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Short Communication

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A Species of the Genus *Eubulus* (Coleoptera: Curculionidae): A New and More Destructive Cassava Pest in the Brazilian Cerrado

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Abstract

In 2009, a new pest of cassava crops was observed in the Federal District (Brazil) and identified as *Eubulus* (Kirsch) sp. (Coleoptera: Curculionidae). The pest is currently distributed in the states of Goiás, Minas Gerais, Mato Grosso do Sul, and Paraná. The larvae consume roots, causing the tissue to rot and making it unfit for consumption. The damage can extend to 100% of the roots. Owing to the potential losses that this pest is capable of causing, studies are needed on its biology, ecology, and future management strategies aimed at minimizing the losses, allowing the continuity of cassava cultivation in Brazil. This study reports on the occurrence of the pest in Brazilian Cerrado, its distribution in Brazil, the symptoms of its infestation and estimates the damage caused.

Resumo

Em 2009, uma nova praga foi observada em cultivos de mandioca no Distrito Federal (Brasil) e identificada como *Eubulus* sp. Atualmente esta praga está distribuída nos estados de Goiás, Minas Gerais, Mato Grosso do Sul e Paraná. As larvas consomem as raízes, provocando o apodrecimento do tecido e tornando-as impróprio para consumo. Os danos podem chegar a 100% da produção de raízes. Devido às perdas potenciais que esta praga é capaz de provocar, são necessários estudos sobre sua biologia, ecologia e estratégias futuras de manejo visando minimizar as perdas e permitindo a continuidade do cultivo da mandioca no Brasil. Este estudo relata a ocorrência da praga no Cerrado brasileiro, sua distribuição no Brasil, os sintomas de sua infestação e estima seus danos.

Key words: *Manihot esculenta*, root, insect pest, damage, Brazil

Cassava (*Manihot esculenta* Crantz) is cultivated mainly for its starchy roots and is one of the most important calorie sources in the diet of several tropical countries (Cock 1982, Howeler et al. 2013). The species is very drought tolerant and adapts to varied climate and soil conditions. Cassava roots can be marketed fresh or processed, with a great versatility of uses (human food, food industry, animal feed, and chemical industry, among others; Carvalho et al. 2004, Fernandes et al. 2016, Vieira et al. 2018).

In Brazil, cassava is cultivated in all states of the Federation, from the humid tropical climate of the Amazon to the subtropical climate of Rio Grande do Sul. Due to its wide dispersion, the crop is affected by pests that occur in all crop areas and others that have regional distributions (Oliveira and Paula-Moraes 2013), which may influence the productivity, sustainability, and profitability of the crops.

At the end of 2009, roots of cassava from the experimental areas of Embrapa Cerrados (Planaltina/Federal District, Brazil) showed symptoms of rotting. Examination of the roots revealed the presence of Curculionidae larvae (Insecta: Coleoptera). Adults were collected and identified by Dr. Sergio Antonio Vanin (University of São Paulo, Department of Zoology, Institute of Biosciences, São Paulo, SP, 05508-090, Brazil), Dr. Germano Henrique Rosado Neto (Federal University of Paraná, Department of Zoology, Polytechnic Center, Curitiba, PR, 81531–980, Brazil) and Dr. Charles W. O'Brien (2313 W, Calle Balaustre, Green Valley, AZ 85622), as belonging to the genus *Eubulus* Kirsch (Curculionidae: Cryptorhynchinae). South American species of the genus *Eubulus* have not been described since

1954 (Fiedler 1939, 1952, 1954a,b), and thus a taxonomic identification has not yet been possible. Therefore, the insect of our study will be treated as *Eubulus* sp. or cassava root borer. Vouchers of the material studied are deposited in the Embrapa Cerrados entomological collection (CPAC).

Since its detection in 2009 in Planaltina, the damage and economic losses caused by this insect to cassava crops have been increasing rapidly in several regions of Brazil. This study reports on the occurrence of the pest in the Brazilian Cerrado, its distribution in Brazil, the symptoms of its infestation and estimates the damage caused.

Materials and Methods

Between 2016 and 2018, an experiment was carried out in the Embrapa Cerrados to estimate the damage caused by *Eubulus* sp. The experiment was repeated four times, the first one starting in February 2016 (experiment 1) and the other three in 2017 (experiments 2, 3, and 4). In an area with a history of severe pest attacks, in each experiment, 20 plots of 6 rows with 8 plants per row of the BRS 399 cultivar were planted, with a spacing of 1.2 m between rows, 0.8 m between plants and 3 m between plots, with a total of 960 cassava plants. The sampled area of each plot was the 10 plants of the two central lines, with a total of 200 plants evaluated (10 plants from each of the 20 plots). The cultural practices followed the recommendations for cassava cultivation in the Cerrado biome (Fialho and Vieira 2013).

In each experiment, evaluations were performed 12 mo after planting. For each plot, the percentage of attacked roots was calculated by multiplying the number of roots with attack symptoms (sum of the roots of the 10 plants evaluated per plot) by 100 and dividing by the total number of roots (all roots obtained in the plot). Average percentage of roots with attack symptoms was obtained using the data from the 20 plots. Roots considered attacked by the borer were the ones that presented external holes, internal galleries, and rotting. Healthy and attacked roots per plant were separately weighed, and with the data of the 20 plots we obtained the average values of root weight. The roots were brought to the laboratory, and the number of larvae per root was evaluated by opening all the roots with a blade and counting the number of larvae.

The geographical distribution of *Eubulus* sp. was based on visits carried out between 2009 and 2019 in cassava-producing areas in Brazil, where there were reports of pest occurrence or samples of cassava roots attacked by pests. In all regions visited, the larval samples were collected and specimens were reared until adulthood to confirm that they were *Eubulus* sp. The adults obtained were compared, using external morphology and male genitalia, with samples of *Eubulus* sp. identified and deposited in the Embrapa Cerrados (CPAC).

Regarding the variables analyzed, statistical analysis was performed to verify the influence of the planting seasons represented by the four experiments (treatments). The data obtained did not meet normality assumptions relating to the residues and the homogeneity of the variance. Therefore, nonparametric analyses were used to verify the differences between the treatments. A Kruskal–Wallis analysis was used and a comparison between the four treatments was performed by Nemenyi post hoc comparison with a χ^2 correction (Hicks et al. 2016). The analyses were performed using the PMCMR package (Pohlert 2014) in R (R Core Team 2018).

Results and Discussion

In general, we observed that the damage caused by *Eubulus* sp. increased gradually over time, reaching losses of 100% in the last experiment, indicating total root destruction (Table 1). It was found that the average percentage of attacked roots varied from 85.6 to 100%. The first experiment presented a percentage of attacked roots that was significantly lower than the others ($K = 39.202$, $P \leq 0.0001$; Table 1). The mean weight of healthy roots per plant was always lower than the mean weight of attacked roots. The weight of healthy roots per plant varied from 0.53 kg to 0.04 kg, while the weight of attacked roots varied from 2.74 kg to 0.60 kg. The weight of healthy roots ($K = 47.75$, $P \leq 0.0001$) and attacked roots ($K = 59.73$, $P \leq 0.0001$) was statistically higher in the first experiment compared to the others experiments (Table 1).The mean number of larvae per root ranged from 2.5 to 1.8 with no statistical differences between treatments ($K = 1.02$, $P = 0.5994$; Table 1). The lowest yield obtained was 0 t ha^{-1} and the highest was 5.5 t ha^{-1}; there was, thus, statistically higher yield in the first experiment ($K = 44.56$, $P \leq 0.0001$) (Table 1).

It was observed that in the first experiment, installed in February 2016, the damage caused by *Eubulus* sp. was statistically lower. The experiments installed in 2017, spatially and temporally closer, showed, in numerical terms, an increase in damage but did not differ statistically from each other (Table 1). The

Table 1. Estimated damage caused by *Eubulus* sp. larvae in cassava (BRS 399 cultivar), in field conditions, in Planaltina/DF, Brazil, between the years 2016 and 2018

Experiment	Planting date	APRA[a] (%)	AWHR[b] (kg)	AWAR[c] (kg)	ANLR[d]	Productivity[e] (ton/ha)
1	Feb./2016	85.6 ± 1.90[f]A[g]	0.53 ± 0.06A	2.74 ± 0.21A	2.5 ± 0.02 A	5.5 ± 0.69A
2	Mar./2017	93.1 ± 3.09 B	0.10 ± 0.04B	0.96 ± 0.15B	2.4 ± 0.02 A	1.0 ± 0.38B
3	May/2017	96.9 ± 2.26 B	0.04 ± 0.03B	0.60 ± 0.08B	1.8 ± 0.02 A	0.4 ± 0.29B
4	Dec./2017	100.0B	*	*	*	0.0B

[a]Average percentage of roots attacked per plot.
[b]Average weight of healthy roots per plant.
[c]Average weight of attacked roots per plant.
[d]Average number of larvae per root.
[e]Productivity based only on roots not attacked by the cassava root borer, attacked roots are unfit for human consumption and have not been counted.
[f]Standard error (±SE).
[g]Averages followed by the same letter within each column are not significantly different according to the Nemenyi test post hoc comparison with a χ^2 correction ($P = 0.05$).
*No roots were found in the plants and it is not possible to evaluate the weight of roots and the number of larvae per root.

gradual increase in damage over the four experiments, however, suggests that uninterrupted cassava cultivation in the same area contributed to the population increase of *Eubulus* sp., which is likely to survive in the remains left from the previously planted crop. Rotten roots that break and remain in the soil during harvest can allow the insect to complete its cycle, re-infesting subsequent crops planted.

Eubulus is a neotropical genus that currently has 135 species described in South America, with 87 species occurring in Brazil, of which 69 are endemic (Wibmer and O'Brien 1986). Three species, *E. fairmairei* Jekel, *E. monachus* (Schönherr), and *E. virgatulus* Marshall, were recorded in Brazil attacking the stem of plant species such as *Inga* sp. (Fabaceae), *Vernonia diffusa* (Asteraceae), and a species of Acanthaceae (Costa Lima 1956). More recently, an unidentified species of *Eubulus* was recorded feeding on *Alibertia edulis* (Rubiaceae) (Silva 2014).

An unidentified cassava pest species of the genus *Eubulus* was reported in Colombia in the 1970s (Polanía 1970, Cardenas 1972, Bellotti and van Schoonhoven 1978, Bellotti et al. 1983). However, the larvae of this species were recorded as attacking the stems and branches (not the roots) of plants, suggesting that it is a different species from that which attacks cassava roots in Brazil.

In Brazil, the adults of *Eubulus* sp. found in cassava are about 8.0 mm long, have a dark coloration, and their bodies are covered with red-orange and white bristles (Fig. 1A and B). The eggs are elliptical, milky-white, measuring about 0.8 mm (Fig. 1C and D) and are deposited just below the external pellicle or between the bark and the pulp. The larvae are white in color, have a brown head and no legs, and have a maximum length of about 13.0 mm (Fig. 1E and F). The pupae are exarate, caramel brown in color, and 6 mm long (Fig. 1G and H). Larval feeding produces numerous galleries within the roots. These galleries allow microorganisms (fungi and bacteria) to invade the roots, eventually causing the total rotting of the roots, making them unsuitable for consumption or even for use in the cassava flour and starch industries (Fig. 2).

The results of our study show that *Eubulus* sp. is capable of causing up to 100% yield loss in cassava crops, drastically reducing the yield (Table 1). The cassava cultivar used in our study (BRS 399) is capable of producing approximately 41 t ha^{-1} under commercial growing conditions (Vieira et al. 2018). Comparing the yields obtained in the four experiments with the productive potential of this cultivar in commercial crops, the reduction in yield is in the range of 85 to 100%. Although the other pests that attack cassava in Brazil have the potential to reduce yield (Oliveira and Paula-Moraes 2013), none is capable of causing 100% yield loss. For *Eubulus* sp., there are reports of total losses in areas of the municipalities of Itaberaí/Goiás, Bela Vista/Goiás, Lagoa Formosa/Minas Gerais, Carmo do Paranaíba/Minas Gerais, and Patos de Minas/Minas Gerais. These losses have caused the abandonment of cultivation in many producing regions or the replacement of cassava by another crop. Obtaining more information to assist in creating efficient control measures for this pest is essential for the maintenance and continuity of the cassava crop in Brazil.

With respect to the geographical distribution, to date there have been records of the occurrence of cassava root borers in the states of Goiás, Minas Gerais, Mato Grosso do Sul, Paraná, and the Federal District (Fig. 3), with Paraná being the second largest Brazilian producer of cassava. Together, these states are responsible for 25% of the cassava production in Brazil.

As the pest directly attacks the marketable product, i.e., the cassava roots, making it unfit for human consumption or for the manufacture of flour/starch, there is a requirement for the development of *Eubulus* sp. control measures that prevent the colonization of the crop by adults or measures aimed at preventing oviposition on the roots. This species, however, has a cryptic habit, spending the entire larval phase inside the roots, and the adults remain buried in the soil during the day, which makes it difficult to adopt control measures.

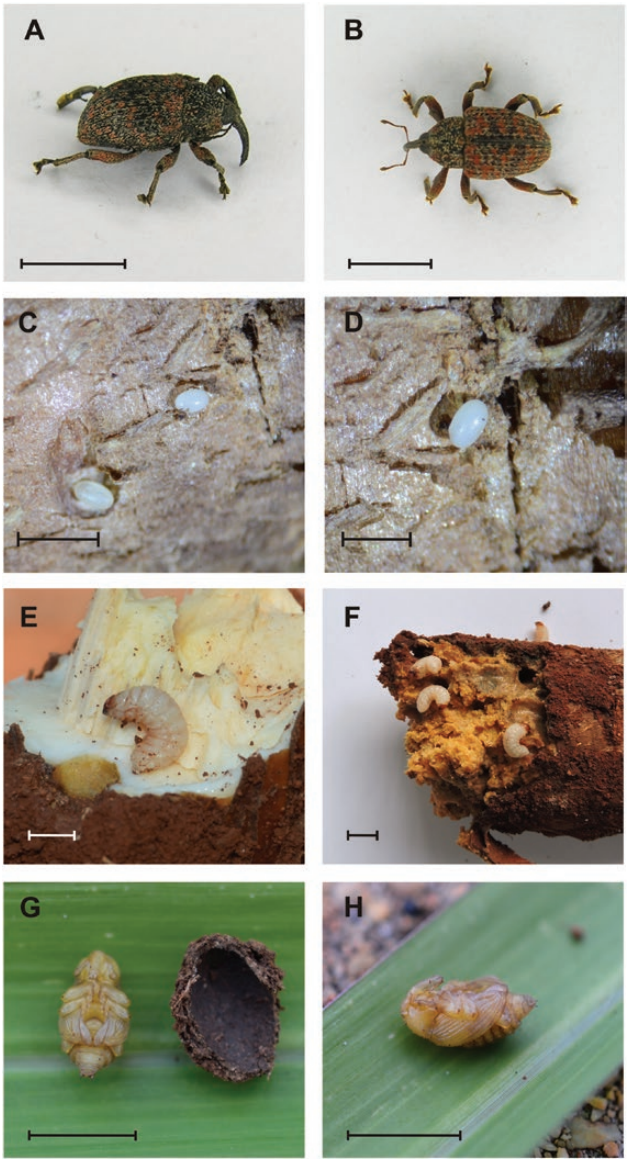

Fig. 1. Biological phases of *Eubulus* sp.: A–B: adults; C–D: eggs; E–F: larvae; and G–H: pupae (bars: A–B, E, G–H = 5 mm; C = 2 mm; D = 1 mm; and *F* = 10 mm).

The largest cassava-producing countries are in Asia and Africa (FAOSTAT 2019), where cassava is the basis for feeding millions of people. Therefore, it is important to avoid the exchange of plant material with these regions, as this may introduce this new pest into these continents.

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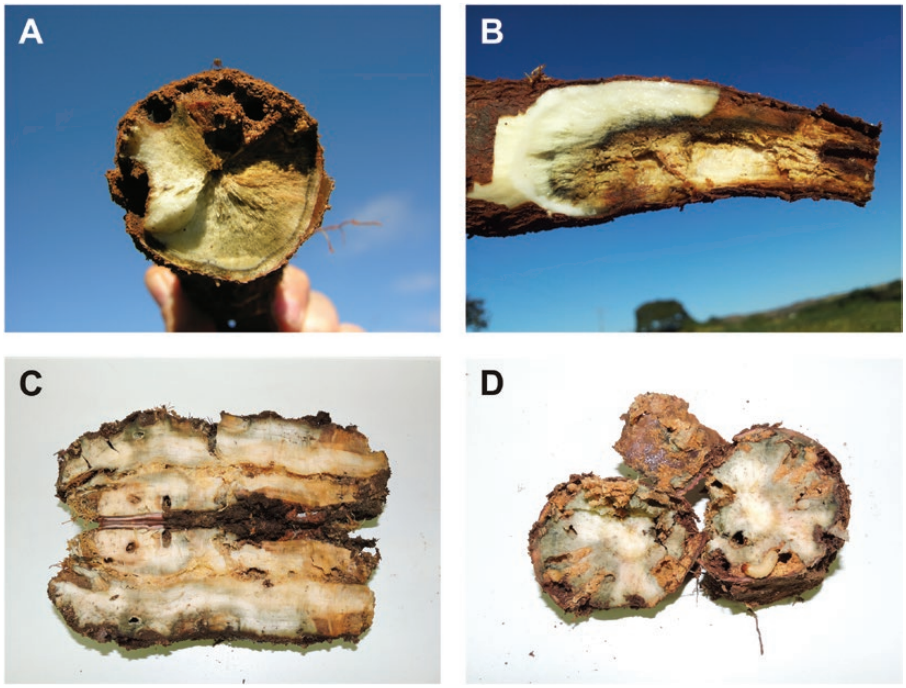

Fig. 2. Damage caused by *Eubulus* sp. to cassava roots.

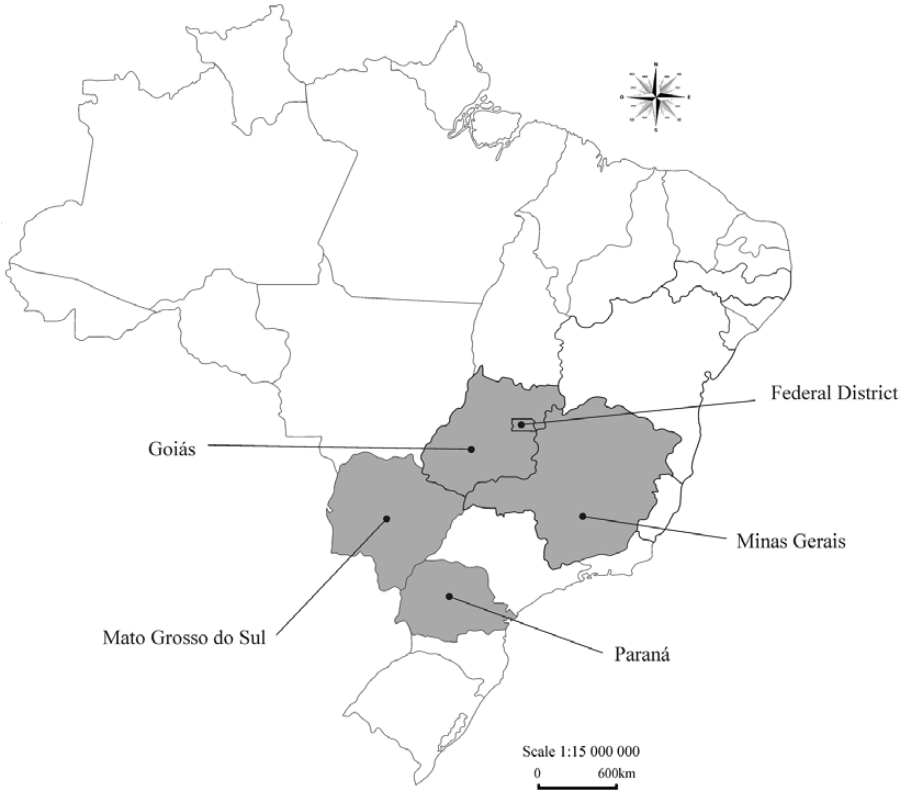

Fig. 3. Geographical distribution of *Eubulus* sp. by the state in Brazil.

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