



Evaluation of Insecticidal Efficacy of Two Leaf Powders for Control of Khapra Beetle, *Trogoderma granarium* (Everts) (Coleoptera: Dermestidae) in Wheat Grains

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Abstract

Experiment was conducted to evaluate the efficacy of leaf powders of *Senna mimosoides* and *Datura alba* for the control of khapra beetle, *Trogoderma granarium* on stored wheat grains. Twenty 0-3 days old unsexed adults of *T. granarium* were introduced into each cup containing 20g of grains and covered with muslin cloth to allow aeration and prevent exit or entry of insects. The powders were applied at 5, 10 and 15% concentrations to study mortality, repellency and seed weight loss. The experiment were laid out in a Completely Randomized Design (CRD) of 5 by 4 (5 treatments and 4 replicates) including standard and experimental controls under laboratory conditions (28±2°C; 74±5% RH) for 28 days. Data obtained were analyzed using Analysis of Variance and means were separated using Turkey's post hoc test. Both powders showed the presence of alkaloids, saponins, cardiac glycosides, flavonoids, phenols and tannins to which insecticidal properties can be attributed against *T. granarium*. There was an increase in mortality with the days of exposure in all concentrations with leaf extract of *S. mimosoides* + *D. alba* being more effective at 15% (1.25± 0.50) when compared with the control. Also, the powders of *S. mimosoides* + *D. alba* at various concentrations exhibited the highest repellency (90%) activity followed by those of *S. mimosoides* and *D. alba* separately. The seeds treated with cocktail of the powders gave the lowest seed damage, followed by that of *S. mimosoides* and *D. alba* when compared to the experimental control. The results indicated that powders used as sole or cocktail significantly ($p < 0.05$) reduced insect populations and offered greater protection and high repellency compared to the control. Since *S. mimosoides* and *D. alba* powders are affordable for small farmers and environmentally safe, they ought to be promoted for use against khapra beetles. This is because they can be used as an alternative to synthetic pesticides in integrated pest management.

Keywords: *Datura alba*, Mortality, Repellency, *Senna mimosoides*, *Trogoderma granarium*, Weight loss

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INTRODUCTION

Botanical insecticides are among the most important classes of safe, efficient, environmentally acceptable, and non-toxic insecticides for animals (Lengai *et al.*, 2020). It has been discovered that naturally occurring botanicals and medicinal plants are more affordable, readily accessible, and easily included into integrated pest management programs. Furthermore, the industrialized world's countries are emphasizing the need to adopt organic farming in order to protect global health and advance sustainable agriculture (Khan *et al.*, 2018).

Mountain flat-bean, *Senna mimosoides*, formerly known as *Cassia mimosoides*, is a member of the genus *Senna* and the family *Caesalpinaceae* (Young, 2000). The plant is a weed that is ubiquitous throughout West Africa and can be found in wastelands, roadsides, and fallow areas in the savannah zone. According to Joy *et al.* (1998), the leaves of certain *Senna* plants can help treat a variety of conditions, including constipation, gastrointestinal disorders, leprosy, skin conditions, splenomegaly, hepatothopathy, jaundice, helminthiasis, dyspepsia, cough, bronchitis, typhoid fever, anemia, and tumors. The insecticidal activity and mode of action of *S. mimosoides* have not been extensively studied. But it's known to be a natural lipase inhibitor, which means it acts as a slimming agent by blocking the absorption of fats from food after it's been digested. Additionally, it has a laxative effect, suggesting that its role is to maintain regular bodily functions and alleviate constipation (Robbins, 2000).

Angel's devils trumpet, *Datura alba* belongs to the family *Solanaceae*. It is an annual herb grown up to 3 feet in height (Ulrike and Preissel, 2002). All the parts of the thorn apple have medicinal values but only the leaves and seeds are officially used. It is widely used for the treatment of asthma, spasm, whooping cough, haemorrhoids and skin ulcers. It is used by Curve's practitioners for all types of wound (Shanmuga *et al.*, 2002). The leaf powder of *D. alba* shows a very good toxicity against aphids and ants (Kungunathan *et al.*, 2008).

MATERIALS AND METHODS

Collection and Preparation of Plant Material

Fresh leaves of *S. mimosoides* and *Datura alba*

were collected from some farms in Ediene Ikot Obio Imo, Uyo, Akwa- Ibom State. The different leaves were washed thoroughly and rinsed in sterile distilled water and were dried for weeks at room temperature. Thereafter, they were blended separately into fine powder using pestle and mortar. The plant powders were put separately in airtight containers and stored in a cool dry place until when needed.

Collection and Disinfestation of wheat Grain: The wheat grains used in the study were bought at Itam market, Itu. Prior to the experiment, the grains were disinfested in the refrigerator for two weeks at 4°C or 40°F to kill any hidden insects before use.

Collection and Rearing of Khapra beetle

The insects were obtained from naturally infested stored wheat grains bought from Itam market, Uyo. The weevils were retrieved from the infested wheat through sieving. Unsexed adult weevils were introduced into two jars containing 1kg of uninfested wheat grains. To let in air and keep out weevils, the jars were sealed with rubber bands and covered with muslin linen. They were then maintained at room temperature. All parent weevils were removed and counted, both dead and alive, after a period of two weeks. For the experiment, newly emerging adult weevils that were 0–3 days old were used.

Phytochemical Analysis of the Plants

Using the standard protocols outlined by Harborne (1999), Evans (2002), Kokate *et al.* (2008), and Prashant *et al.* (2011), a preliminary phytochemical screening of the various plants was conducted in the Department of Chemistry Laboratory, University of Uyo, Akwa Ibom State, Nigeria.

Mortality Assessment

The method described by Udo (2005) and Oboho *et al.* (2022) was adopted. Healthy grains were kept in a freezer at 4°C or 40°F for a week to control hidden infestation. The grains were then left to equilibrate to room temperature. Twenty (20 g) of the grain was measured into 300 ml plastic cups and treated with sole and cocktail of the botanicals at 5%, 10 % and 15% w/v. A conventional insecticide, Aluminium phosphide at 0.25g concentration was used as standard, while the experimental control was set up without any treatment. Twenty 0-3 days old unsexed adults of *T. granarium* were introduced into each cup and

covered with muslin cloth to allow aeration and prevent exit or entry of insects. The treatment was replicated four (4) times for each concentration. The experiment was laid out in a completely randomized design (CRD) and kept on the laboratory bench for observations. The numbers of dead khapra beetle were counted weekly for four weeks. When an insect did not react to three attempts at being prodded with a blunt dissecting probe, it was considered dead and counted (Equation 1).

$$\% \text{ Mortality} = \frac{\text{Number of dead } T. \text{ granarium}}{\text{Total number of } T. \text{ granarium}} \times 100 \quad \text{Equation 1}$$

Repellency test

The laboratory used typical room temperature and relative humidity for the repellent bioassay. A slightly modified area preference method of Obeng-Ofori *et al.* (1998); Oboho *et al.* (2016) and Essien *et al.* (2023) was used for the evaluation. Test regions in the study were made up of half-cut 22 cm Whatman No. 1 filter sheets. A filter paper disc that had been cut in half was coated with one gram of various extracts. Deionized water was applied to the opposite half of the filter paper just as a control. After an hour of air drying, the treated and control half discs were combined to create a new whole disc, which was then sealed with cello tape. Twenty weevils were positioned in the center of each filter paper in a petri dish, and the lids were perforated and covered with white muslin cloth. Every treatment was set up in a fully randomized fashion and duplicated four times. After 30 minutes, the number of weevils in the treatment (Nt) and control (Nc) strips was counted. Percent repellency (PR) values were computed with the formula (Equation 2):

$$\text{PR (\%)} = \frac{(Nc - Nt)}{(Nc + Nt)} \times 100 \quad \text{Equation 2}$$

Where PR= percent repellency

Nc= number of insects present in the control half paper

Nt= number of insects present in the treated half and negative PR values was treated as zero.

Positive (+) values = repellent

Negative (-) values = attraction

Seed Weight Loss Assessment

To prevent undetected infection, a kilogram of wheat grains was stored at 4°C, or 40°F, in a deep freezer for a period of two weeks. Grain weighing twenty grams (20g) was weighed and placed into plastic cups. Leaf powders were

added at concentrations of five, ten, and fifteen percent w/v. In order to ensure full randomness, ten pairs of *T. granarium* were placed inside the cups and covered with white muslin material that was secured in place with rubber bands. Ten pairs of insects were used in each of the four replications of each treatment, which were then allowed to stand undisturbed for four weeks. Each cup was sampled 50% of the time (Udo, 2005), and the quantity of undamaged and damaged grains (grains with distinctive holes) was weighed and tallied. Percent weight loss was calculated following the method (Equation 3) described by Oboho *et al.* (2022) as follows:

$$\% \text{ weight loss} = \frac{(UaN - (U+D))}{UaN} \times 100 \quad \text{Equation 3}$$

Where: U= weight of undamaged fraction in the sample,

N= total number of grains in the sample

Ua= average weight of one undamaged grain, and

D= weight of damaged fraction in the sample

Number of damaged grains (grains with characteristics holes) and undamaged grains were counted and weighed using the method by Proctor and Rowley (1983):

$$\% \text{ Grain damage} = \frac{(\text{Number of damaged grains})}{(\text{Total number of grains})} \times 100 \quad \text{Equation 4}$$

Statistical Analysis

ANOVA was performed on the collected data using the Statistical Package for Social Sciences (SPSS version 26.0). Means were separated using Turkey's Post hoc test at 5% level of significance (Aina *et al.*, 2021). Clustered charts were used to compare mean mortality for different days.

RESULTS

The result of the qualitative phytochemicals present in the powders of *S. mimosoides* and *D. alba* is presented in Table 1. The powders of *S. mimosoides* and *D. alba* showed the presence of phenols, saponins, cardiac glycosides, terpenes, steroids, flavonoids. Alkaloids were present in *S.*

mimosoides but absent in *D. alba*. Tannins was present in *D. alba* but absent in *S. mimosoides*. Anthraquinones was absent in both plants studied.

Table 1: Phytochemical constituents present in the leaf powders of *S. mimosoides* and *D. alba*

Phytochemical constituents	<i>S. mimosoides</i>	<i>D. alba</i>	Name of Test
Alkaloids	+++	-	Dragendoff's reagent
Phenols	+	+	Ferric chloride
Tannins	-	++	Ferric chloride
Saponins	+	+	Frothing test
Anthraquinones	-	-	Borntrager's test
Flavonoids	+	+	Magnesium metal test
Cardiac glycosides	+	+	Salkowski test
			Leiberman test
Terpenes	+	+	Acetic anhydride
Steroids	+	+	

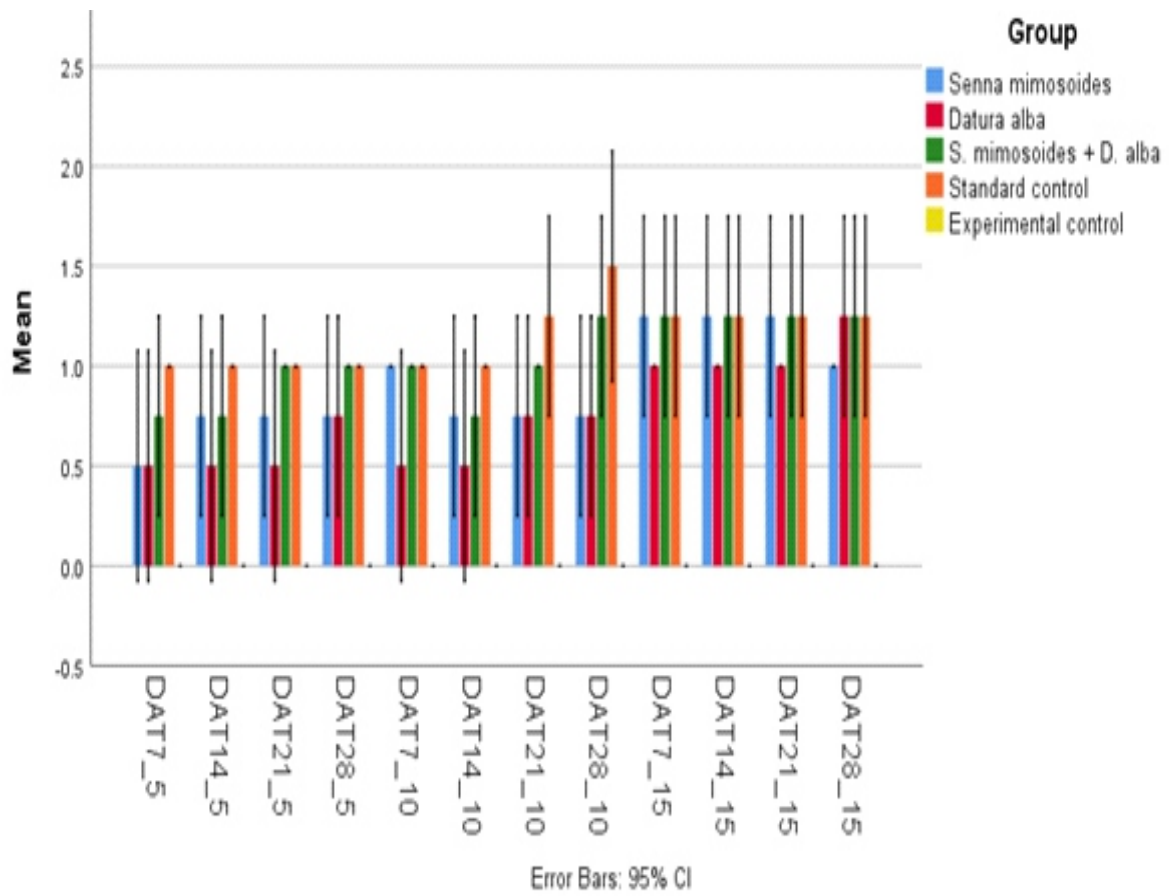
- Negative; + Positive

The highest mean mortality was recorded in the cocktail powder of the *S. mimosoides* + *D. alba* (1.25±0.50) in all the days after treatment, followed by the sole powder of *S. mimosoides* and then *D. alba*. The observed mortality was concentration and time dependent; as the concentration of the powders increased, the mortality rate also increased as shown in Table 2. The mortality recorded in the synergistic application of the powders was statistically significant ($p < 0.05$) comparable to the standard control.

Table 2: Effects of plant powders on mortality of *Trogoderma granarium* on wheat grains

Treatments	Mean % mortality ± S.E. at 7 to 28 days after treatment (DAT)												
	5%				10%				15%				
	7 days	14 days	21 days	28 days	7 days	14 days	21 days	28 days	7 days	14 days	21 days	28 days	
<i>Senna mimosoides</i>	0.50 ± 0.58	0.75 ± 0.58	0.75 ± 0.50*	0.75 ± 0.50*	1.00 ± 0.00*	0.75 ± 0.50	0.75 ± 0.50	0.75 ± 0.50	0.75 ± 0.50*	1.25 ± 0.50*	1.25 ± 0.50*	1.25 ± 0.50*	1.00 ± 0.00*
<i>Datura alba</i>	0.50 ± 0.58	0.50 ± 0.58	0.50 ± 0.58	0.75 ± 0.50*	0.50 ± 0.58	0.50 ± 0.58	0.75 ± 0.50	0.75 ± 0.50	1.00 ± 0.00*	1.00 ± 0.00*	1.00 ± 0.00*	1.25 ± 0.50*	
<i>S. mimosoides</i> + <i>D. alba</i>	0.75 ± 0.50	0.75 ± 0.50	1.00 ± 0.00*	1.00 ± 0.00*	1.00 ± 0.00*	0.75 ± 0.50	1.00 ± 0.00*	1.25 ± 0.50*	1.25 ± 0.50*	1.25 ± 0.50*	1.25 ± 0.50*	1.25 ± 0.50*	
Standard control	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00*	1.00 ± 0.00*	1.00 ± 0.00*	1.00 ± 0.00*	1.25 ± 0.50*	1.50 ± 0.58*	1.25 ± 0.50*	1.25 ± 0.50*	1.25 ± 0.50*	1.25 ± 0.50*	
Experimental control	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00*	0.00 ± 0.00*

Significant ($p < 0.05$) at 0.05 level of significance



Clustered charts comparing mean mortality of both extracts in different days after treatment

Table 3: Percentage Repellency of *Trogoderma granarium* at 24hours after application of different leaves powders of *S. mimosoides* and *D. alba*

Extracts	5%	10%	15%	Overall PR
<i>D. alba</i>	55	73	85	55
<i>S. mimosoides</i>	60	79	90	65
<i>D. alba</i> + <i>S. mimosoides</i>	80	90	99	90
Standard control	90	95	100	100
Experimental control	0	0	0	0

The leaf powders of *D. alba* and *S. mimosoides* exhibited some repellency activity against *T. granarium* compared to the standard and experimental controls. Following an exposure of the insects to different treatment levels of the two plant powder percentage repellency differed among treatments with the experimental control exhibiting the least repellency activity (0%) against the weevils, while the treatment with cocktail formulation of both powders (*S. mimosoides* + *D. alba*) recorded highest overall percentage repellency (90%) followed by sole treatment of *S. mimosoides* (65%) and *D. alba* (55%). The repellency of the powders increases as the concentration of the powders increased as shown in Table 3 above.

Table 4: Percentage Grain damage and weight loss in wheat grains treated with leaf powders of *Senna mimosoides* and *Datura alba*

Treatments (%)	Percentage grain damage	Percentage weight loss (%)
<i>D. alba</i> 5%	35%	43%
10%	30%	37%
15%	25%	30%
<i>S. mimosoides</i> 5%	35%	40%
10%	30%	30%
15%	25%	25%
<i>S. mimosoides</i> + <i>D. alba</i> 5%	30%	30%
10%	25%	35%
15%	20%	25%
Experimental control	90%	100%
Standard control	20 %	15%

Wheat grains treated with powders of *S. mimosoides* and *D. alba* at various doses effectively reduced *T. granarium* damage as the least dose showed about 35% grain damage while the highest dose showed 25% grain damage when compared with the standard control (20%). The percentage weight loss in the grains recorded 43% weight loss for the least dose while 25% was recorded for the highest doses. In a dose-dependent manner, the powders provided significant protection to wheat grains. When compared to the experimental control, a higher concentration resulted in a considerable reduction in *T. granarium* damage with a low percentage weight loss, because it provides more than 90% protection, the aluminum phosphate pesticide considerably reduced weight loss. Table 3 shows the percentage grain damage and weight losses to different concentrations of the different plant powders.

DISCUSSION

The result of the phytochemicals revealed the presence of various bioactive constituents like phenols, tannins, saponins, flavonoids, cardiac glycosides and terpenes in the leaves of *S. mimosoides* and *D. alba*. This result is in concordance with the work of Anitha *et al.*, (2014), who reported on the presence of alkaloids, tannins, saponins, flavonoids and cardiac glycosides in the leaves of *D. alba*. This result also agrees with Mahama *et al.*, (2017) who recorded similar bioactive compounds from the acetone and methanolic leaf extract of *C. mimosoides*. Similar result was obtained by Akharaiyi, (2011) who identified saponins, flavonoids, phenols, alkaloids, glycosides, and steroids in aqueous extract.

The adult mortality rate of *T. granarium* was found to be considerable in all powders of *S. mimosoides* and *D. alba* used in this investigation. The plant powders varied depending on the concentration and time of application. The presence of secondary metabolites in the plant powders may be the cause of the mortality observed in the different plant powders. Rubabura *et al.* (2014) reported that plant secondary metabolites are employed in a variety of functions, including insecticidal actions, according. Zijp *et al.* (2000) claimed that the powders' contain alkaloids, saponins,

steroids, phenolic compounds, and tannins functioned more like antinutrients, preventing the assimilation of nutrients; however, Zimudzi *et al.* (2014) and Yallappa *et al.* (2012) claimed that the terpenoid compounds affected the insect nervous system by disrupting sodium and potassium ion exchanges, which ultimately caused the insect to die. An increase in the amount of active components responsible for the insecticidal activity may account for the mortality increases with dose and exposure duration. The outcomes are similar to those of Daniel *et al.* (2015), who found that hexane extract of *Gnidia kaussiana* significantly increased *C. maculatus* mortality over exposure time and dose when compared to acetone and methanol extracts. These recorded mortalities in insect could be related to the direct food intake mixed with plant products.

Ali *et al.* (2017) conducted a study to examine the toxic effects of *Datura innoxia* acetone extracts on three insect species: *Tribolium castaneum*, *Trogoderma granarium*, and *Sitophilus granarius*. The results demonstrated that *D. innoxia* extracts are highly lethal to these insects and can cause maximum mortality rates of 15.12%, 13.52%, and 14.07% in *T. castaneum*, *T. granarium*, and *S. granarius*, respectively. The findings of this investigation conflict with those of Mahfuz and Khanam (2007), who found no harmful effects of *Datura*

stramonium leaf extract on adult *Tribolium confusum*. Similar findings have been reported by Monira and Munan (2012) and Al-Snafi (2017), who found that *Datura metel's* methanolic seed extracts are active against *Helicoverpa armigera* (Hubner) and negatively impact a number of developmental stages, such as larval survival, pupal period, pupation percentage, and adult emergence. Furthermore, *Aedes aegypti* (86.25 µg/mL), *Anopheles stephensi* (16.07 mg/L), and *Culex quinquefasciatus* (6.25 mg/L) were all successfully repelled by the ethanolic leaf extracts of *Datura stramonium*, according to Gaire and Subedi (2013) and Swathi (2012). This was demonstrated by the half lethal dose (LD50) values for larvicidal activity given in brackets and the complete protection time for mosquito repellency. Additionally, *D. stramonium* was shown to have larvicidal effects on *T. castaneum* (PascualVillalobos and Robledo, 1997). In addition, the acaricidal activity of this plant against the 2-spotted mite, *T. urticae*, was demonstrated by Kumral *et al.* (2009).

The different leaf powders demonstrated some degree of repellency ranging from 55% to 99% at different concentrations and the PR values for different treatment significantly increased with increased concentration. The degree of attractance or repellence was greatly influenced by the different plant powder, dosage and the phytochemicals present. The results is in agreement with Essien *et al.* (2023) who reported that the powder of *Carica papaya* roots and leaves exhibited high repellence effect against *S. zeamais*. Similarly, Hall (1990) observed that the leaf powder of *Eucalyptus* sp have a repellent effect on the olfactory and gustatory system of *S. zeamais*. Furthermore, against a number of insect pests, including the rice moth, *C. cephalonica* St. (Lepidoptera: Pyralidae), *D. cingulatus* (Fabricius), *S. litura*, and *P. ricini*, whole-plant extracts of *D. stramonium* were found to have repellent and antifeedant qualities (Devaraj and Srilatha

1993; Prakash and Rao, 1997). Seed weight loss, as shown in table 4 for the leaf powders was highest in the experimental control and least in the standard control. Over the course of a 28-day exposure to *T. granarium* weevils, the wheat grain treated with 5% leaf powder saw the largest grain weight loss among the concentrations, whereas the grain treated with 15% powders had the lowest mortality. Low weevil mortality and high weevil survival led to increased grain damage and, consequently, substantial grain weight loss in the wheat grain treated with 5% leaf powder. Overall, the findings show that weight loss and stored grain degradation are inversely correlated with adult weevil mortality. The results corroborate those of Muzemu *et al.* (2013), who found that treatment of maize grains with *C. papaya* extracts lowers weight loss and seed damage caused by high *S. zeamais* death rates. With a weight loss of only 12%, 15% leaf powders acted as a safeguard against significant wheat grain weight loss caused by *T. granarium*. This is due to the high death rate of the 15% leaf powder, which suffocated and dehydrated the weevils, reducing their ability to damage grains and lose weight. According to Parwada *et al.* (2012), ground plant extracts work by smothering and drying out weevils as well as by limiting their movement, which lessens damage to grains and decreases weight loss. According to Ileke *et al.* (2016), there is evidence to suggest that the way botanicals work involves interfering with regular breathing, which can lead to asphyxia. High insect mortality rates caused by plant powders often result in the obstruction of the spiracles on the insect's body, which hinders respiration and ultimately kills the insect.

Conclusion: Since *S. mimosoides* and *D. alba* powders are affordable for small farmers and environmentally safe, they ought to be promoted as an alternative to synthetic pesticides for control of khapra beetles for ecofriendly management of the insect.

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