# Native Enemies of Strategus aloeus (Coleoptera: Scarabaeidae) in Oil Palm Plantations in Colombia

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# Native enemies of *Strategus aloeus* (Coleoptera: Scarabaeidae) in oil palm plantations in Colombia

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*Strategus aloeus* (L.) (Coleoptera: Scarabaeidae: Dynastinae: Oryctini) is a pest of economic importance in oil palm crops under 5 yrs of age and has caused damage in plantations in Brazil, Colombia, Ecuador, Guyana, Mexico, Peru, Suriname, and Venezuela (Genty et al. 1978; Pardo-Locarno et al. 2005, 2012; Neita-Moreno et al. 2006, 2008; García et al. 2009; Lugo-García et al. 2011; Luna-León et al. 2017). The establishment of new areas, the replanting of oil palm crops, and the accumulated decomposing stipe in the surrounding areas have favored the development of populations of *S. aloeus*, which find ideal conditions to reproduce, feed and develop within oil palm plantations (Aldana et al. 2010).

In oil palm plantations, biweekly monitoring is conducted to determine the presence of *S. aloeus* through the galleries they create in the palm. One of the commercially carried-out management practices by palm growers is the periodic application of synthetic insecticides, which leads to insecticide resistance, the destruction of biological controllers like *Phileurus didymus* (L.) (Coleoptera: Scarabaeidae) and other beneficial insects, and costly production (Aldana 2000). Therefore, this study aimed to identify the beneficial fauna of *S. aloeus* present in the agroecosystem of oil palm cultivation in plantations of the central zone in Colombia and to determine the potential of *P. didymus* predation on the larval stage of *S. aloeus* under laboratory conditions.

*Strategus aloeus* and *P. didymus* larvae and adults were collected every 20 d for 3 yrs in 3 commercial oil palm plantations in Puerto Wilches (Santander, Colombia), that have the same environmental conditions, the same planting material and the management of the pest insect is the same (application of chemical insecticides). Plantation 1 (7.2691 °N, 73.8483 °W, 75 m.a.s.l.), Plantation 2 (7.3447 °N, 73.8275 °W, 99 m.a.s.l.), and Plantation 3 (7.2350 °N, 73.8740 °W, 79 m.a.s.l.). Average weather conditions of the study: temperature 27.1 ± 3.4 °C and relative humidity 79.1 ± 27.1%. Insects were sampled between 08:00 AM and 12:00 PM, in replanting lots of the hybrid *E. oleifera* × *E. guineensis*, which had decomposing stipes, where the female oviposits, and the larvae and pupae of *S. aloeus* develop. With the help of a chain saw and a stick, 25 entire stipes were cut down and each stipe was cut into small pieces. During the sampling, all the development stages of *S. aloeus* and *P. didymus* were collected to observe the presence of parasitoids and microorganisms that naturally affect the populations of this pest insect. The collected insects were transported to the Cenipalma Entomology Laboratory (Barrancabermeja, Santander, Colombia) in plastic containers with pieces of decomposing stipes for feeding. Larvae and adults were disinfected with 1% sodium hypochlorite for 30 and 60 s, respectively, and then washed 3 times with distilled water. The insects were identified in the laboratory considering the taxonomic traits of external morphology and genitalia of the original specimens and previous studies carried out by Dr. Jhon César Neita Moreno, curator of the Alexander Von Humboldt Institute of Biological Resources Research (Colombia). Voucher specimens were conserved in the entomological collections of Cenipalma (Barrancabermeja, Santander, Colombia).

Disinfected *S. aloeus* larvae were deposited in 12 L plastic containers containing sterilized decomposing stipe pieces for feeding and covered with a lid that had holes. Disinfected pupae were deposited in 0.7 L plastic containers containing soft sterile decomposing stipe and covered with a piece of black fabric to maintain natural development conditions. The stipe was sterilized for 30 min at 120 °C in an autoclave. The adults of *S. aloeus* and *P. didymus* were separated and placed in 40 L plastic containers containing a 13 cm sterile layer of soil mixed with decomposing stipe. *Strategus aloeus* adults were fed fruits (apple, pear, banana, or plantain), and the adults of *P. didymus* were fed third-instar larvae of *S. aloeus*.

The individuals of *S. aloeus* affected by entomopathogens were collected, placed in a humid chamber to cultivate the microorganism, and sent to the Cenipalma Entomopathogenic Microorganisms Laboratory (Bogotá, Cundinamarca, Colombia) for identification of the pathogen.

Due to the constant presence of the predator *P. didymus* in the samples, further investigation of its interactions with *S. aloeus* was conducted. For this, 15 larvae of each instar of *S. aloeus* were placed individually in 12 L plastic containers that contained sterilized stipe pieces for feeding, then a *P. didymus* adult collected in the field was added, and observations were made every 2 mins until the predation of the larva was complete. Time of attack, time of death, and time of consumption were recorded.

In a second experiment, a group of *S. aloeus* larvae and an adult of the predator *P. didymus* (experimental unit) were placed in 12 L plastic containers containing sterilized stipe pieces. The experiment was developed under a factorial design, in which treatments corresponded to 3 groups of 3rd instar larvae of *S. aloeus* (5, 7, and 10 larvae per experimental unit, factor 1) in 3 exposure times (6, 12, and 24 h after the experiment was established, factor 2). The bioassay had 5 replicates per treatment. Sampling was performed to quantify the number of predated *S. aloeus* larvae per experimental unit at different exposure times.

It was observed that the largest number of individuals of *S. aloeus* and the predator were in the middle and basal part of the stipe. The larval stage of *S. aloeus* predominated in all the samples. The *S. aloeus*

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samples were affected by the predator *P. didymus* (Figs. 1D and 1E) and the entomopathogenic fungus *Metarhizium anisopliae* (Metschnikoff) Sorokin (Deuteromycotina: Hyphomycetes) (Fig. 1A). Additionally, this entomopathogenic fungus was found infecting *S. aloeus* pupae and adults (Figs. 1B and 1C).

*Phileurus didymus* was present in 64.7% of the samples. In Plantation 1, there was a greater presence of this predator (83.3%), followed by Plantation 2 with 66.7% presence of this predator; and in Plantation 3, the presence of this predator was lowest with 44.4%; likewise, in this plantation, the largest amount of *S. aloeus* larvae was collected with 1,142 larvae; and in Plantation 1 and 2, 700 larvae were collected per plantation.

It was observed that the females of *P. didymus* oviposited in the same stipe sites where the larvae of *S. aloeus* are located. Moreover, Veiga (1985) and Rozas et al. (1991) reported that the Scarabaeoidea superfamily that this predator belongs to has highly varied feeding habits. Some species are saprophagous and phytophagous, although some mycophagous and zoophagous species have been recorded, the latter being the strangest and rarest, limited to the family Scarabaeidae, such as *Canthon virens* Mannerheim (Coleoptera: Scarabaeidae) and *Canthon dives* Harold (Coleoptera: Scarabaeidae), predators of the ant *Atta* spp. (Hymenoptera, Formicidae) (Forti et al. 2012; Araújo et al. 2015; Aquino et al. 2018); *Deltochilum valgum* Burmeister (Coleoptera: Scarabaeidae) specific predator of millipedes (Larsen et al. 2009); *Hybosorus ittigeri* Reiche (Coleoptera: Scarabaeoidea) predator of coprophagous insects (Veiga 1985; Rozas et al. 1991); and *P. didymus*, a predator of *Platycoelia valida* Burmeister (Neita-Moreno & Morón 2017) and *S. aloeus* larva, which was evidenced during this study.

Another of the natural enemies of *S. aloeus* identified was the entomopathogenic fungus *M. anisopliae*, which was isolated from larvae (Fig. 1A), pupae (Fig. 1B), and adults (Fig. 1C). The entomopathogenic fungus in the development stages of *S aloeus*, began to be observed in the rainy seasons of the study area as these conditions favored the manifestation of this natural microorganism (personal observation). The incidence in the larval stages was higher in Plantation 1 with an infection percentage of 1.4%. In contrast, in Plantations 2 and 3, lower infection percentages were recorded with 0.1% and 0.9%, respectively. Although the natural incidence of *M. anisopliae* in the *S aloeus* populations in the 3 plantations was low, Valencia et al. (2011) and Matabanchoy-Solarte et al. (2015) determined that under laboratory, shade, and field conditions, 2 strains of *M. anisopliae* caused larval mortality greater than 90%. Indriyanti et al. (2017) also determined that this fungus can kill 100% of *Oryctes rhinoceros* (Linnaeus) (Coleoptera: Scarabaeidae) larvae after 7 wks of being sprayed on mounds containing the larvae under shaded conditions. *Metarhizium* sp. can infect all stages of development of *O. rhinoceros*, causing a greater effect on third-instar larvae (Moslim et al. 2006; 2007).

It was observed that adult *P. didymus* caused the death of *S. aloeus* larvae at 4.9 ± 2.5 mins after making contact, and the total time to consume the larva was 5.7 ± 1.3 mins for the first instar and 17.3 ± 3.2 mins for the second instar and 36.1 ± 6.9 mins for the third instar. The adults of the predator *P. didymus* can kill 1 or 2 larvae of *S. aloeus* before consuming them. Statistically significant differences were observed in the effect of predation of *P. didymus* on *S. aloeus* larvae and the exposure time, given that *P. didymus* must search for its prey (Fig. 1D) and predate it (Fig. 1E). The percentage predation was 29.3% and 81.3% 6 and 24 h after introducing *P. didymus*, respectively (Table 1). Significant differences were found in the predation of *P. didymus* when placed with different size groups of *S. aloeus* larvae (Table 1). When the group size was larger there was an increased percentage of predation. Fellowes et al. (2007) determined that when the density of beneficial insects in an agroecosystem increase, the natural enemy spends more time finding prey. Acevedo (2020) mentions that beetles' search method to find their prey is with chemical, visual, mechano-sensory, and vibration signals; the chemical signals coming from the prey insects, the main stimuli used in the process of searching by the predator. Due to its presence within the agroecosystem, search capacity, and predation capacity that *P. didymus* has on the larvae state of *S. aloeus*, this

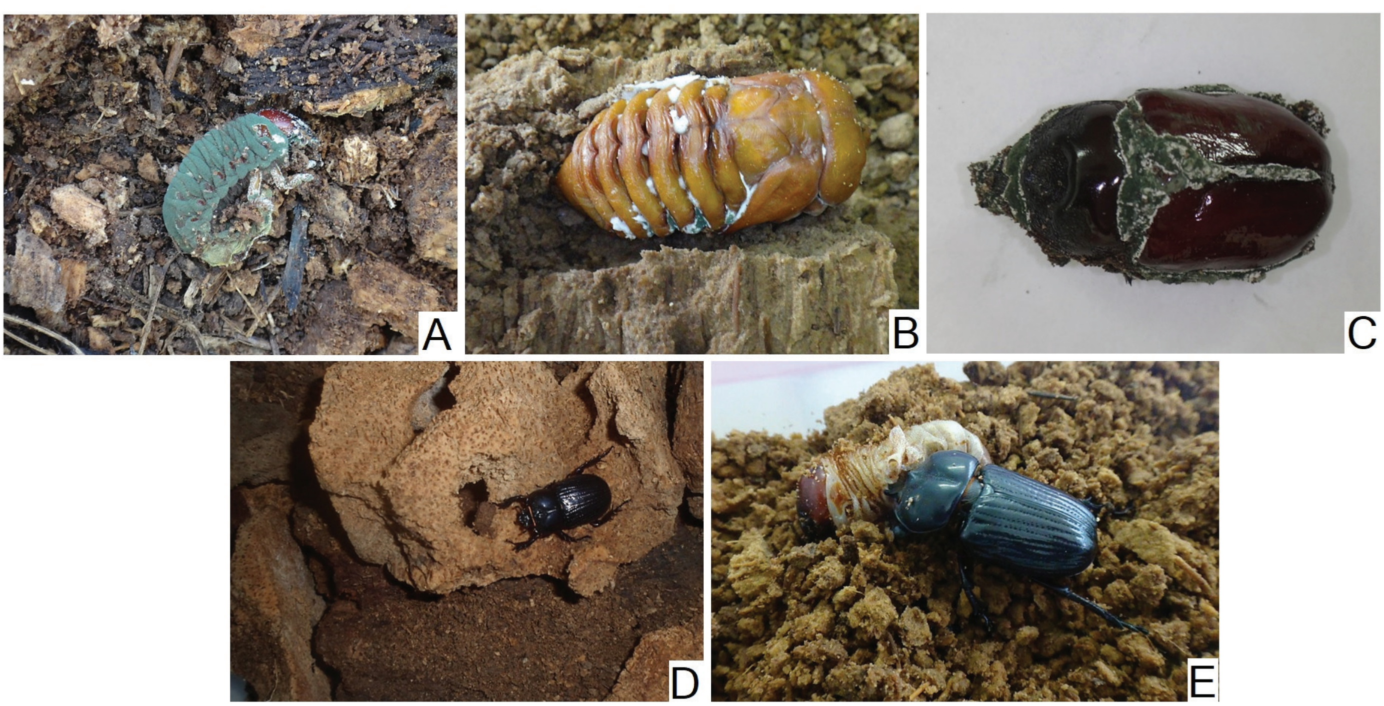


**Fig. 1.** Natural enemies of *Strategus aloeus*. *Metarhizium anisopliae* infecting *S. aloeus* in: A. larvae, B. pupae, and C. adult of *Phileurus didymus,* D. searching for prey and **E.** preying on 3rd stage larvae of *S. aloeus.*

**Table 1.** Predation of *Phileurus didymus* on *Strategus aloeus* larvae (mean ± SD).

| Number of larvae/experimental unit | | Exposure time | |
|---|---|---|---|
| Number of larvae | Predation (%) | Time (h) | Predation (%) |
| 5 | 58.7 ± 22.0 a | 6 | 29.3 ± 10.5 a |
| 7 | 48.6 ± 26.3 b | 12 | 56.6 ± 13.1 b |
| 10 | 60.0 ± 23.6 a | 24 | 81.3 ± 9.3 c |

*Data with the same letter are not significantly different (Tukey $P \leq 0.05$).

natural enemy could regulate the populations of this pest insect in oil palm cultivation.

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## Summary

The adult *Strategus aloeus* (L.) (Coleoptera: Scarabaeidae: Dynastinae: Oryctini) is a pest insect that causes damage in young oil palm plantations in Colombia. The indiscriminate use of insecticides for their control affects the beneficial fauna of the agroecosystem, reducing their populations. Therefore, it is essential to identify *S. aloeus* native enemies and establish their importance in regulating pest populations. Sampling was performed every 20 d for 3 yrs in plots with decomposing stipes in 3 plantations of the central zone (Colombia). The predator *Phileurus didymus* (L.) (Coleoptera: Scarabaeidae: Dynastinae: Oryctini) was found in 64.7% of the collected samples. *Strategus aloeus* larvae, pupae, and adults also were naturally infected by the fungus *Metarhizium anisopliae* (Metschnikoff) Sorokin (Deuteromycotina: Hyphomycetes). Under laboratory conditions, adults of *P. didymus* caused the death of *S. aloeus* larvae 3 to 7 mins after finding their prey, taking 6 to 36 mins to consume the larvae. The percentage predation of *S. aloeus* larvae by *P. didymus* was a function of exposure time. At 24 h of exposure, approximately 81.3% of the population was predated. Due to the presence within the agroecosystem of the oil palm, the habits of oviposition, the search factor, and the predation capacity, this natural enemy (*P. didymus*) should have strong effects on the regulation of the populations of *S. aloeus* in oil palm cultivation.

Key Words: rhinoceros palm beetle; predation; *Elaeis guineensis; Metarhizium anisopliae; Phileurus didymus*

## Sumario

El adulto *Strategus aloeus* (L.) (Coleoptera: Scarabaeidae: Dynastinae: Oryctini) es un insecto plaga que causa daños en plantaciones jóvenes de palma de aceite en Colombia. El uso indiscriminado de insecticidas utilizado para su control afecta a la fauna benéfica presente en el agroecosistema que regula sus poblaciones. Por lo tanto, es fundamental identificar a los enemigos nativos de *S. aloeus* y establecer su importancia en la regulación de las poblaciones de la plaga. Se realizaron muestreos cada 20 días durante 3 años en parcelas con estípites en proceso de descomposición de 3 plantaciones de la zona central (Colombia). El depredador *Phileurus didymus* (L.) (Coleoptera: Scarabaeidae: Dynastinae: Oryctini) se encontró en el 64,7% de las muestras colectadas. Las larvas, pupas y adultos de *S. aloeus* fueron infectados naturalmente por el hongo *Metarhizium anisopliae* (Metschnikoff) Sorokin (Deuteromycotina: Hyphomycetes). En condiciones de laboratorio, los adultos de *P. didymus* causaron la muerte de las larvas de *S. aloeus* después de 3 a 7 mins de encontrar su presa, tardaron entre 6 a 36 mins en consumir las larvas. El porcentaje de depredación de las larvas de *S. aloeus* por *P. didymus* estuvo en función del tiempo de exposición. A las 24 h de exposición, aproximadamente el 81,3% de la población fue depredada. Debido a su presencia dentro del agroecosistema del cultivo de palma de aceite, a los hábitos de oviposición, al factor de búsqueda y la capacidad de depredación, este enemigo natural (*P. didymus*) debería tener fuertes efectos en la regulación de las poblaciones de *S. aloeus* en el cultivo de palma de aceite.

Palabras Clave: escarabajo rinoceronte de la palmera; depredación; *Elaeis guineensis; Metarhizium anisopliae; Phileurus didymus*

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