Pest's of stored beans and their economic importance in Latin America

A.v. Schoonhoven
Entomologist, Bean Program,
CIAT - Apt. Aéreo 67-13
Cali, Colombia.

Paper to be presented in the Symposium on Tropical Stored Product Entomology, during the 15th. International Congress of Entomology, August 19-27, 1976, Washington D. C. U.S.A.

ABSTRACT

Although bean production in Latin America in 1968-71 amounted to 3.86 million tons per year, literature on bean storage and storage losses in this region is virtually non-existent. Among the most important storage pests are *Acanthoscelides obtectus* (Say) and *Zabrotes subfasciatus* (Boheman). The two species are similar but differ in oviposition behavior in that *A. obtectus* drops the eggs among the seed, while *Z. subfasciatus* attaches them to the seed coat. *A. obtectus* is a pest in colder areas (higher altitudes or higher latitudes) infesting beans in the field and in storage, while *Z. subfasciatus* is confined to warmer areas and is a warehouse pest which does not attack beans in undamaged pods. Several minor pests reported in the literature to occur on stored beans may have accidentally been found on them.

In a survey of 30 warehouses in Colombia the average storage period for beans was 44 days. Although bruchids were considered the major storage problem, only 60% of the storeholders fumigated beans. In 20% of the warehouses beans showed the presence of storage insect attack. We hypothesize that due to the high susceptibility of beans to storage pests and the high value of the product, beans are stored for short

periods. Under this system few losses from insect attack occur.

Introduction:

Dry beans (*Phaseolus vulgaris* L.) play an important role in the protein supply in Latin America. An average of 3.86 million tons per year were produced in the region during the 1968-71 period. This is about 34% of the world production of beans. About 60% of the beans in Latin America are produced in Brazil (Infante et al, 1974). With such a large quantity of beans produced in Latin America, which is the center of origin of beans, it is surprising how little documentation exists on the occurrence of and losses from bean storage pests.

The insects on stored beans:

The principal stored bean pests are two Bruchids, *Acanthoscelides obtectus* (Say) and *Zabrotes subfasciatus* (Boheman) (Table 1). Both pests are widely distributed being reported from Chile northward to the United States. While several other insects are reported on stored beans, they are of minor importance or only accidentally found on beans. They may have come from other stored products in the same storage area (Table 2). They have no economic importance on beans according to literature reports and our own observations, and in the following part of this paper only the first two mentioned species are considered.

Biology of the principal pests:

The life history of the two principal bean pests. A. obtectus and Z. subfasciatus is broadly similar and is studied in detail by Howe and Currie, (1964) who used an African strain of Z. subfasciatus. The principal difference is in their oviposition behavior. A. obtectus females scatter eggs among stored seeds, or when infesting beans in the field, they lay their eggs in cracks or cuts of the growing pods. The newly hatched larvae of A. obtectus wander freely, until they penetrate the seed. By contrast, Z. subfasciatus eggs are firmly attached to the seed. On hatching the young larvae bore through the eggshell and seedcoat in one process. The two species differ in their optimal condition for development. These are at 30°C and 70% R.H. for A. obtectus (in 27.4 days) and are for Z. subfasciatus at 32.5°C and 20% R.H. (25.0 days). Generally adults of Z. subfasciatus live shorter than those of A. obtectus (7.6 and 11.8 days, respectively) and lay less eggs (35.5 and 63.0 eggs per female, respectively), (Howe and Currie, 1964).

Larvae of both species moult 4 times before pupating. During the last larval instar, the feeding and pupation cell becomes externally visible as a circular window in the seed as the larvae feed on the lower surface of the testa. After pupation the adult may remain in the cell for several days before pushing out the window. It has limited ability to escape by eating away the exit and here mortality occurs. Adults do not eat usually, but will take water or nectar. They lay their eggs rapidly after emergence and are usually short lived (Howe and Currie, 1964).

Both species have a preoviposition period of less than one day, and eggs are laid at a maximum rate during the first days after emergence (Howe and Currie, 1964).

Howe and Currie (1964) state that at 70% RH, optimal development occurs at 30°C, for A. obtectus and at 32.5°C for Z. subfasciatus. In our observations, A. obtectus is distributed over the higher latitudes and altitudes, while Z. subfasciatus is found predominantly in the warmer areas. Competition between the two species exists. In studies by Giles in Nicaragua (Giles pers. comm.) at 56 m, 450 m or 680 above sea level, beans were initially infested with A. obtectus (99.7%) and Z. subfasciatus (0.3%). After 16 weeks the ratios were 0:100% at 56 m, 4.6: 95.4% at 450 m and 27.3: 72.7 at 680 m. The average temperatures at these three elevations were 28.2°C, 25.2°C and 24.3°C respectively. This indicates that A. obtectus is a stronger competitor at lower temperatures (Table 4).

In the Cauca valley (24°C and 1,000 m) where CIAT is located Z. subfasciatus is the major pest of stored beans, and we have not found A. obtectus here. At CIAT Z. subfasciatus is a major post-harvest problem. We have not yet been able to establish colonies of A. obtectus, although our conditions are well within the range of environmental conditions for development stated by Howe and Currie.

Losses from weevils:

No precise information was found in the literature on economic losses in stored beans caused by insects. McGuire and Crandall (1967) estimate that for Mexico, Central America and Panamá storage losses are as high as 35%. They do not specify if these losses are from insects or other causes. Z. subfasciatus, was found in all countries surveyed, and A. obtectus was found in all these countries except El Salvador and Panamá.

In a marketing survey in Brazil (Recife area), 75% of the bean producers did not store beans. Average storage and handling losses, which are not specified, during the market process amounted to 13.3%. Those who stored beans used metal silos. (Slater et al, 1969).

Survey of losses from weevils in Colombia:

To form a better idea about bean storage losses due to insects, we surveyed 30 Colombian warehouses, 18 in the Cali area and 12 in Medellin. Both cities are close to important bean production areas. Elevation at Cali is 1,000 m and at Medellin, 1,470 m.

Colombia principally produces red mottled beans, and only black beans when export markets are available. Beans are harvested in the various producing areas around June and December-January. Our survey was made in August-September 1975.

Farmers usually hand harvest and hand thresh their beans. The average lenght of storage on the farm ranged from 4 days (Departamento Nariño) to 38 days (dept. Huila). However when black beans, planted in the survey period for export, were exluded, than the on farm-storage periods were 2 and 8 days average, respectively. (Economy dept., Bean Program, CIAT).

The average storage period in warehouses was 44 days, approximately the duration of one generation of stored grain insects at those altitudes. Of the stores surveyed, 63% held beans less than 1 week. Warehouse owners stated that bruchids were their principal problem in storing beans but only 60% of them stated that they had fumigated beans to control an insect infestation. Based on cleanliness of store rooms, construction, maintenance, organization of storage, etc, we classified 1/3rd of the warehouses acceptable for storing beans.

During the survey six of the 30 stores had bruchid infested beans. This means beans with adult bruchids, exit windows or perforations or eggs glued to the seed. The percentage infestation ranged from 0.2% of the bags present at the survey. (among 600 bags) to 75%(among 12 bags). An average of 2.3% of all the bags surveyed were weevily. The percentage of infested seeds per bag ranged from 5-100%, averaging around 8%. It is therefore estimated that 0.2% of the individual beans were infested with weevils. All infested lots were, or were going to be fumigated.

Sixty percent of the warehouses refused to buy some beans in 1975 because they were weevil infested. The estimated refusal percentage was 5.1% of all beans offered. These beans were usually processed for animal feed. Therefore, the estimated losses of beans for human consumption during storage are estimated at 2.3% plus 5.1%, amounting to 7.4% (Table 5). Additional storage losses do occur from insect attack between wholesaler and consumer. Because of the high price of beans and the smallness of the retailer, which is mostly the public market place we estimate that this period is very short, and therefore will not greatly increase the losses due to insects. We observed that prior to the harvest periods beans are scarce and of poor quality. They are discolored, often shriveled, of mixed colors and this may explain why prices do not seem to be related to shortages. We are continuing our survey here, prior to and directly after the harvest periods.

All insects found attacking beans in this survey were Z. subfasciatus, except in one store where we found A. obtectus. We think that this does not represent the relative importance of the two species accurately, as during the period of our survey beans were shipped in from lower altitudes. At other times of the year the relative frequency of the two species of stored bean insects may be different.

Storing beans at the farm can be economically important due to price fluctuations. As an example, in the period from March-August 1974 the bean price incrased by 65%, while from July to November 1975 the price dropped 21% (Table 6). The bean prices in each of the last 4 years declined from August to October and rose from October to August, and did not seem to be related to the harvest periods of June and December-January. Fumigation charges by commercial pest control operators were Col. $5.oo per bag, or 0.24% of their market value (average 1975 prices). This cost doubles when the beans are picked up at the store, fumigated elsewhere and then returned.

Farmers and non chemical control measures:

Local farm practice to control weevils is to apply wood ashes from fireplaces to the stored beans needed for future planting. The value of this method was tested by adding up to 20 g wood ash to 100 g samples of beans. As a physical barrier for the weevils, it appeared to be effective (Table 7).

Storing beans in undamaged pods is a safe control measure against Z. subfasciatus attack. Eggs deposited on the podwalls hatched and larvae penetrated the podwalls but died inside the pods, without penetrating the seed (Table 8). The adults emerging from pods undamaged at storage appeared to have resulted from pods, which split open during storage and permitted adults to oviposit on the seeds in these pods, (0.8 eggs and adults per replicate average). Although effective for Z. subfasciatus, this method cannot be used to control A. obtectus as this insect is able to attack beans in the pods. Labeyrie (1957) showed that storing beans unshelled or delaying the harvest greatly enhance A. obtectus attack. The practice of storing beans together with the debris from threshing, as compared with clearing away plant debris, soil, etc, had little effect on controlling Z. subfasciatus. Prsence of 20% by weight of plantdebris added to beans resulted in 88.4% undamaged beans after 3 months as compared with 99.8% in the samples without foreign material.

Another farmer practice is being investigated. In Asia and Africa pulses are protected against Bruchid attack by vegetable oils. Another non chemical method for controlling weevils is the use of black pepper. One gram of ground pepper per 385 g beans reduced infestations of _A. obtectus_ by 78% after 4 months storage compared with untreated lots. At 4.26g per 385 g the reduction was 97.9% (Lathrop and Keirstead, 1946).

Inert dusts, especially crystalline silica, bentonite and magnesium carbonate were effective in killing _A. obtectus_, especially the fraction of the finest particles of a dust was most effective. The killing of adults (50% killed in 12 hrs, for bentonite) was ascribed to dessication (Chiu, 1939).

In our laboratory we tested about 700 accessions of _P. vulgaris_ for resistance to _Z. subfasciatus_. Several accessions rated very resistant, but some of these were classified susceptbile when tested in the next generation. We cannot explain this change in resistance classification, but contribute it to environmental factors, and sampling error not too breakdown of resistance nor to weevil strain selection. Seed should maintain its resistance for at least 3 generations of testing before it can be called resistant and used for further studies. Resistance to _A. obtectus_ has been reported by other authors (e.g. Lefebre, 1950).

Chemical control methods:

Chemical control of weevils is readily obtained with a variety of products. Of the many references on chemical control only a few are cited. We assume that based on literature informations best suited for on-farm use are: malathion (P.Golob, pers comm.) and pyrethrins (Sales and Ruppel, 1959), (Mc Farlane, 1970). These products were also effective under our experimental conditions.

In our survey most warehouses used only few products to control stored insects. A total of 33.3% of the warehouse owners used phostoxin, 40% used methyl bromide, 26.7% used CS_2, and 13% used pyrethrin. One store owner confessed he used aldrin to control bruchids. They stated that CS_2 had affected quality of the beans. It "burned" beans prolonging the required cooking time.

Future research.

There is a great lack of knowledge about the importance of bean storage and storage losses from insects. Surveys are needed to establish the importance of these losses. On-farm storage methods in particular should be investigated. Farmers can gain economically by storing beans to wait for better prices and storage should also help to stabilize prices as well, by providing a more continuous supply. Chemical as well as non-chemical insect control measures for properly designed storage units should be developed, as has been done in Africa by the Tropical Stored Product Centre.

The distribution of the principal stored product insects is not understood. Biological data from laboratory experiments do not explain why A. obtectus is found in the cooler regions, while Zabrotes is principally found in the hot climates. Also the competition between the two species is not understood when they are confined to storage areas. The competition appears to be related to ambient conditions.

Search for resistance to the principal stored grain insects should continue. This resistance may not affect the nutritive value of beans and should be incorporated in commercial varieties.

Acknowledgement

The help of the bean economics-group during our survey, and especially the assistance of N. Londoño, is greatly appreciated.

References

Alate, J. 1973. Lista de insectos y otros animales dañinos a la agricultura en el Perú. Manual No. 38. Min. de Agric. Est. Expt. La Molina. pp. 176.

Chiu, S. F. 1939. Toxicity studies of so-called inert materials with the bean weevil Acanthoscelides obtectus (Say) J. Econ. Entomol. 32 (2): 240-248.

Howe, R. W. and J. E. Currie, 1964. Some laboratory observations on the rate of development, mortality and oviposition of several species of Bruchidae breeding in stored pulses. Bull. Entomol. Res. 55(3): 437-477.

Infante, M.A., G. M. Scobie and U. Gutierrez, 1974. Producción y consumo de fríjol seco y su distribución a la oferta de proteina a nivel mundial. XX Reunión Anual del PCCMCA, San Pedro de Sula, Honduras, 11-14 febrero 1974.

Labeyrie, V. 1957. Influence des technique de recoltes des haricots secs sur l'intensité des attaques de la Bruche (Acanthoscelides obtectus Say). Conte Rendu Acad. Agric. 43 (3): 138-140.

Lathrop, F. H. and L. G. Keirstead, 1946. Black pepper to control bean weevils. J. Econ. Entomol. 39: 534.

Lefebre P. C. 1950. Bruchus obtectus Say ou bruche des haricots (Phaseolus vulgaris L.). Public. de L'Inst. Natl. pour L'Etude Agron. du Congo Belge. (INEAC), 48: 1-65.

Mancía, J.E. and M. R. Cortéz, 1975. Lista de insectos clasificados encontrados en el cultivo del fríjol, Phaseolus vulgaris L. Siades 4 (4): 120-136.

McGuire, J. U. and B.S. Crandall, 1967. Survey of insect pests and plant diseases of selected food crops of Mexico, Central America and Panamá. Int. Agric. Dev. Serv.,Agric. Res. Serv. USDA, AID Oct. 1967. pp. 157.

Peña R. and J. A. Sifuentes, 1973. Lista de Cultivos y sus principales plagas en México, 1973. Agric. Tecnica en México. 3(5): 178-193.

Ruppel. R. F. and E. Idrobo, 1962. Lista preliminar de insectos y otros animales que dañan fríjoles en América. Agricultura Tropical; 18 (11): 651-679.

Salas, L. and R. F. Ruppel, 1959. Efectividad de insecticidas aplicados en polvo para controlar las principales plagas del fríjol y maíz alamacenados en Colombia. Agric. Trop. (Colombia): 15 (2): 93-108.

Slater, C:C. M. Ruley, V. Farace, K. Harrison, F. Neves, A. Bogatay, M. Dortoroff, D. Larson, R. Nason, and T. Welb, 1969. Market process in the Recife area of Northeast Brazil, Rept. 2. Latin America Studies Centre, Michigan St. Univ.

Vieira C., J.A. H. Freire and J. O. Gómez, 1971. Doencas e pragas do feijoeiro (Phaseolus vulgaris L.) Revista Ceres. 18 (99): 369-380.

Table 1. The two principal pests of stored beans (*Coleoptera*, *Bruchidae*)

Acanthoscelides obtectus (Say)
Zabrotes subfasciatus (Boheman)

Table 2. List of additional insects reported from stored beans.

Order, Family and species	Reported from	Reference
Coleoptera:		
Bruchidae		
Acanthoscelides puellus (Scharp)	El Salvador	Mancía and Cortez,1975
A. morosus (Sharp)	El Salvador	" " "
A. surrubresus (Pic.)	El Salvador	" " "
A. sp.	El Salvador	" " "
A. armitagei (Pic.)	Brasil, Colombia	Ruppel and Idrobo,1962
A. chilensis (Sch.)	Argentina,Uruguay	" " " "
A. obreptus Brid.	S. and C. America	" " " "
A. obvelatus Brid.	Mexico	" " " "
Bruchus rufimanus Both.	Arg. Cuba, Pt. Rico, Perú, Uruguay	Ruppel and Idrobo,1962
	Mexico	Peña and Sifuentes,1972
B. pisorum (L.)	Mexico	Peña and Sifuentes,1972
	Peru	Alata, 1973
Callosobruchus analis (Fabr.)	Brazil	Vieira et.al, 1971
C. maculatus (F.)	N.S. and C.America,	Mancía and Cortez,1975.
		Ruppel and Idrobo,1962
C. chinensis (L.)	S. and C. America	Mancía and Cortez,1975
		Ruppel and Idrobo,1962
Sennius bivulneratus (Horn)	El Salvador	Mancía and Cortéz,1975
S. discolor (Sharp.)	El Salvador	" " " "
Zabrotes sp.	Mexico	Ruppel and Idrobo,1962
Anobiidae		
Stegobium paniceum (L.)	Chile	Ruppel and Idrobo,1962

Table 2. (Cont.)

Order, Family and species	Reported from	Reference
Anthribidae		
Araecerus fasciculatus (Degeer)	Brazil	Vieira et.al, 1971
Euparius sp.	El Salvador	Mancía and Cortéz,1975
Bostrychidae		
Rhyzopertha dominica (F.)	Perú	Ruppel and Idrobo,1962
Cucujidae		
Cathartus quadricollis Guerin	Brazil	Vieira et al, 1971
Curculionidae		
Sitophilus granarius (L.)	Chile	Ruppel and Idrobo,1962
S. oryzae (L.)	Brazil Peru	Vieira et.al, 1971 Alata, 1973
Dermestidae		
Trogoderma simplex Jagne.	El Salvador	Mancía and Cortéz,1975
Scarabacidae		
Sericoides rufeola (Sol.)	Chile	Ruppel and Idrobo,1962
Tenebrionidae		
Tribolium castaneum (Abst.)	El Salvador	Mancía and Cortéz,1975
Asida sp.	El Salvador	Mancía and Cortéz,1975
Lepidoptera		
Blastobasidae		
Blastobasis sp.	Chile	Ruppel and Idrobo,1962
Galleridae		
Corcyra cephalonica (Stainton)	Brazil	Vieira et al, 1971
Gelechidae		
Sitotroga cerealella (Ol.)	Perú	Alata, 1973

Table 3. Life cycle of life of A.obtectus and Z.subfasciatus at 30°C and 70% RH. (Adapted from Howe and Currie, 1964).

Development stage	Duration in days	
	A.obtectus	Z.subfasciatus
Egg	4.9 }	
Larval and pupal	22.5 }	26.5
Adult life (outside seed)	11.8	7.6
No. of eggs per female	63.0	35.5

Table 4. Competition in storage between A. obtectus and Z. subfasciatus (from P.H. Giles, pers. comm.)

Altitude (m)	Avg. Temp. (°C)	Original rel. frequency A. obtectus: Z. subfasciatus	Rel. frequency after 16 weeks storage
56	28.2	99.7 : 0.3	0 : 100
450	25.2	99.7 : 0.3	4.6 : 95.4
680	24.3	99.7 : 0.3	27.3 : 72.7

Table 5. Losses from storage insects in a survey of 30 warehouses in Colombia.

Percent of stores with infested beans	20.0%
Percent of bags infested	2.3%
Percent of refused bags due to weevils	5.1%
Estimated loss from weevils 2.3 + 5.1 = 7.4%	

Table 6. Examples of changes in average bean price (Col. $/Kg.) (Source DANE)

Date	Price	% change
March 1974	17.82	
August 1974	29.40	+ 65%
July 1975	35.34	
Nov. 1975	28.00	- 21%

Table 7. Control of Z. subfasciatus with wood ash.

Ash addition (g)	% undamaged seeds, with ash applied Before infest.	15 days after infest.
0	0	0.0
5	10.6	3.4
10	38.4	4.0
20	78.4	19.3

(100 g seed of Calima, infested with 10 pairs of adults for 3 months).

Table 8. Development of *Zabrotes subfasciatus* on shelled and non-shelled beans.

Treatment	No. eggs/♀	No. adults/♀
Shelled	29.1	23.2
Undamaged pods	0.8	0.8
Damaged pods	23.1	16.0

Table 9. Mortality of Z. subfasciatus adults 96 hours after infesting seed treated with malathion and lindane (after P.Golob, pers. comm.)

Product	ppm	% mortality when infested: Immediately after treatment	% mortality when infested: 20 weeks after treatment
Malathion	8	85	0
	12	99	0
Lindane	2	100	85
	4	100	97