

REDUCTION OF STORED PRODUCT INSECTS DURING PNEUMATIC UNLOADING OF SHIP CARGOES

Igor BAHR

Zentrales Staatliches Amt für Pflanzenschutz und Pflanzenquarantäne -
Quarantänelaboratorium - Hermannswerder 20 A, Postdam DDR - 1560

ABSTRACT

Stored product insects within grain and other goods suitable for suction conveyance decrease during pneumatic discharge of ship-loads. Dependent on pest species, the reduction of the insects in grain (including inside the grains) was 48 to 95 % and more. A pneumatic elevator with more sucking capacity did not kill more insects than an older machine with lower capacity. Insects occurring outside the grains were nearly completely killed (about 99 % after 3 to 7 days). Within sunflower seeds the number of insects (Oryzaephilus surinamensis, Tribolium castaneum, Cryptolestes ferrugineus) decreased by 95 %. In cottonseed expeller the kill was more than 98 % (mostly *O. mercator* and *T. castaneum*). Pupae were very susceptible.

The susceptibility of the tested species declines in the following order :

Oryzaephilus spp.

Trogoderma granarium

Tribolium castaneum

Rhizopertha dominica

Cryptolestes ferrugineus

Sitophilus spp.

Sitotroga cerealella.

The reduction of the infestation during pneumatic unloading of ship cargoes should be considered, if other control measures are intended.

1 . INTRODUCTION AND METHODS

If grain containing stored product insects is moved, e. g. by conveying plants, a part of the pests are damaged and killed (TRISVJATSKI, 1969 - GREEN and TYLER, 1966 - COGBURN et al., 1972; - LOSCHIAVO, 1978). Not only are the insects outside grains killed but those partly within the grains are also affected (BAILEY, 1969 - JOFFE, 1963 - JOFFE and CLARKE, 1963). Because in sea ports bulk cargoes of stored products are unloaded mainly by pneumatic dischargers, we studied the effect of suction conveyance on the insect infestation of some shiploads (BAHR, 1973 - BAHR and KARSTEN, 1985). The thereby were examined by sieving just before and just after

sucking, and were also examined for a second time at least 6 weeks later after incubation at 25°C, to detect the hidden infestation inside the grain kernels.

The question was, if further control-measures were needed because of the reduction of insects during pneumatic transshipment. Stored products can be effective fumigated within the holds of ships or in barges, if they are carried in sacks (BOGS, 1974), but it is more difficult to fumigate loose goods-especially the crushed residues of oilseeds (WOHLGEMUTH et al., 1976; RODZIEWICZ, 1978; ANTOSZCZYSZYN, 1980, 1982; MORDKOVIC and TKACENKO, 1985). Our investigations on the effect of pneumatic unloading of ship cargoes are summarized in the following and supplemented by some further data.

2 . GRAIN

2.1 Wheat and rye

Table 1 shows, that the reduction of the insect population by some older pneumatic conveyors in the port or by a mobile machine can be at least 48 % in wheat and rye and can reach - dependent on pest species and the portion of hidden infestation within the kernels - 95 % and more. Immediately after the pneumatic transshipment some living adults of *Sitophilus oryzae* were found outside or between the grains (about 15 %), but most of them were damaged and died within a week at 25°C. So not more than 1 % survived finally. STRATIL and WOHLGEMUTH (1989) observed similar post mortality of some stored product insect species after treatment with an entoleter. The high mortality of *O. surinamensis* is connected with the fact, that the adults and larvae of this species are particularly susceptible and live mainly outside the grain kernels.

Table I: Degree of insect infestation of rye and wheat and per cent survival after pneumatic conveyance with different suction elevators. (BAHR, 1973, 1975)

Insect species	Suction elevator in the port of Wismar (37.5 t rye/tube/h)		Suction elevator in the old port of Rostock (19 t wheat/tube/h)		Mobile suction- and pressure conveyor (15 t wheat/tube/h)	
	Volume of samp- les before and after suction	5 l; 10.5 l	10 l each	15 l each		
	Insects per l and (in brackets) percentage of hid- den infestation	Per cent survival	Insects per l and (in brackets) percentage of hid- den infestation	Per cent survival	Insects per l and (in brackets) per- centage of hid- den infestation	Per cent survival
<i>Oryzaephilus surinamensis</i>	111.1 (5.5 %)	0.2	18.9 (25.4 %)	5.3		
<i>Cryptolestes ferrugineus</i>	5.6 (89,3 %)	3.6	20.5 (91.2 %)	31.2	286.0 (67.3 %)	14.3
<i>Sitophilus oryzae</i>			228.7 (95.2 %)	51.6		
<i>Rhizopertha dominica</i>					25.5 (94.0 %)	7.8
All insects	116.7 (9.5 %)	0.3	322.1 (90.8 %)	47.8	311.5 (69.5 %)	13.8

Mortality depends also on the prevailing stage of development. 99 % of pupae of *C. ferrugineus* were destroyed for instance in one test, while on the other hand much more of the older larvae survived the treatment (Fig. 1). Investigations by JAHR showed, that stored product mites also decreased by 97 % during pneumatic unloading of wheat in the old port of Rostock (BAHR, 1973).

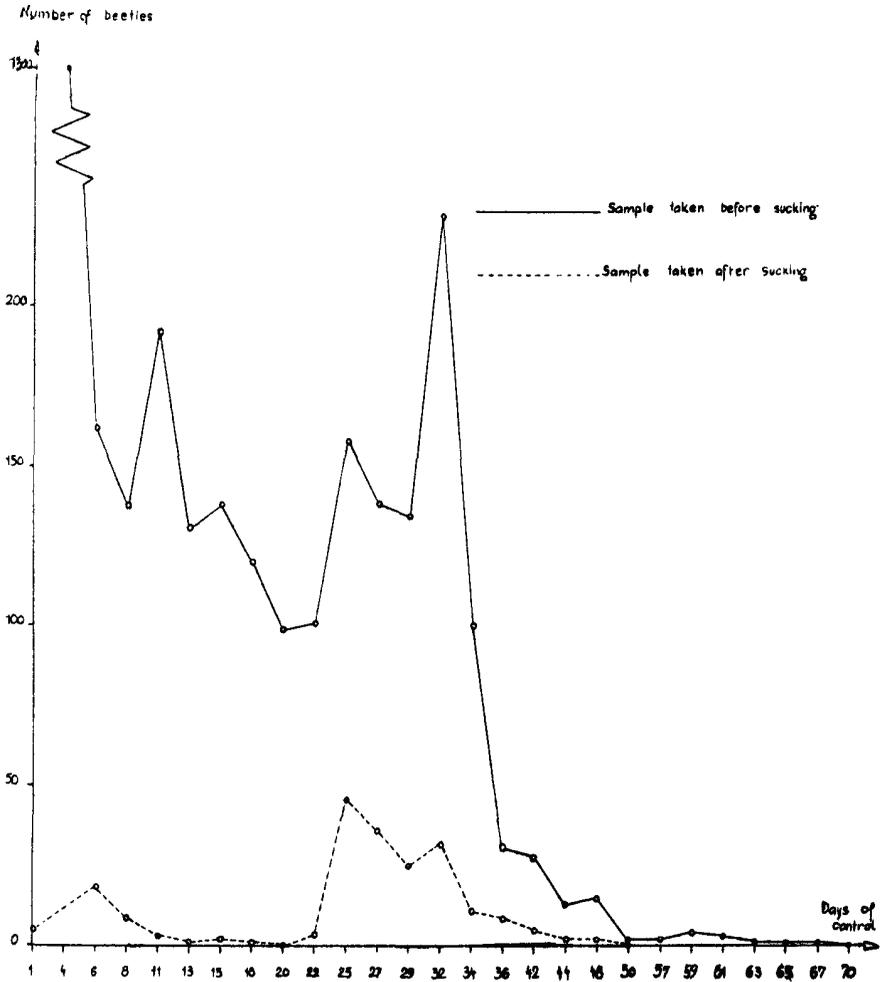


Figure 1 : Number of *Cryptolestes ferrugineus* (adults) emerged at 25°C in wheat samples before (————) and after (-----) sucking by a mobile suction and pressure conveyor (15 t/tube/h). The beetles at the 13 th - 20 th day of control were in the pupae stage during the suction treatment.

2 . 2 . Maize

The maize weevil, S. zeamais, seems to be as susceptible as S. oryzae. Not more than 1 % of these weevils also survived the pneumatic transshipment outside or between maize kernels after 3-7 days. This was confirmed by the plant quarantine station in Rostock-Overseaport with a cargo of maize that was discharged by a modern powerful conveyor. The effect on the hidden infestation of this species was not investigated, but with other insect species a reduction of the whole infestation to one fourth was seen in an another cargo of maize (Table II). However in spite of the higher output of the modern suction conveyor more C. ferrugineus (76 %) and R. dominica (30 %) survived within the kernels as in investigations with wheat and rye.

Table II: Degree of insect infestation of maize and per cent survival after pneumatic transshipment in Rostock-Overseaport (350 t/tube/h). Weight of samples before and after suction: 74 kg; 140 kg

Insect species	Insects per kg and (in brackets) percentage of hidden infestation	Per cent survival
<u>Cryptolestes ferrugineus</u>	7.5 (61.3 %)	37.8
<u>Rhizopertha dominica</u>	8.8 (95.3 %)	11.3
<u>Tribolium castaneum</u>	0.4 (60.3 %)	12.0
<u>Sitotroga cerealella</u>	.0.1 (100 %)	34.7
All insects	16.0 (78.4 %)	24.2

3 . SUNFLOWER SEEDS

With sunflower seeds the output of the suction conveyor was only the half compared with maize. After transshipment no living O. surinamensis, C. ferrugineus and Tribolium castaneum were found by sieving the sunflower seeds. Only within the formerly damaged kernels some insects survived, the reduction amounted to about 95 % (Table III). As with grain O. surinamensis was the most susceptible species.

Table III: Degree of insect infestation of sunflower seeds and per cent survival after pneumatic transshipment in Rostock-Overseaport (150 t/tube/h). Weight of samples before and after suction: 74 kg each

Insect species	Insects per kg and (in brackets) percentage of hidden infestation	Per cent survival
<u>Tribolium castaneum</u>	37.8 (74.8 %)	6.3
<u>Oryzaephilus surinamensis</u>	22.0 (85.8 %)	1.5
<u>Cryptolestes ferrugineus</u>	19.9 (88.5 %)	5.3
All insects	79.9 (81.3 %)	4.8

4 . COTTONSEED EXPELLER

In cottonseed expeller the insects - mainly O. mercator - were almost completely destroyed (more than 98 %) by the pneumatic conveyor, which was already used for maize and sunflower seeds (Table IV). T. castaneum did not survive at all. The reduction was nearly the same in the more infested top layer of the shipload as in the deeper layers with fewer insects. Even after 3 months at 25°C the portion of survivors was similar in samples from both layers. Only Lasioderma serricorne, which bores into the compact pieces of the expeller, survived somewhat more. No living insects were found in another cargo after unloading, although 0.6 insects were present per kg before suction. The mechanical power was very effective on the cottonseed expeller itself, so that the small pieces (below 3 mm diameter) increased 1.6 - 2.5 fold during the suction conveyance. Thus the introduction of insects with pneumatic conveyed residues of oilseeds is rather low.

Table IV: Degree of insect infestation of cottonseed expeller and per cent survival after pneumatic transshipment in Rostock-Overseaport (170 t/tube/h). Weight of samples before and after suction: 19 kg each

Insect species	A. Top layer		B. Deeper layer		A + B Per cent survival
	Insects per kg	Per cent survival	Insects per kg	Per cent survival	
1. Just before and just after unloading					
<u>Oryzaephilus mercator</u>	18.4	1.2	4.2	0	0.9
<u>Tribolium castaneum</u>	5.8	0	0.5	0	0
<u>Lasioderma serricorne</u>	0.6	0	0.05	0	0
<u>Corcyra cephalonica</u>	0.3	0	0.05	0	0
All insects	25.1	0.9	4.8	0	0.7
2. After keeping samples at 25 °C (3 months)					
<u>O. mercator</u>	81.5	2.6	62.2	2.0	2.3
<u>T. castaneum</u>	47.6	0	1.0	0	0
<u>L. serricorne</u>	0.2	0	1.1	5.0	4.3
<u>C. cephalonica</u>	17.1	0	0	0	0
All insects	146.4	1.3	64.3	1.8	1.5

5 . TAPIOCA PELLETS

Tapioca pellets from Thailand are nearly always attacked by some stored product insects. However living insects never have been found in shipments of thousands of wagons and some hundred barges at the DDR-border after transshipment of the pellets outside the country in Hamburg. The inspection of 2 shiploads during a visit in Hamburg just before and just after pneumatic conveyance showed, that at best one tenth of Rhizopertha dominica survived immediately after unloading outside or between the pellets (Table V).

However one can expect a further decline down to 1 % by post mortality within a week, so that the detectable infestation of R. dominica decrease from some insects per kg before suction to about 1 living adult per 25-300 kg after it. It is very difficult to discover such a low degree of infestation. The examination of samples at 25°C showed that, after suction conveyance the hidden infestation within the pellets was about 1 R. dominica per kg. But in an unheated room only 1 adult emerged per 26 kg within a 5 months period ending the 30th of July. So the infestation is very low, if the pellets are stored relatively cool in our temperate climate.

Table V: Degree of insect infestation of tapioca pellets determined by sieving and survival outside or between the pellets after pneumatic transshipment in Hamburg (100 - 200 t/tube/h). Weight of samples before and after suction: 149.5 - 230 kg.

Snip	Insect species	Just before unloading Insects per kg	Just after unloading Insects per kg	Per cent survival
A	<u>Rhizopertha dominica</u>	0.294	0.029	9.9
B	<u>Rhizopertha dominica</u>	4.322	0.135	3.2
E	<u>Cryptolestes ferrugineus</u>	0.335	0.005	1.2

6 . SUSCEPTIBILITY OF TROGODERMA GRANARIUM

There was no opportunity, to study the reduction of khapra beetle population during pneumatic discharge of shiploads. Therefore, we made tests with an industrial vacuum cleaner. After repeated suction of grain with some broken kernels and rolled oasts (4 times) all the O. surinamensis and 99.6 % of the khapra beetle individuals were killed, while the control of other insect species was lower - inclusive within the grains (Table VI). The examined samples originally contained 3072 individuals of T. granarium (mostly larvae), 9616 S. oryzae, 6576 R. dominica, 2138 S. granarius, 800 O. surinamensis and 464 S. cerealella. In another test with cottonseed expeller and khapra beetle alone (5000 individuals) the mortality after the first suction was 85 % and after the fourth time it reached again nearly 100 %. No living individuals were observed after the samples were sucked 8 times. So the khapra beetle has been shown to be very susceptible to suction conveyance.

Table VI: Per cent mortality of *Trogoderma granarium* and other insect species in samples of cottonseed expeller (C) and wheat with some broken kernels and rolled oats (W) after pneumatic conveyance (1 - 8 times) through an industrial vacuum cleaner (Length and diameter of the tube: 6 m and 7 cm)

Frequency of suction	1	2	4	4	8
Medium	C	C	C	W	C
Insect species					
<i>Sitotroga cerealella</i>				72.4	
<i>Sitophilus granarius</i>				73.4	
<i>Sitophilus oryzae</i>				74.5	
<i>Cryptolestes ferrugineus</i>				91.0	
<i>Rhizopertha dominica</i>				93.9	
<i>Trogoderma granarium</i>	85.0	99.8	99.9	99.6	100
<i>Oryzaephilus surinamensis</i>				100	

7. USEFULNESS OF THE FINDINGS

Because all or nearly all the insects outside or between the kernels of loose stored products are killed or damaged during pneumatic conveyance and because the control within the grains is lower than outside, it is easier to detect the infestation before unloading the cargo. Shiploads with dangerous infestations should at least not be discharged without pneumatic conveyance. After pneumatic unloading the objective, should be to process the infested goods as soon as possible. Grain, sunflower seeds, residues of oilseeds and tapioca pellets are imported into the DDR mainly for industrial processing (e. g. mixed feed production). Under the climatic conditions of this country, the spreading of insect pests with these goods is not significant after suction conveyance, provided the imports are consumed soon.

As it was seen with *R. dominica*, the emergence of the adults seems to be delayed after pneumatic transshipment, especially at temperatures of 20°C and lower (BAHR, 1975). In sunflower seeds the beetle populations would not increase further, if the seeds were cooled down to this temperature (HOWE, 1965) after pneumatic conveyance. Since we know that insects within expeller are almost completely killed by suction conveyance, fumigation is, as rule, not necessary in case of infested oilseed residues that pass the pneumatic conveyor. Plant quarantine stations in DDR-seaports take into account the probable effect of the transshipment by suction.

The lack of fumigation of some stored product cargoes with certain pest infestation does not mean -because of the pneumatic unloading - a substantially greater risk of pest introduction. In last years insect, infestation of stored grain within the country did not increase, but it declined because of more unfavourable ecological conditions for the pests by ventilation cooling (REUTER and BAHR, 1988).

Our investigations have shown, that the line of susceptibility of the tested insect species against pneumatic transshipment declines as follows :

- Oryzaephilus spp.
- T. granarium
- T. castaneum
- R. dominica
- C. ferrugineus
- S. spp.
- S. cerealella.

The reduction of insect pests in grain that can be expected following suction, may be seen in table VII. It shows the lowest kill found in our investigations (i. e. the most unfavourable case).

Table VII. Lowest per cent kill of insect by pneumatic discharge of grain in the port.

Insect species	Per cent mortality	
	of the total population	of the population within the grains
<i>Oryzaephilus surinamensis</i>	95	81
<i>Rhizopertha dominica</i>	89	70
<i>Tribolium castaneum</i>	88	59
<i>Sitotroga cerealella</i>	65	65
<i>Cryptolestes ferrugineus</i>	62	24
<i>Sitophilus oryzae</i>	48	46

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LA REPRODUCTION DES POPULATIONS D'INSECTES DES PRODUITS STOCKES PENDANT LE DECHARGEMENT PNEUMATIQUE DES CARGOS

Igor BAHR

Zentrales Pflanzenschutzamt, Quarantänelaboratorium
Hermannswerder 20 A, Postdam, DDR-1560

RESUME

Le nombre d'insectes des produits stockés se trouvant dans le grain et dans les autres produits soumis à l'aspiration des convoyeurs pneumatiques diminue pendant le déchargement des cargos. La diminution du nombre des insectes (y compris des formes cachées) qui dépend de l'espèce, était de 48 à 95 % et plus. Un élévateur pneumatique moderne possédant une plus grande puissance de succion n'a pas tué plus d'insectes qu'un appareil plus ancien d'une puissance moindre. Les insectes se trouvant à l'intérieur du grain ont presque tous été tués (environ 99 % après 3 à 7 jours). Dans les graines de tournesol, le nombre d'insectes a diminué de 95 % (*Oryzaephilus surinamensis*, *Tribolium castaneum*, *Cryptolestes ferrugineus*). Dans un éjecteur de graines de coton, le taux de mortalité était supérieur 98 % (surtout *Oryzaephilus mercator*, et *Tribolium castaneum*). Les nymphes étaient les plus sensibles. La sensibilité des espèces étudiées a décru selon l'ordre suivant : *Oryzaephilus spp.* > *Trogoderma granarium* > *Tribolium castaneum* > *Rhyzopertha dominica* > *Cryptolestes ferrugineus* > *Sitophilus spp.* et *Sitotroga cerealella*. Il faudrait prendre en considération cette réduction de l'infestation lors du chargement des cargos lorsque d'autres mesures d'élimination sont appliquées.