wheat.

Effective management of pests within storage facilities of edible raw materials, such as hard wheat, is critical for maintaining an abundant, affordable, and safe food supply. However, the quality of the grain risks being compromised by the invasive action of animal pests, particularly insect species. The objective of stored grain management is to slow or deter this loss of quality so that grain can attain its highest potential market value (Trematerra and Süß, 2006).

As reported by the grain managers of the warehouses visited during our surveys, in both the traditional and commercial facilities stored wheat was harvested in the area where the warehouses were located. The main differences between the on-farm and commercial stores were in their structural characteristics, the general hygienic conditions and control measures adopted against stored product pests; these factors seem to be highly relevant in determining the greater complexity found for the insect pest fauna in traditional storehouses compared to commercial facilities.

As a matter of fact, the traditional granaries visited in the Molise, Apulia and Basilicata regions are generally poorly constructed, and farmers are mostly unaware of safe storage practices, such as warehouse preparation for the reception of new products, the removal of old products, regular checks of the sanitary state of the warehouse, product control during the storage season and the application of quick and appropriate interventional measures against the emergence of pests. Consequently, these facilities are frequent sources of stored pests also for commercial warehouses where the grain is

usually transferred for lengthy storage.

As our investigation has showed, pest control is in any case most successful in commercial granaries, silos and large flat warehouses and is usually based on carrying out both preventive and curative measures in integrated stored product protection systems. However, in some commercial warehouses the surveys conducted led to the discovery of numerous species of harmful insects, which may indicate poor storage conditions.

Pest control of Italian commercial storehouses is generally based on chemical treatments carried out by the use of fumigants or contact insecticides. Of these, the most important chemical products are the fumigants aluminium phosphide and magnesium phosphide. The fumigations are carried out several days after the grain is stored or when an infestation is detected by sample analysis. To prevent phosphine residues in grain bulk, the use of fumigants in bags is the preferred technique of fumigation. Furthermore, in some types of silos it is possible to apply a technique where gas is circulated inside the mass by means of a special fan without adding the fumigants directly to the grain.

Regarding contact insecticides, several products containing pyrethrum extracts, pyrethroids or organophosphates are registered in Italy for use on cereals.

The request for pesticide residue-free raw materials on the part of leading industrial semolina-mills induces grain managers to adopt an integrated pest management (IPM) approach to avoid pest problems in commercial warehouses. This type of approach in protecting stored grain includes both preventive and control methods, such as sanitation and structural maintenance, aeration, monitoring, alternative control methods and judicious use of effective chemical insecticides only when needed to avoid the economic impact caused by infestation. In this sense, IPM techniques should be considered as tools in a toolbox: not all of them are needed every time, but they still need to be made available.

In Italian commercial warehouses, sanitation procedures for empty storage facilities are usually

carried out: storage structures are emptied of old grain and cleaned before storing the new crop; the structure is well sealed and repaired before harvest, especially the bin walls, roofs, doors and hatches; the grain handling equipment is kept in good condition; for additional protection against infestation, the inside surfaces of storage facilities are sprayed with residual insecticides 4-6 weeks prior to harvest.

Aeration is often used to cool stored grain and to prevent moisture migration when ambient temperature drops below that of the grain temperature. Prevention of moisture migration by maintaining a uniform temperature throughout the grain mass greatly reduces the possibility of mould development and insect feeding and reproduction. Aeration is generally obtained by passive airflow through the upper openings of the storage facility or by mechanically moving the bulk; only a few silos are equipped with fans.

Monitoring is recognized as an important IPM post-harvest procedure of stored grain. In particular, grain managers frequently monitor grain quality and temperature, but only in a few cases improved pest-monitoring procedures are developed and adopted. Sampling of insect pests is often limited to counting the number of adult insects in the wheat samples taken for the purpose of grain grading. Furthermore, only in sporadic cases probe traps are used to verify the presence of insect pests.

Considering the alternative methods to chemical control, not many techniques of physical control have been widely accepted and carried out in Italian storehouses. The main methods employed are modified atmosphere, especially based on carbon dioxide (CO₂), and nitrogen atmosphere (N₂) as well; low temperature treatments (chilled aeration) and inert dusts are also employed. These techniques, however, are carried out only for organic products that still are of negligible importance on the Italian food market. Yet, despite the considerable number of possibilities for biological and biotechnological control of stored wheat pests, none of them is currently employed in Italy under practical conditions (Trematerra, 2002; Süß and

Trematerra, 2003; INEA, 2005).

Besides pest management techniques, another critical factor affecting the potential growth of insect pests inside commercial wheat stores is commodity history before its arrival to the granaries. Reports show that in many cases an infestation that has occurred in a traditional warehouse is transferred to a commercial facility with the grain. Moreover, wheat is often transported by means of trucks that usually carry many types of products and are not cleansed of potentially infested grain or debris. Finally, as farm production frequently amounts to a few tons, it is possible for a single storehouse to hold wheat that comes from many suppliers; consequently, the bulk can be entirely infested by pests arriving with a single grain load.

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