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Survey of Insects that Attack Stored Bean Grains *Vigna unguiculata* (L.) and *Phaseolus vulgaris* L. in Porto Velho, Rondônia, Brazil

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Abstract. Beans are a staple component of human diet. However, grain storage for consumption is difficult due to pest attack. The objective of the present study was to conduct a survey of insects acting on the beans *Phaseolus vulgaris* L. and *Vigna unguiculata* (L.) in commercial stores in Porto Velho, Rondônia, Brazil. Samples were collected in small, medium-sized, and large markets. Percent infestation and weight loss caused by insects was evaluated during nine weeks. For *V. unguiculata*, 3.70% infestation was recorded from store PT 7 and the medium-sized market; the most serious situation occurred on the fifth week, when infestation reached 2.93%; weight loss was recorded from PT2 and PT7, with 19.19 g and 23.57 g. For *P. vulgaris*, infestation reached 3.70% in material from PT6; in small markets, infestation attained 0.84%; on the ninth week, 1.29% was recorded; weight loss from insects infestation occurred in samples from PT1 and PT6, 18.50 g and 9.78 g. Insect species found were *Callosobruchus maculatus* (Fabr.), *Zabrotes subfasciatus* (Boh.) and *Acanthoscelides obtectus* Say. Insect infestation did not significantly differ between both bean species.

Keywords: Bruchids; Grain; Market; Plague; Stored Product.

Levantamento dos Insetos que Atacam os Grãos de Feijão Armazenado *Vigna unguiculata* (L.) e *Phaseolus vulgaris* L.em Porto Velho, Rondônia, Brasil

Resumo. O feijão é um componente fundamental na alimentação dos seres humanos. Entretanto, o armazenamento dos grãos para consumo se torna uma enorme dificuldade devido ao ataque de insetos. O presente estudo teve como objetivo realizar um levantamento de insetos que atacam feijão armazenado *Phaseolus vulgaris* L. e *Vigna unguiculata* (L.) em estabelecimentos comerciais de Porto Velho, Rondônia, Brasil. As amostras foram coletadas em mercados de pequeno, médio e grande porte, nas quais foi avaliado o percentual de infestação e perda de peso ocasionado pelos insetos durante nove semanas. Para *V. unguiculata* PT 7 registrou 3,70% de infestação, o mercado de médio porte atingiu 3,70%, a 5ª semana foi a mais agravante alcançando 2,93% de infestação, já a perda de peso ocorreu em PT2 e PT7 sendo 19,19 g e 23,57 g. Para *P. vulgaris* a infestação em PT6 chegou a 3,70% , em mercados de porte pequeno a infestação resultou em 0,84%, na 9ª semana observou-se 1,29%, em relação a perda de peso por infestação de insetos ocorreram em PT1 e PT6, sendo de 18,50 g e 9,78 g. As espécies de insetos encontradas foram *Callosobruchus maculatus* (Fabr.), *Zabrotes subfasciatus* (Boh.) e *Acanthoscelides obtectus* Say, em ambas as espécies de feijão não houve diferença significativa em relação as infestações pelas pragas.

Palavras-chave: Bruquídeos; Grão; Mercado; Praga; Produto Armazenado.

Bean is one of the most important grains used for human and animal food worldwide important nutrients. For example, the contents of *Vigna unguiculata* (L.) Walp. (Fabales, Fabaceae) are 24.5% protein, 54.4% carbohydrates, and 19.4% food fibers, and the energetic value is 323.4 kcal.100 g^{-1} (Frota *et al.* 2008); *Phaseolus vulgaris* L. (Fabales, Fabaceae) 25.7% protein, 67.1% carbohydrates, and 5.67% fibers (Mesquita *et al.* 2007). Furthermore, beans are economically and socially important in several countries, including Brazil. Brazilian agricultural survey estimates conclude that 70% of bean grain are produced by family level agriculture. This reveals the crop's economic potential, since it involves a production chain that generates employment, income, and nutrition for several communities countrywide. However, several factors limit production, among which little investment in technology, that remains low, and climate (Santi *et al.* 2006). Furthermore, precarious storage conditions favor proliferation of fungi and insects, that cause serious damage to grains and seeds (Brangantini 2005).

The main insect species that attack stored bean grains are *Zabrotes subfasciatus* (Boh.), *Acanthoscelides obtectus* Say, and *Callosobruchus maculatus* (Fabr.) (Coleoptera, Bruchidae), commonly designated beetles and weevils (Karel & Autrique 1989). According to the Schoonhoven & Cardona (1986), insect infestation in stored bean causes quantitative, as well as qualitative, losses in grains and seeds. Quantitative losses are related to consumption of seed and grain content, or parts of it, by insects. Qualitative losses correspond to contamination from rests of insect excrements or bodies. Bruchid (mainly, larvae) metabolism causes grain mass temperature and relative humidity to rise, favoring fungi and bacteria settlement.

The objective of the present study was to conduct a survey of insects of stored *V. unguiculata* and *P. vulgaris* beans in commercial stores in Porto Velho, Rondônia, Brazil.

MATERIAL AND METHODS

Three lots of samples of *V. unguiculata* and *P. vulgaris* beans were collected between 2013 and 2014 in six supermarkets and two free markets in the city of Porto Velho, Rondônia State, Brazil, totaling eight sampling points (Table 1). These points were selected for being the main places where consumers purchased stored bean. The criterion for inclusion and selection of store size

followed the classification proposed by Parente (2000), based on the dimension of the units. Unit names were kept secret during the study, and codes were assigned to them.

Table 1. Sample collection points, represented by size and geographical coordinates, in the city of Porto Velho, Rondônia – 2013 and 2014.

Store	Store size*	Geographical coordinates
PT1	Small (free market)	8°45'53.57"S 63°54'28.15"W
PT2	Small (free market)	8°45'47.16"S 63°53'46.12"W
PT3	Large	8°45'45.00"S 63°53'44.15"W
PT4	Large	8°45'37.88"S 63°53'05.37"W
PT5	Large	8°46'00.93"S 63°52'59.54"W
PT6	Large	8°47'31.19"S 63°53'10.55"W
PT7	Medium	8°44'55.37"S 63°54'38.32"W
PT8	Large	8°45'33.05"S 63°50'39.26"W

*According to characterization by Parente (2000) p. 30.

To ensure sample uniformity, *P. vulgaris*, Group 1- "Feijão-anão", Class "Preta"; and *V. unguiculata*, Group 2- "Feijão-de-corda", Class "Brancão" were used (Brasil 1987). At each collection point, 1 kg of beans of each species was acquired. Next, samples were taken to the Microscopy Laboratory of Faculdades Integradas Aparício Carvalho – FIMCA and split into three 333.33 g subsamples with a precision analytical balance to aid the observation of grain infestation. Next, grains were counted, and whole and healthy grains of each sample were weighed.

Grains were transferred to 700 mL plastic cups, which were covered with organza fabric fixed to the cups with rubber bands. Bean samples were kept in conditions simulating those of a residential store-room, in dim light. Air temperature and relative humidity were measured three times a day during the entire experiment (Figure 1).

Figure 1. Experimental display of the plastic cups containing samples of *Vigna unguiculata* and *Phaseolus vulgaris* beans from different stores.

Samples were analyzed weekly for infestation and recording of the biological cycle stages of detected pests. Each experiment was conducted during nine weeks of observation, after which the presence of insects was no longer detected. Athié & Paula's (2002) identification keys were used for the systematic identification of insects.

RESULTS

Two species were found infesting *P. vulgaris*: *A. obtectus*, the most frequent, with 62% infestation; and *Z. subfasciatus*, with 38%. Only *C. maculatus* was found infesting *V. unguiculata* (Table 2). *V. unguiculata* infestation occurred in samples from PT2 and PT7, with 2.88% and 3.70% infestation, respectively; however, results between stores were not significantly different (Table 3). *P. vulgaris* infestation was detected in PT1, PT4, and PT6, with 1.69%, 0.01% and 3.70%, statistically similar to the other points (Table 4).

Table 2. Percent infestation of *Phaseolus vulgaris* and *Vigna unguiculata* by insect species in the city of Porto Velho, Rondônia - 2013 and 2014.

Species	*P. vulgaris*	*V. unguiculata*
Callosobruchus maculatus	-	100%
Acanthocelides obtectus	62%	-
Zabrotes subfasciatus	38%	-

Table 3. Average percent infestation of *Vigna unguiculata* by *Callosobruchus maculatus* in different commercial stores in the city of Porto Velho, Rondônia – 2013 and 2014.

Store	Infestation (%)*	Standard error
PT1	0.00a	±0.00
PT2	2.88a	±1.76
PT3	0.00a	±0.00
PT4	0.00a	±0.00
PT5	0.00a	±0.00
PT6	0.00a	±0.00
PT7	3.70a	±2.27
PT8	0.00a	±0.00
CV %= 36.46 DF= 23 F= 0.86 P= 0.55		

*Same letter indicates no difference between averages at 5% significance level. Data were transformed into $\sqrt{x+1}$ or data analysis.

Table 4. Percent infestation of *Phaseolus vulgaris* by insect species in different commercial stores in the city of Porto Velho, Rondônia - 2013 and 2014.

Store	Infestation (%)*	Standard error
PT1	1.69a	±1.03
PT2	0.00a	±0.00
PT3	0.00a	±0.00
PT4	0.01a	±0.01
PT5	0.00a	±0.00
PT6	3.70a	±2.27
PT7	0.00a	±0.00
PT8	0.00a	±0.00
CV %= 43-96 DF= 23 F= 0.87 P= 0.55		

*Same letter indicates no difference between averages at 5% significance level. Data were transformed into: $\sqrt{x+1}$ for data analysis.

Point stratification based on the installed capacity of the markets revealed that *V. unguiculata* bean infestation occurred in small and medium-sized stores, 1.44% and 3.70%, respectively. For *P. vulgaris*, infestation was detected in small and large stores, with 0.84% and 0.74% (Table 5). Statistical analysis showed that

insect percent infestation did not differ in relation to store size for either bean species.

As to infestation during observation weeks, again, no statistically significant differences were found either for *V. unguiculata* or *P. vulgaris*. In *V. unguiculata*, infestation occurred from the first to sixth week, most evidently between the second and sixth, varying from 1.01% to 2.67%, peaking on fifth week, with 2.93% (Table 6). In *P. vulgaris*, infestation was recorded on every observation week, and attained the highest percent value between the fifth and ninth weeks, during which it varied from 0.97% to 1.29%. In the remaining weeks, it stayed below 0.41% (Table 7).

V. unguiculata grain weight loss data are in Table 8. Weight loss in grains infested by *C. maculatus* was recorded only in samples from PT2 (small) and PT7 (medium-sized) stores, respectively, 19.19 g and 23.57 g. However, these values did not differ statistically (Table 8). For *P. vulgaris*, weight loss was detected from PT1 (small), with 18.50 g, and PT6 (large) stores, with 9.78 g, which also did not differ statistically (Table 9).

Insects caused damages, like grain boring and burring, formation of farinaceous material inside samples, caused by foraging and elimination of debris, with consequent weight loss in some samples from both bean species.

DISCUSSION

Three species of insects that damage stored bean were found in this study, in different stores in the city of Porto Velho. In *V. unguiculata*, only the weevil *C. maculatus* was found, whereas the weevils *A. obtectus* and *Z. subfasciatus* were found in *P. vulgaris*.

Table 5. Average percent infestation of insects in two bean species traded in stores of different sizes in the city of Porto Velho, Rondônia – 2013 and 2014.

Species	Market (size)			Statistics			
	Small	Medium	Large	CV (%)	DF	F	P
Vigna unguiculata	1.44±1.44a	3.70±3.70a	0.00±0.0a	65.77	8	0.59	0.58
Phaseolus vulgaris	0.84±0.84a	0.00±0.0a	0.74±0.74a	33.27	8	0.50	0.62

*Same letter indicates no difference between averages at 5% significance level. Data were transformed into: $\sqrt{x+1}$ for data analysis.

Table 6. Average percent infestation of *Vigna unguiculata* by *Callosobruchus maculatus* per sampling week in Porto Velho, Rondônia – 2013 and 2014.

Week	Infestation (%)*	Standard error
1st	0.16a	±0.09
2nd	1.01a	±0.01
3rd	0.99a	±0.57
4th	0.64a	±0.37
5th	2.93a	±1.69
6th	2.67a	±1.54
7th	0.00a	±0.00
8th	0.00a	±0.00
9th	0.00a	±0.00
CV (%)= 49.89 DF= 26 F= 0.67 P= 0.71		

*Same letter indicates no difference between averages at 5% significance level. Data were transformed into: $\sqrt{x+1}$ for data analysis.

Table 7. Average percent infestation of *Phaseolus vulgaris* by insects per sampling week in Porto Velho, Rondônia – 2013 and 2014.

Week	Infestation (%)*	Standard error
1st	0.16a	±0.09
2nd	0.04a	±0.02
3rd	0.41a	±0.24
4th	0.39a	±0.13
5th	0.97a	±0.30
6th	0.70a	±0.29
7th	1.22a	±0.60
8th	0.88a	±0.45
9th	1.29a	±0.57
CV (%)= 29.04 DF= 26 F= 0.52 P= 0.82		

*Same letter indicates no difference between averages at 5% significance level. Data were transformed into: $\sqrt{x+1}$ for data analysis.

Table 8. Average weight loss (g) caused by *Callosobruchus maculatus* to *Vigna unguiculata* in different commercial stores in the city of Porto Velho, Rondônia – 2013 and 2014.

Store	Weight loss (g)*	Standard error
PT1	0.00a	±0.00
PT2	19.19a (5.75%**)	±11.75
PT3	0.00a	±0.00
PT4	0.00a	±0.00
PT5	0.00a	±0.00
PT6	0.00a	±0.00
PT7	23.57a (7.07%**)	±14.44
PT8	0.00a	±0.00
CV %= 128.54 DF= 23 F= 0.86 P= 0.55		

*Same letter indicates no difference between averages at 5% significance level. Data were transformed into: $\sqrt{x+1}$ for data analysis. **Sample percent weight loss.

Table 9. Average weight loss (g) caused by insects to *Phaseolus vulgaris* in different commercial stores in the city of Porto Velho, Rondônia – 2013 and 2014.

Store	Weight loss (g)*	Standard error
PT1	18.50a (5.55%**)	±11.33
PT2	0.00a	±0.00
PT3	0.00a	±0.00
PT4	0.00a	±0.00
PT5	0.00a	±0.00
PT6	9.78a (2.93%**)	±5.99
PT7	0.00a	±0.00
PT8	0.00a	±0.00
CV %= 110.82 DF= 23 F= 0.87 P= 0.55		

*Same letter indicates no difference between averages at 5% significance level. Data were transformed into: $\sqrt{x+1}$ for data analysis. **Sample percent weight loss.

According to the literature, *C. maculatus* is the main pest insect of the bean *V. unguiculata* (Almeida *et al.* 2005), and is not found in *P. vulgaris*, which can possibly be explained by physiological reasons pertaining to digestibility of certain protein compounds (Silva *et al.* 2003). The finding of *A. obtectus* and *Z. subfasciatus* in *P. vulgaris* agrees with the literature, which considers them the main insects of their grains (Karel & Autrique 1989; Athié & Paula 2002). Dunkel (1992) points out that bruchids are the main responsible for damage in grains and seeds of Black Bean, and

losses can be significant if no control measures are implemented in the storage system.

Infestation levels were very low for both species of beans evaluated, when compared with other regions in Brazil and other countries. In the Northeast, *C. maculatus* heavily infests *V. unguiculata*, the main bean planted and consumed in the region (Costa & Boiça-Júnior 2004). The low infestation levels were corroborated by results obtained by Germain *et al.* (1987) with *V. unguiculata*; the authors attribute differences in infestation among sites to climatic interference. In Colombia, Baier & Webster (1992) recorded damages by *A. obtectus* to *P. vulgaris* seeds of approximately 57% after 36 weeks of storage. Garcia *et al.* (2000) stored 5 kg of *P. vulgaris* for eight months, and observed a 3.08% infestation of *Z. subfasciatus*.

Susceptibility of beans of genus *Vigna* to *C. maculatus* has also been reported in the literature. Kaliramesh *et al.* (2013) evaluated 2,400 grains of *Vigna radiata* L. (Fabales, Fabaceae) for 25 days, and recorded up to 2,100 grains infested by *C. maculatus*, adding up to an infestation of 84%. As noted by Carpinera (2001), cowpea bean is the most susceptible group to *C. maculatus*.

Akintunde (2012) collected samples of *V. unguiculata* from the largest supermarkets in the town of Abeokuta, Nigeria, and stored them during 100 days, after which he detected a 5.5% infestation by *C. maculatus*. Results of this study approached those of that author, which varied between 5.75% and 7.07% weight loss.

According to Schmale *et al.* (2002), *P. vulgaris* bean samples were collected inside and outside a cultivation area, where they were stored for 16 weeks. During this period, the index of infestation by *A. obtectus* was 34% inside and 5.7% outside the area. According to Negasi (1994) *apud* Abate & Ampofo (1996), in Ethiopia, damages caused by *A. obtectus* and *Z. subfasciatus* attained 38% of the sample, with corresponding weight loss of approximately 3.2%. In the present study, infestation was low in positive sampling points, but weight loss varied from 2.9 to 5.5%, values similar to those reported by those authors.

In this research, infestation of both bean species occurred in samples collected from small markets, and medium-sized markets for *V. unguiculata*. At those places, storage conditions and hygiene were precarious, favoring the maintenance and development of insects. These data highlight the importance of the effective action of the municipality's sanitary vigilance agencies to secure access of Porto Velho consumers to a food supply with no contamination and a nutritional content that meets the caloric needs of human diet.

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