

*Full Length Research Paper*

# **Effects of harvesting date on the level of initial infestation and damages caused by insect pests on the seeds of *Acacia macrostachya* Reichenb. ex DC., in the district of Boulkiemde in Burkina Faso**

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The seeds of *A. macrostachya* are increasingly consumed by the Burkinabe population, especially during customary and religious ceremonies. However, these seeds are rapidly degraded after harvest by insect pests, when no control method is undertaken. This study was therefore conducted to determine the level of initial infestation and damage caused by insect pests. The harvest of dry pods on 30 trees of Saria's spontaneous vegetation was carried out from November 2018 to January 2019. These pods were collected on 5 different dates at 10-day spacing. After shelling in the laboratory, the seeds obtained were placed in glass jars of 1-liter capacity. Monitoring of the 1st generation of insect emergences continued for 45 days. The results indicated that *Bruchidius silaceus* was the most dominant insect pests' compared to *Caryedon furcatus* and *Bruchidius* sp. Seven parasitoid species also were recorded with *Eupelmus* sp. being the most abundant. The initial infestation rate ranged between 44.75 and 55.85%. The rates of seed perforation and weight loss increased from the 1st to the last harvest from 5.15 to 35.07% and 0.98 to 6.50% respectively. It is concluded from this study that timely and prompt harvest of pods of *A. macrostachya* are essential to lessen damage of the seeds by insect pests.

**Key words:** *Acacia macrostachya*, *Caryedon furcatus*, *Eupelmus* sp., *Bruchidius silaceus*, Infestation level, Damage

## **INTRODUCTION**

In West Africa, non-timber forest products (NTFPs) are important in the livelihoods of people from the Sahelian region (Hill et al., 2007). Indeed, these products are a good source of food supplements, and their marketing

also generates significant financial income for this population (Maisharu and Larwanou, 2015). Thus, in the context of fighting poverty and food insecurity which is endemic in this part of Africa, promoting NTFPs becomes

imperative. In Burkina Faso in particular, several plant species provide NTFPs. Among these species, *Acacia macrostachya* Reichenb. ex DC. occupies an important place because of the multiple benefits of its seeds, in terms of food (Sawadogo et al., 2011; Hama-Ba et al., 2017) and economics (Ganaba, 1997; Hill et al., 2007). Thus, its protein, fat and digestible carbohydrate content is respectively 39.8-43.6; 9.7-11.5 and 16.6-26.4 (g/100 g dry weight) (Drabo et al., 2020). Boiled seeds are eaten as a stew, or in combination with cereals (Hama-Ba et al., 2017). In addition, recent work by Msika et al. (2017) has shown an interest in the seeds of this wild legume in the fields of cosmetic and dermatology. Regarding these many advantages, a timely harvest and good post-harvest management of the seeds is essential. A study conducted by Yamkoulga et al. (2018), reported that insects are a major constraint for preserving the seeds of *A. macrostachya*. In general, the seminivorous insects that develop at the expense of wild and cultivated legume seeds are Bruchinae beetles (Huignard et al., 2011). They undoubtedly constitute a major obstacle for developing legume seeds (Alzouma, 1990). In the specific case of *A. macrostachya*, two beetles of the Subfamily Bruchinae and genera *Caryedon* and *Bruchidius* have been identified as seed pests. These are *Caryedon furcatus* (Varaigne-Labeyrie and Labeyrie, 1981; Delobel et al., 1995; Delobel, 1999; Delobel et al., 2000; Anton and Delobel, 2004) and *Bruchidius silaceus* (Fahr.) (Delobel, 1999). Damage by these insect pests increases 3 days after threshing if no protective measures are taken (Ganaba, 1997). Seed perforation is even already noticeable at harvest (Yamkoulga et al., 2018). Thus, the seeds of *A. macrostachya* could perhaps be heavily infested by insect larvae before pods harvesting. However, to the authors' knowledge, no study has been carried out yet to assess the quality and level of infestation of *A. macrostachya* seeds at the time of pods harvesting. The date or time of harvest is an important factor in preserving the quality of seeds as food (Ntatsi et al., 2018). The present study was conducted with the general objective to evaluate the effect of harvest date on the quality of *A. macrostachya* seeds. The specific objectives were to determine (i) the rate of perforation of the seeds after different date of harvesting; (ii) the percentage of seed weight loss; (iii) the seed initial infestation rate and (iv) the abundance of the insect pests of the seeds.

## MATERIALS AND METHODS

### Description of the study site

Pods were harvested in Saria (Latitude: 12°16'W; Longitude: 2°02'O; Altitude: 300 m) from November 2018 to January 2019. Saria is

located in the Centre-West region of Burkina Faso, more precisely in the district of Boulekiemdé. Saria is located in the North Sudanese phytogeographic domain, with an average annual rainfall that varies between 600 and 900 mm. However, no rain was recorded during the period of the study. The vegetation of Saria is characterised by savannas with annual grasses. The woody vegetation is mainly composed of *Parkia biglobosa*, *Vitellaria paradoxa*, *Faidherbia albida*, *Lannea macrocarpa*, *Tamarindus indica* and *Khaya senegalensis*. Shrub vegetation is dominated by sparse thickets of *Guiera senegalensis*, *Combretum nigricans* and *Piliostigma reticulatum* (Yelemou et al., 2008).

### Pod harvesting and seed conditioning

Pod harvesting began when they were dry on the plant. The first harvest occurred on November 26, 2018; date on which dry pods were first noticed in spontaneous vegetation. Thirty trees were previously randomly selected and marked for harvesting. On these trees, four batches of pods were harvested and placed in four polypropylene bags of 50 kg to constitute four replications. The pods were collected by hand. Each pod contains an average of 3 seeds, so 350 pods were collected for each batch. Taking into account the different productivity of the plants, and to ensure that the pods were available until the end of the experiment for each batch, the harvest was carried out on 7; 7; 8 and 8 plants respectively for batches 1; 2; 3 and 4. The bags were brought back to the laboratory where the pods were immediately shelled. After shelling, 1000 seeds were randomly collected for each batch. Out of the 1000 seeds, the number of undamaged (without holes) and damaged seeds (with holes), the dry weight of undamaged and damaged seeds were determined. After counting, each batch of seeds was placed into a glass jar of 1-liter in capacity. Each glass jar was then closed with a mosquito net, held in place by a rubber band, to follow the emergence of the first generation of insects. Monitoring for emergence continued for 45 days under ambient conditions. The average temperature and relative humidity were  $25.59 \pm 2.07^{\circ}\text{C}$  and  $33.92 \pm 9.62^{\circ}\text{C}$  respectively. To avoid re-infestation, as soon as emergences occurred, the seeds in each jar were sieved to remove larvae using a sieve of 2.5 mm diameter mesh. For each jar, the collected insects were kept in flasks of 60 cc, containing 70% alcohol. A total of five pod harvests, 10 days spacing, were carried out and treated as previously described. The last harvest occurred on January 7, 2019. The pods, which were dry on the plants at the first harvest, remained in the same state of maturity until the last harvest.

### Identification and counting of insects

Insect identification was made under a binocular magnifying glass (Leica EZ4HD) in the Laboratory of Fundamental and Applied Entomology (LEFA) of Joseph KI-ZERBO University. The study used as a reference the specimens previously identified by the International Institute of Tropical Agriculture (IITA), Benin station.

These insects were subsequently counted by species.

### Measured parameters

The following parameters were calculated: Seed weight loss at

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**Table 1.** Weight losses and seeds perforation rate (%) according to the harvest dates.

Harvest dates	Weight loss (%)	Perforation rate (%)
26/11/2018	0.98 ± 0.17 <sup>C</sup>	5.15 ± 0.49 <sup>E</sup>
07/12/2018	1.71 ± 0.4 <sup>BC</sup>	7.32 ± 1.35 <sup>D</sup>
17/12/2018	2.37 ± 0.72 <sup>B</sup>	12.47 ± 0.57 <sup>C</sup>
27/12/2018	5.82 ± 0.58 <sup>A</sup>	24.82 ± 1.41 <sup>B</sup>
07/01/2019	6.50 ± 0.5 <sup>A</sup>	35.07 ± 2.16 <sup>A</sup>
<b>Probabilities</b>	$\chi^2 = 17.486$ df = 4 P = 0.0015	$\chi^2 = 18.299$ df = 4 P = 0.0011

The Means ± standard deviations within the same column with the same letters are not significantly different at the 5% probability level.

harvest (SWLH) using the formula of Gwinner et al. (1996):

-Seed weight loss at harvest (SWLH)

$$SWLH (\%) = ((a \times d) - (c \times b)) / (a \times (d + b)) \times 100$$

where: a = dry weight of undamaged seeds, b = number of undamaged seeds, c = dry weight of damaged seeds and d = number of damaged seeds.

-Seeds Perforation Rate at Harvest (SPRH)

$$SPRH (\%) = (\text{Number of seeds damaged at harvest}) / 1000 \times 100$$

-Seeds initial infestation rate (SIIR)

$$SIIR (\%) = \frac{\text{Number of damaged seeds after emergence of the first generation of bruchids}}{\text{Total number of seeds}} \times 100$$

**-The mean abundance of each insect species:** correspond to the average number of insects emerged per species.

**-The relative percentage (RP) of each bruchid species:** correspond to the percentage of the number of individuals of each bruchid species out of the total number of bruchids counted.

$$RP = \frac{(\text{Number of individuals of each species of bruchids})}{(\text{Total number of bruchids counted})} \times 100$$

### Statistical analysis

The verification of the data distribution with the Shapiro - Wilk test using the shapiro.test function was performed in order to choose the appropriate test (Hervé, 2011). This verification allowed for two types of analysis. First, an analysis of variance following the Kruskal Wallis model was used to test the mean abundance of *Caryedon furcatus*, *Bruchidius silaceus*, *Eurytoma* sp., *Anisopteromalus* sp., *Entedon nr bruchivorus*, *Dinarmus basalis*; the relative percentage of *C. furcatus*, *B. silaceus* and *Bruchidius* sp. When the probability was significant, a comparison of the means was performed using the pairwise.wilcox.test function.

Next, a linear analysis of variance model was used to test the mean abundance of *Bruchidius* sp., *Eupelmus* sp., *Dinarmus magnus*, *Entedon nr bruchivorus* and the seed initial infestation rate. In each case, when the p-value was significant, means

comparisons were done using the pairwise.t.test function. All the tests were performed with R software version 3.4.3 (2017-11-30) at the probability level of 5%.

## RESULTS

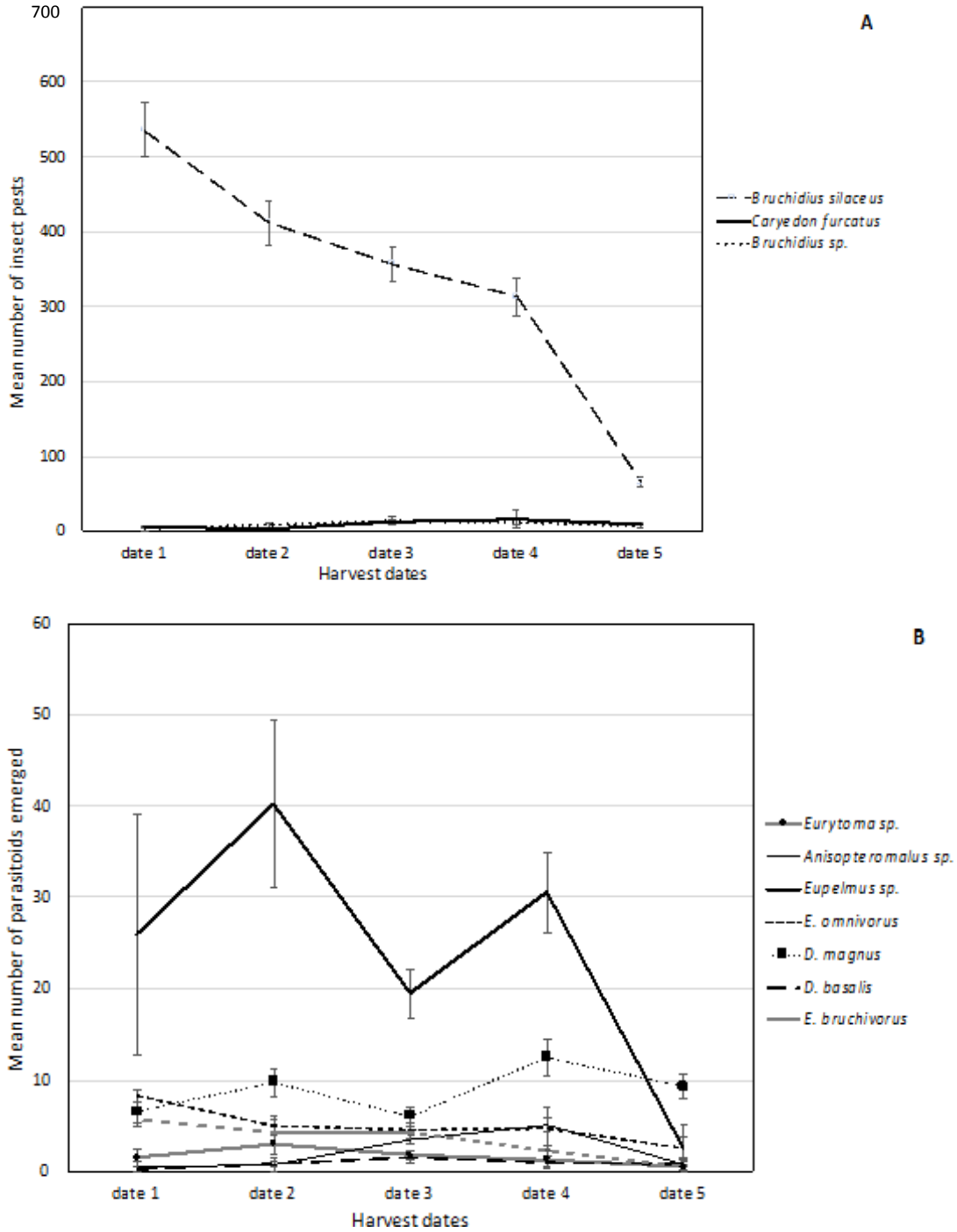
### Weight losses and seeds perforation rate at harvest

Seed weight losses at harvest increased significantly between the 1st and 4th harvests ( $\chi^2 = 17.486$ ; df = 4; P = 0.0015). At the 2nd harvest (07/12/2018) the weight loss was 1.71% (Table 1). This was not statistically different from that of the 1st harvest with 0.98%. At the 3rd and 4th harvests, seed weight loss significantly increased to 2.37 and 5.82% respectively. The rate of seed perforation, on the other hand, increased significantly at each harvest ( $\chi^2 = 18.299$ ; df = 4; P = 0.0011). From an average of around 5% at the first harvest, this rate increased to an average of 35% at the last harvest (Table 1).

### Mean abundance of insect pests and natural enemies

At each harvest date, the seeds were infested by three species of primary insect pests (*Bruchidius silaceus* (Fahr.), *Bruchidius* sp. and *Caryedon furcatus* (Anton and Delobel)) (Figure 1A) and seven species of parasitoids (*Eupelmus* sp., *Eurytoma* sp., *Anisopteromalus* sp., *Dinarmus basalis* (Rondani), *Dinarmus magnus* (Rohwer), *Entedon nr bruchivorus* (Rasplus) and *Entedon omnivorus* (Rasplus)), (Figure 1B). Compared to *Bruchidius* sp. and *C. furcatus*, *B. silaceus* was the most abundant pest at each harvest date. However, every 1000 seeds its number decreased significantly from 550 individuals at the 1st harvest date to an average 50 individuals at the 5th harvest date (Figure 1A).

In contrast to *B. silaceus*, the average number of *C. furcatus* (5 and 3 individuals at the 1st and 2nd harvest dates respectively) and *Bruchidius* sp. (3 and 9 individuals at the 1st and 2nd harvest dates respectively), was low at the first two harvest dates, and gradually



**Figure 1.** Mean abundance of different insect pest species (A) and parasitoids (B) recorded at different dates of harvest of the pods of *Acacia macrostachya*. (date 1 = 26/11/2018; date 2 = 07/12/2018; date 3 = 17/12/2018; date 4 = 27/12/2018; date 5 = 07/01/2019).

increased to reach a maximum of 25 individuals on at the 4th harvest date (Figure 1A). Among the seven parasitoids species recorded, *Eupelmus sp.* was the most abundant (Figure 1B).

The numbers of the parasitoids fluctuated in a saw-

tooth pattern, with two peaks observed at the 2nd and 4th harvest dates, respectively. The highest numbers of individuals were observed on the 2nd harvest date with an average number of 40 individuals while the lowest numbers were observed on the 5th harvest date with an

**Table 2.** Relative proportion (RP) of each bruchids species (%) emerged according to the harvest date.

Harvest dates	Relative percentage of each bruchid species (mean $\pm$ standard deviation)		
	<i>Bruchidius silaceus</i>	<i>Caryedon furcatus</i>	<i>Bruchidius sp.</i>
26/11/2018	97.30 $\pm$ 0.59 <sup>A</sup>	0.96 $\pm$ 0.26 <sup>C</sup>	1.74 $\pm$ 0.53 <sup>B</sup>
07/12/2018	97.09 $\pm$ 0.68 <sup>A</sup>	0.82 $\pm$ 0.56 <sup>C</sup>	2.09 $\pm$ 0.81 <sup>B</sup>
17/12/2018	93.12 $\pm$ 0.71 <sup>B</sup>	3.29 $\pm$ 0.68 <sup>BC</sup>	3.59 $\pm$ 1.17 <sup>B</sup>
27/12/2018	91.96 $\pm$ 3.27 <sup>B</sup>	4.47 $\pm$ 3.04 <sup>B</sup>	3.57 $\pm$ 0.63 <sup>B</sup>
07/01/2019	80.21 $\pm$ 2.98 <sup>C</sup>	11.19 $\pm$ 1.71 <sup>A</sup>	8.60 $\pm$ 3.40 <sup>A</sup>
<b>Probabilities</b>	$\chi^2 = 16.714$ df = 4 P = 0.0021	$\chi^2 = 14.043$ df = 4 P = 0.071	$\chi^2 = 14.843$ df = 4 P = 0.005

The Means  $\pm$  standard deviations within the same column with the same letters are not significantly different at the 5% probability level.

**Table 3.** Seeds initial infestation rate (SIIR) (%) according to the date of harvest.

Harvest dates	Initial infestation rate (mean $\pm$ standard deviation)
26/11/2018	46.62 $\pm$ 2.57 <sup>C</sup>
07/12/2018	55.85 $\pm$ 2.76 <sup>A</sup>
17/12/2018	44.75 $\pm$ 2.66 <sup>C</sup>
27/12/2018	48.00 $\pm$ 2.08 <sup>C</sup>
07/01/2019	51.12 $\pm$ 1.39 <sup>B</sup>
<b>Probabilities</b>	P = 6.753e-05 ; F = 13.702 ; df = 4

The Means  $\pm$  standard deviations within the column with the same letters are not significantly different at the 5% probability level.

average number of 5 individuals.

### Relative proportion of each bruchid species

*B. silaceus* represented on average, more than 90% of the insect pest species recorded for the 1st four harvest dates. There were no statistical differences in the percentages between the first and 2nd harvest dates and also between the 3rd and 4th harvest dates (Table 2). The relative percentage of *B. silaceus* however, dropped significantly to 80% on the 5th harvest date. In contrast, the mean percentages of *C. furcatus* and *Bruchidius sp.*, were very low at the 1st harvest date (about 1 and 2% respectively), then increased significantly at the latter harvest dates to 11 and 9% respectively at the 5th harvest date.

### Level of seeds initial infestation

The highest initial infestation rate of the seeds (55.85%) was recorded on the second harvest date of 12/07/2018 (Table 3). This was followed by the infestation rate of 51.75% on the fifth harvest dates of 01/07/2019. However, the infestation rates of the seeds harvested on the other dates were lower and similar.

## DISCUSSION

The results allowed the establishment of the relationship between the date of harvest and the seeds perforation at harvest. Seed perforation is generally the result of the emergence of insect pests. According to Or and Ward (2003) and Ahmed (2008), many Acacia species are subjected to infestation by seed beetles of the family Bruchidae. In the present study, *B. silaceus* was significantly the most abundant of the three species of bruchids present regardless of the date of harvest. This predominance of *B. silaceus* could be explained by its ability to adapt to the conditions of spontaneous vegetation compared to the storage conditions which perhaps was more favorable to *C. furcatus*. A similar finding was made by Lale and Igwebuikwe (2002) on the infestation of *Faidherbia albida* seeds by *Bruchidius atrolineatus* (predominant species) and *Caryedon serratus*. Among the parasitoids associated with the pests, *Eupelmus sp.* was predominant. It can therefore be used for the biological control of *A. macrostachya* seeds insect pests. Indeed, several *Eupelmus* species are also known to be associated with numbers of bruchids and parasitoids biological models (Tuda et al.

2001, Alkhatib et al., 2014). However, for its effective use as a biological control agent, it is first necessary to specify its exact role among all these parasitoid species agents as recommended by Hoelmer and Kirk (2005). Monitoring of seed infestation from pods harvested on different dates showed that the initial seed infestation rate was higher than those reported by, Yirgu and Tsega (2015) and Rugemalila et al. (2017) who respectively obtained rates of, 27% for *Faidherbia albida* seeds and 0.61% for *Acacia robusta* seeds. Cunningham and Walsh (2002) have reported higher infestation rate of 72% for *Cassia brewsteri* and *C. tomentella* seeds infested with *Caryedon serratus* in Australia. The low infestation rate of *Acacia* seeds could be due to the presence of defense compounds in these seeds. In fact, to protect against insect pests, these seeds secrete phenolic contents that directly interfere with the performance of bruchids (Kestring et al., 2009). The reproductive success of beetles, measured in terms of numbers of infested seeds and numbers of emerging beetles, may be limited by the level of defense compounds produced by the host (Or and Ward, 2004). On the other hand, in the case of *A. macrostachya*, bruchid beetles may adapt a mechanism to profit from the compounds rendering the seeds vulnerable to more infestation (Rugemalila et al., 2017). The low regeneration of *Acacia macrostachya* in Burkina Faso may be in part, the consequence of the high seed predation. According to Rodriguez-Perez et al. (2011), the low regeneration capacity of many *Acacia* species in arid savannas is a consequence of a combination of reduction in seed dispersal and high seed predation. The variation in the infestation rate could perhaps be due harvesting pods from several different trees. Derbel et al. (2007) showed that the seed infestation rate of 10 different trees of *Acacia tortilis subsp. raddiana* ranged from 25.9 to 85.6%. The results also showed that while the population size of *B. silaceus* was declining, that of *C. furcatus* was increasing at latter harvest dates. This observation was likely due to the fact that *B. silaceus* colonizes *A. macrostachya* species earlier than *C. furcatus*. Females of *Bruchidius* genus generally lay their eggs on the surface of maturing or fully mature pods (Delobel et al., 2003). In contrast, members of the genus *Caryedon* colonize *A. macrostachya* crops late and females lay eggs both on fully developed pods and directly on seeds after pod dehiscence (Delobel et al., 2003). These Bruchinae have a very limited behavioral plasticity as they can only lay eggs on dry pods in crops at the end of fruiting of the host plant, but also on seeds in storage systems (Huignard et al., 2011).

There is a close link between the date of harvest on the one hand and the percentages of weight loss and seed perforation on the other. Since the seeds were dry before harvest and did not undergo further drying, the weight loss at harvest could be explained by the feeding activity of the larvae of the various insect pest species that feed by consuming the starch reserves contained in the

cotyledons of the seeds. Perforation is due to the emergence of adults of these pests. According to Sanon et al. (2018), perforation and seed weight loss are the two main types of damage caused to *A. macrostachya* seeds by Bruchidae. Fox et al. (2012) have shown that infestation of *Acacia greggii* seeds by a single larva of the pest *Stator limbatus* caused a reduction of about 6% of their mass when the seeds were harvested late. The bruchids have time to emerge before the harvest and get disseminated in the wild. Early harvest could therefore minimize damage of these bruchids. The gradual decline in the numbers of *B. silaceus* individuals over time could be linked to the emergence of a large number of adults of this species before harvest.

## Conclusion

This study highlights the high initial infestation rate of *A. macrostachya* seeds, regardless of the harvest date. However, the rate of seed perforation and the percentage of seed weight loss increased as the harvest were delayed. These two parameters are due to the emergence of three primary insect pests, *Bruchidius silaceus*, *Bruchidius* sp. and *Caryedon furcatus*. Harvesting of pods as they dry could greatly reduce this damage.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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