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Morphological identification and assessment of biodemographic parameters of *Spermophagus niger* motschulsky (Coleoptera: Chrysomelidae), insect pest of kenaf (*Hibiscus cannabinus* L.) seeds during post-harvest storage in Burkina Faso: First report

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Abstract

Spermophagus niger L. is a well-known pest of roselle (*Hibiscus sabdariffa* L.) seeds in West Africa and responsible of mostly damage. This study first reported the presence of *S. niger* Motschulsky in kenaf (*Hibiscus cannabinus* L.) seeds stored. Samples of kenaf seeds collected at four locations in Burkina Faso. In the laboratory, the seeds were incubated until adults' insects emerged. The emerged insects were first identified morphologically and their biodemographic parameters studied under controlled conditions (32°C ± 0.1, 43% ± 1 r.h.). The results showed that *S. niger* (Coleoptera: Chrysomelidae) was the only pest encountered on *H. cannabinus* seeds in storage and was able to complete its development cycle there. Over the course of its life, which lasts an average of 7 days, the female laid around 40 eggs, resulting in 24 individuals dominated by females. The embryonic and total development time were average 5 and 26 days, respectively. *Spermophagus niger* population doubled in 6 days, with an intrinsic rate of natural increase of 0.105. The finite rate of increase and the generation time averaged 1.11 and 31.86 days, respectively. This study pointed out for the first time that *S. niger* is able to evolve successfully on *H. cannabinus* seeds in storage conditions and therefore, could be a serious pest of this important crop. The data from this study could therefore be used as a basis for the post-harvest management of *H. cannabinus* seeds.

Introduction

Kenaf (*Hibiscus cannabinus* L.) (Malvales: Malvaceae), an annual herbaceous is cultivated worldwide for its leaves, stems, and seeds (Giwa Ibrahim *et al*., 2019; Kujoana *et al*., 2023). The seeds contain important bioactive compounds (Adnan *et al*., 2020), and are rich in nitrogen (21.4%), oil (20.4%), and potassium ash (6%) (Nyam *et al*., 2009). Kenaf oil extracted from the seeds contains a high level of unsaturated fatty acids, essential for health and normal growth, but also for lowering blood cholesterol levels. The oil contains 45.3% oleic acid, 23.4% linoleic acid, 14% palmitic acid, and 6% stearic acid (Webber and Bledsoe, 2002). Ethnobotanical surveys carried out by Kabré *et al.* (2022) in Mossi and Gurunsi areas, two ethnic communities in Burkina Faso, have shown that among these two ethnic groups, fresh leaves were used in the preparation of local dishes known as 'babenda' and 'kanzaga' and in the pharmacopeia. According to Jin *et al.* (2013), kenaf leaves are used to treat diabetes, bilious coughs. Stems are used to produce fibers only biodegradable composite material, which are mostly appreciated (Ochi, 2008).

Kenaf significantly contributes to household food security. However, during storage, the seeds showed perforations similar to those of *S. niger* on *H. sabdariffa* seeds. *S. niger* is a Chrysomelidae beetle that was first identified on *Urena lobata* (L.) (Malvales: Malvaceae) seeds in Vietnam (Borowiec, 1991). In Burkina Faso, this insect has been identified as the main pest *of Hibiscus sabdariffa* L. (Malvales: Malvaceae) seeds in storage (Koussoubé *et al*., 2016; Sanon *et al*., 2017). This pest is also present in West Africa with considerable morphological and biological variations (Kabore *et al*., 2025). Without protecting, Amadou *et al.* (2016) reported that, damages caused by *S. niger* on roselle seeds increased ten times after 6 months storage. Insects of the order Coleoptera and belonging to Chrysomelidae family possess great behavioural plasticity, enabling them to adapt to plants of the same or different families from those of their usual hosts (Huignard *et al.*, 1996).

This study aims to document for the first time the insects' pests infesting kenaf seeds in storage. Adults of the pests emerged from samples seeds were then morphologically identified and their biodemographic parameters studied under controlled conditions.

Materials and methods

Identification of Spermophagus niger strain

Origin of samples

In November 2022, five batches of 1 kg kenaf seeds newly harvested were collected from farmers at four following locations: Bané (W 0°21′29.6"/N 11°34′40.5"), Gogo (W 0°57′41.2"/N 11°33′43.6"), Manga (W 001°05′27.1"/ N 11°41′39.1"), and Manni (W 0°12′35.4"/N 13°15′36.7") (figure 1). These locations belong the province where cultivation of kenaf is more practiced (Kabré *et al.*, 2019). The seeds batches of each location were brought to Laboratory of Fundamental and Applied Entomology from Joseph Ki-Zerbo University, Ouagadougou (W 001°29′51.3"/N 12°22′43.0").

Monitoring of emergence

In the laboratory, the seeds of each location were transferred to plexiglass boxes (18 × 11 × 4 cm) and were then kept an incubator (32°C ± 0.1, 43% ± 1 r.h.). until the emergence of adult insects.The emerged insects were divided into two batches. The first batch was stored in tubes containing 70°C alcohol for identification. The second one was used for rearing.

Morphological identification

The insects kept into the tubes were transferred to Petri dishes, thoroughly inspected under a binocular loupe LEICA EZ4HD.Their various morphological characteristics were determined in comparison with those described by Borowiec (1991) and Sanon *et al.* (2017) for *S. niger*. This includes body colouration, shape and number of antennae articles, shape of the pygidium, and shape of the femur and tibia.

Study of biodemographic parameters

Morphological characteristics of Hibiscus cannabinus seeds used

The seeds used came from Manga. In the laboratory, they were sorted and then placed in a freezer set at −18°C in order to eliminate possible infestation. The morphological characteristics

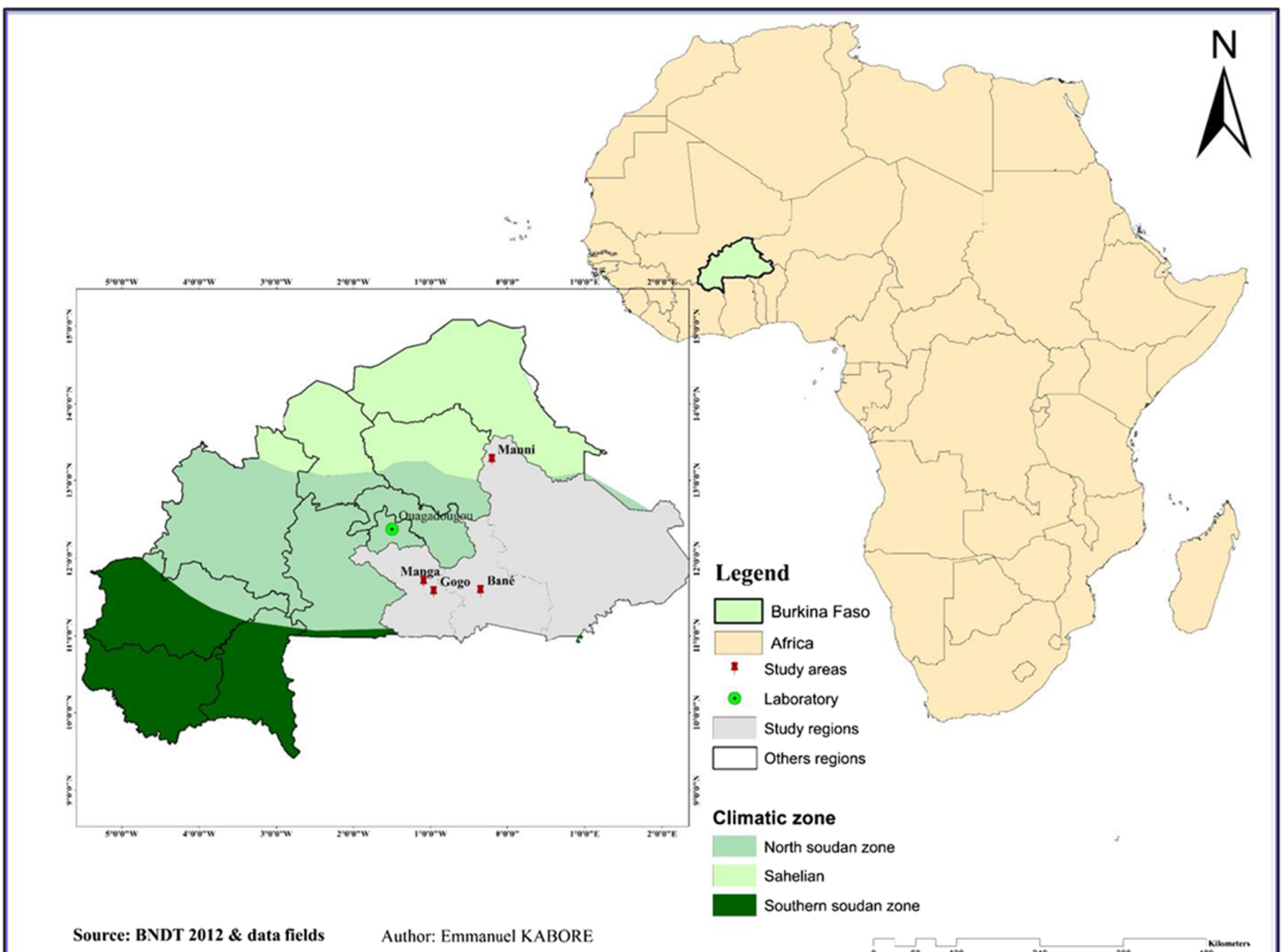

Figure 1. Origin of insects studied. The red dots represent the sampling locations.

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of the seeds assessed were diameter, mass, texture, and colour. The diameter and mass of 150 seeds chosen randomly were individually assessed using an electronic calliper (Electronic Digital Calliper; precision: ± 0.03 mm) and a sensitive OHAUS (Analytical Standard scale precision: 10^{-3} mg), respectively. Texture was determined using touch and colour observations.

Rearing of selected strain

The strain *S. niger* used come from Manga location samples. This location was selected because it was observed that this location presented a more infestation level of seeds.

For rearing, 30 insects emerging from seed samples brought back from Manga were introduced into Plexiglas boxes (18 × 11 × 4 cm) in contact with 25 g of healthy *H. cannabinus's* seeds from Manga for 48 h. The insects were then removed, and the infested seeds were kept into an incubator (32°C ± 0.1, 43% ± 1 r.h.) under total darkness and monitored until the emergence of adult insects.

Assessment of biodemographic parameters

Embryonic development

Five pairs of *S. niger* no more than 24 h old were placed in contact with 10 g of healthy *H. cannabinus's* seeds in Petri dishes (9 mm diameter) and placed in an incubator (32 °C ± 0.1, 43% ± 1 r.h.) under total darkness. Three hours later, the insects were removed from the boxes, and 50 seeds bearing a single fresh egg were sorted and divided into five batches of 10 seeds in Petri dishes and then placed back into the incubator. Every day, we observed the eggs under a binocular loupe, and the number of hatched eggs was counted until the end of the hatching period. Hatched eggs were characterized by a reddish spot inside the egg corresponding to the head capsule of the neonate larva (Koussoubé, 2018).

Post-embryonic development

One pair of newly emerged *S. niger*, no more than 24 h old, was placed in contact with 30 healthy *H. cannabinus's* seeds in Petri dishes (9 mm diameter) and placed in incubator (32 °C ± 0.1, 43% ± 1 r.h.) under total darkness. This experiment has been replicated 20 times. Seeds were daily renewed until each pair of insects died.

The seeds collected each day were kept into the incubator and 7 days later, they were removed, observed under a binocular loupe, and the hatched and unhatched eggs were counted. After counting the eggs, the seeds were returned to the incubator and monitored until emergence. The adult insects that emerged were sexed, counted, and removed each day from the Petri dishes. Sixty emerged adult insects, including 30 males and 30 females, were individually weighed using an OHAUS (Analytical Standard scale precision: 10^{-3} mg), and their sizes were determined using binocular loupe LEICA EZ4HD coupled with a desktop computer and LAS EZ software.

At the end of the monitoring, the following parameters were computed:

- lifespan of adults (male and female): it's the time ranged between the insect's emergence and the day it dies;
- number of eggs laid by the female throughout her life;
- number, size, and weight of insects (male and female) emerged;
- larval survival rate (S) which corresponds of the ratio between the number of insects that emerged and the number of eggs that hatched × 100;
- sex ratio determined by the following formula: (Number of males) / (Number of females);
- development time (T): it's the mean time between egg laying and emergence of the resulting adult. It was obtained through the following equation: $\sum^{n} ixi / \sum^{x} i$

  with: xi = number of insects emerged per day; ni = corresponding number of days;

The parameters such as females' lifespan, number of eggs laid, larval survival rate, and development time were used to determine the following demographic growth parameters:

- intrinsic rate of natural increase (R_m): the instantaneous growth expressed when the population is growing in an unrestricted environment and when the age structure has become stable (Mondedji *et al.*, 2002). It is estimated using the equation of Giga and Smith (1983):
- $R_m = \ln(NS) / \left(T + \frac{1}{2L}\right)$, where ln = Napierian logarithm, L = females' lifespan; N = mean number of eggs laid per female; S = larval survival rate; T = development time;
- population doubling time (DT): time required for the population size to double. It is obtained using the following equation (Ndoutoume-Ndong, 1996): $DT = ln2/Rm$
- finite rate of increase (λ): it is obtained using the following equation (Birch, 1948; Carey, 1993): ($\lambda = e^{rm}$);
- generation time (GT): the mean time between the birth of the parents and the birth of their descendants. It is calculated using the following equation (Tricault, 1995):

GT = T (development time) + mean age of a female at the time of laying all her eggs.

Data analysis

Shapiro–Wilk test and Bartlett test were used to assess the normality and homogeneity of all data before applying parametric tests, respectively. Thus, we performed the one-sample Student's *t*-test to compare the average number of hatchlings, average number of eggs laid, natural growth rate, population doubling time, finite rate of increase, generation time, and development time. Emergent body size, weight, and lifespan were tested with one-way analysis of variance followed by Tukey'post hoc test using 'agicolae' package (Mendiburu, 2021). The significance level was set at 5%, and the data were presented as mean ± standard error. All the analysis was performed using R software 4.2.2.

Results

Identity of emerged insects

All insects that emerged from *H. cannabinus's* seed samples brought back from Bané, Gogo, Manga, and Manni belonged to the same species, namely *S. niger* (L.), as described by Borowiec (1991) and Sanon *et al.* (2017). The emerging insects had dark brown body hairs. The antennae were filiform and composed of 11 articles. The elytra did not completely cover the abdomen. The pygidium is curved or straight in males and females, respectively. The legs were moreover dark brown, with strong tibia and femora in the hind legs.

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Table 1. Average (±SE) of the diameter and mass of 150 *Hibiscus cannabinus* seeds and physical characteristics (texture and colour)

Diameter (mm)		Mass (mg)		Texture	Colour
Mean (± SE)	Min–Max	Mean (± SE)	Min–Max	Rough	Grey
2.24 ± 0.21	2.03 − 2.63	24.08 ± 3.14	15.2 − 29.60		

SE: Standard error Min–Max: minimum and maximum values of the different measurements.

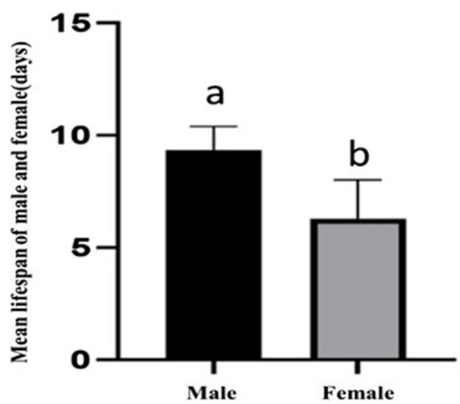

Figure 2. Average lifespan (days) of adults (male and female) of *Spermophagus niger* reared on *Hibiscus cannabinus's* seeds in petri dishes. Histograms represent means and error bars correspond to standard errors. Different alphabetic letters on the bars indicate significant differences between the means according to Fischer's LSD test at the 5% threshold.

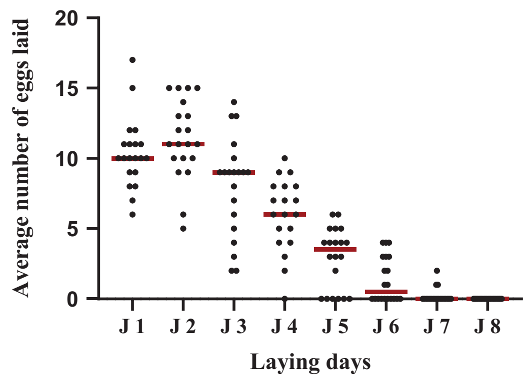

Figure 3. Evolution of the mean number of eggs laid per day (±standard error) throughout the life of *Spermophagus niger's* female (n = 20 replicates) exposed to *Hibiscus cannabinus* seeds in petri dishes.

Morphological characteristics of H. cannabinus seeds

Seeds diameter varied between 2.03 and 2.63 mm with an average of 2.24 ± 0.21 mm. The mass ranged from 15.2 to 29.60 mg, with an average of 24.08 ± 3.14 mg (table 1). In terms of physical characteristics, *H. cannabinus's* seeds were rough and grey in colour.

Lifespan of S. niger adults on H. cannabinus seeds

Males of *S. niger* brought into contact with *H. cannabinus's* seeds had a significantly longer lifespan than females in the same conditions ($F = 46.06$; $P = 4.79e^{-08}$) (figure 2). The lifespan of males ranged from 9 to 13 days with an average of 9.35 days, whereas that of females was ranged from 4 to 9 days with an average of 6.30 days (figure 2).

Oviposition activity of the female S. niger

Spermophagus niger's females when brought into contact with *H. cannabinus's* seeds took an average of 7 days to lay all their eggs. The highest fecundity, observed on the second day, decreased progressively with time and was finally cancelled by the seventh day. It takes the female 4 days to lay 90% of her eggs (figure 3).

Number of eggs laid, egg hatching rate, larval survival rate, number of offspring, and sex ratio

During its lifetime, the number of eggs laid by *S. niger* females in contact with *H. cannabinus* seeds varied from 13 to 57 eggs, with an average of 40.10 eggs (table 2). An average of 83.67% of the eggs laid were able to hatch, and at the end of post-embryonic development, 24.35 adult insects of the first generation were recorded, corresponding to an average larval survival rate of 71.97% (table 2). The offspring produced was in favour of the females (table 2).

Table 2. Mean number (±standard error) of eggs laid, hatching and larval survival rates, number of emergents, and sex ratio of *Spermophagus niger* reared on *Hibiscus cannabinus's* seeds under controlled conditions

Parameters	Mean number
Eggs laid	40.10 ± 11.67
Egg hatching rate (%)	83.67 ± 3.94
Larval survival rate (%)	71.97 ± 10.171
Emerging insects	24.35 ± 8.41
Sex ratio	0.71 ± 0.276

Table 3. Embryonic and total development time of *Spermophagus niger* reared on *Hibiscus cannabinus's* seeds in the petri dish under total darkness

Parameters	Mean ± Standard error
Embryonic development time (days)	5.75 ± 0.96
Total development time (days)	26.53 ± 1.02

Embryonic and total development time

The eggs freshly laid by *S. niger* female on *H. cannabinus* seeds took between 4 and 5 days to hatch, i.e. to produce a neonate larva, with an average duration of 5.75 days (table 3). The development time of *S. niger* from the egg stage to the adult stage took an average of 26.53 days, with a minimum and maximum duration of 25.12 and 28.83 days, respectively (table 3).

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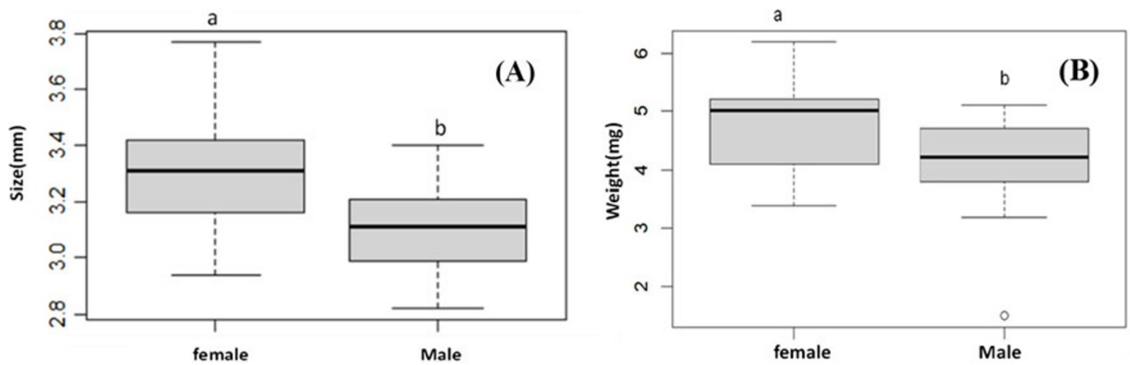

Figure 4. Size (A) and weight (B) of adults (males and females) from the first generation of *S. niger* (n = 60) derived from *H. cannabinus's* seeds. Bars represent means; error bars correspond to standard errors. Different alphabetic letters on the error bars indicate significant differences between means according to Fischer's LSD test at the 5% threshold.

Table 4. Demographic growth parameters of *Spermophagus niger* rearing on *Hibiscus cannabinus* seeds. R_m, intrinsic rate of increase (days^{-1}); DT, doubling time (days); λ, finite rate of increase; GT, mean generation time (days)

Parameters	Mean ± Standard error
R_m	0.105 ± 0.012
DT	6.73 ± 0.96
λ	1.11 ± 0.01
GT	31.86 ± 1.91

Size and weight of emergents

Spermophagus niger's female emerging from *H. cannabinus's* seeds had a significantly higher mean height and weight than males ($F = 18.4$, $P = 6.87e^{-05}$; $F = 11.46$, $P = 0.00128$) (figure 4A, B).

Demographic growth parameters

At the end of the development of *S. niger* on *H. cannabinus* seeds, the intrinsic rate of increase (R_m) was 0.105 ± 0.012 days (table 4). The population doubled (DT) in size every 6.73 ± 0.96 days and 31.86 ± 1.91 days for the generation time (GT). The finite rate of increase (λ) was 1.11 ± 0.01 (table 4).

Discussion

Morphological identification showed that the insects emerged from *H. cannabinus's* seeds belonged to *S. niger* species. The morphological characteristics correspond to those described by Borowiec (1991) and Sanon *et al.* (2017). *Spermophagus niger* managed to complete its development cycle on *H. cannabinus's* seeds, as demonstrated by Koussoubé *et al.* (2018) on *H. sabdariffa's* seeds. This means that *H. cannabinus's* seeds contain the quantity and quality of nutrients required for the development of various larval stages of the pest. The presence of proteins and carbohydrates in the seeds could justify this result, because according to Shazali (1989), these two compounds provide the essential nutrients for development of Bruchidae beetles.

To fend off insect herbivores, more than 200 000 specialized metabolites, with toxic, growth-reducing or anti-nutritive effects, are known to be produced by plant species (Mithöfer and Boland, 2012; Zhu-Salzman *et al.*, 2008). The reproductive success of *S. niger* could be justified by the absence of toxic compounds such as tannins in *H. cannabinus* seeds, which according to Boughdad *et al.* (1986a, b) are highly toxic to Bruchid larvae. Furthermore, this development skill could be justified by an adaptation following detoxification of any toxic compounds present in the seeds by the larvae. Indeed, many insects have developed a variety of counter-adaptations to overcome chemical defence of plants, as demonstrated by Desroches *et al.* (1995, 1997). This result confirms those of Huignard *et al.* (1996), who showed that Coleoptera belonging to the Chrysomelidae family have great behavioural plasticity, enabling them to easily adapt to plants of the same family.

The average lifespan of adult males is significantly longer than that of females. These results corroborate those of Koussoubé *et al.* (2018), who had found that the average lifespan of female on Roselle's seeds was shorter than that of males. The short lifespan of the female could be explained by the effort she expended during egg-laying. These results confirm with those of Nguyen *et al.* (2008), who considered the energy expended by females during oviposition, to be a crucial factor in regulating longevity. *Spermophagus niger's* females in contact with *H. cannabinus's* seeds laid an average of 40 eggs in 7 days. This fecundity was lower than that recorded by Koussoubé *et al.* (2018) for *H. sabdariffa's* seeds of the *Sabdariffa* and Altissima's varieties, which averaged 50 eggs in the same conditions. This difference in results could be explained by the difference in size between *H. cannabinus* and *H. sabdariffa* seeds, as the latter species are relatively larger. This result corroborates those of Teixeira and Zucoloto (2003) on *Zabrotes subfasciatus* (Coleoptera: Chrysomelidae) and Yang and Fushing (2008) on *Callosobruchus maculatus* (Coleoptera: Chrysomelidae), who showed that the size of the oviposition substrate available to the female influences the number of eggs laid. *Spermophagus niger* female has therefore reduced her fecundity on *H. cannabinus* seeds, as has already been observed in the female of *C. maculatus*, which has the ability to rapidly adjust its oviposition behavior in response to several host traits, such as host species and host size (Mitchell, 1990). This difference could also be explained by the fact that the seeds of the two species have different chemical compounds on their surface, which, according to Parr *et al.* (1998), play an important role in egg induction. *Hibiscus sabdariffa's* seeds would therefore have more chemical compounds conducive to the induction of *S. niger's* eggs.

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The results also showed that the average number of adult insects that emerged was 24.35 adults. This value was lower than the average value of 32 for *H. sabdariffa's* seeds (Koussoubé *et al*., 2018). The offspring produced are numerically in favour of females. It could be explained by parental selection. Indeed, for a given insect population, having more females may be advantageous because this increases the number of eggs laid and subsequently the chance of larval survival and emergence. Several authors who have worked on stored commodity insects, particularly *Rhyzopertha dominica* (Coleoptera: Bostrichidae) on maize (Waongo *et al*., 2018), *S. niger* on roselle seeds (Koussoubé *et al*., 2018) and *Caryedon serratus* (Coleoptera: Chrysomelidae) on tamarind (Ki *et al*., 2024), have confirmed a sex ratio in favour of females. Emerged female individuals were statistically superior to male individuals in terms of size and weight. This difference could be explained by the fact that during larvae stage, females accumulate enough nutrients reserves for her reproduction. Further studies will be interesting to confirm these hypotheses. However, the values of these two parameters were lower for *H. cannabinus* than *H. sabdariffa* seeds. Stillwell *et al.* (2007) showed that seed size is a factor likely to reduce the size of *Stator limbatus* (Coleoptera: Chrysomelidae). The larger size of *H. sabdariffa's* seeds, which have greater nutrient reserves, could explain these results.

For growth parameters, we note that the intrinsic rate of natural increase was 0.105 with a population doubling time of 6.73 days. These values are nearly similar to those recorded by Koussoubé *et al.* (2018) at 30°C. With these high rates, accelerated degradation of seed stocks could be caused by *S. niger* population on *H. cannabinus's* stored seeds.

Spermophagus niger L. is the pest found on *H. cannabinus*' seeds stored in Burkina Faso. It completes its development cycle with a high larval survival rate. It has the potential to become a serious pest of *H. cannabinus* seeds. Although *H. cannabinus* and *H. sabdariffa* are plants of the same genus, the developmental performance of *S. niger* on *H. sabdariffa* seeds such as number of eggs laid, larval survival rate, and number of emerging insects are superior to that found on *H. cannabinus* seeds. In the world, there are around 200 to 300 species of plants in *Hibiscus* genus, mainly in tropical and subtropical regions (Yann, 1998). Due to the behavioural plasticity of Chrysomelidae beetles, *S. niger* may not be restricted to *H. sabdariffa* and *H. cannabinus* seeds. It would be necessary to investigate in another cultivated genus. Furthermore, our study should pave the way for further investigations leading to the development of sustainable approaches for managing insect pests associated with *Hibiscus* seeds.

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Competing interests. The authors declare that they have no conflict of interest.

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