Entomological Science, 2001, 4(4): 403–405

Suppression of Fungal Development on Carcasses by the Burying Beetle *Nicrophorus quadripunctatus* (Coleoptera: Silphidae)

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Abstract. Burying beetles bury and treat carcasses with secretions to provide them for their offspring as food. I tested whether *Nicrophorus quadripunctatus* reduces the growth of mold, a potential competitor, by burial and treatment of carcasses, based on simple field experiments using mold-infested raw chicken meat. Mold colonies developed on most of the chicken meat pieces placed on ground without burying beetles. Mold also developed on artificially buried meat pieces. However, the development of mold was limited on meat pieces treated by burying beetles, whether the pieces were buried or not. These results clearly indicate that the carrion treatment, rather than the burial itself, effectively prevents mold growth on carcasses.

Key words: Burying beetle, *Nicrophorus,* carrion burial, carrion treatment, mold.

Introduction

Burying beetles (*Nicrophorus* spp.) search for the carcasses of small vertebrates to use as food for their offspring. Upon obtaining a carcass they bury it in its soil (Pukowski, 1933; Scott, 1998), remove any fur or feathers covering the outer surface, roll it into a ball, and treat it with anal and oral secretions (Milne & Milne, 1976; Scott, 1989; Fetherston *et al.*, 1990).

It have been suggested that the burial and preparation of carrion (rolling and treating with secretions) is advantageous in reducing intra- and interspecific competition, in preventing discovery by other burying beetles (Trumbo, 1994; Suzuki, 1999) and in preventing fly infestations (Suzuki, 2000). The present study aims to examine whether treatment by burying beetles prevents the growth of mold, which could be a potential competitor for the burying beetle through its function of decomposing carrion.

Material and Methods

Experiments were conducted in a grove on the campus of Hokkaido University, Sapporo, southwestern Hokkaido using *Nicrophorus quadripunctatus* Kraatz, 1897. All beetles were caught in the field with hanging traps baited with rotten meat at the Naebo Forest Park in Otaru, near Sapporo. Beetles were used for experiments on the day or the next they were collected.

I placed small pieces of raw chicken meat on wet tissue paper in a small plastic case, which kept at field temperature until mold appeared on the meat or paper. Using tweezers, I then took a small piece of the mold colony, and spread it over another piece of chicken (about 10 g). Using the meat pieces thus treated, and a soil-filled plastic container (81 mm diameter and 58 mm depth), I conducted the following four series of experiments in August, 2000.

In experiment 1 (artificial burial, 17 replicates) a meat piece was buried in a container without beetles about 1 cm under the ground to mimic burial by burying beetles. This is the average depth for *N. quadripunctatus* (Suzuki, unpublished data). In experiment 2 (beetle treatment, 11 replicates) a meat piece was placed on the soil and a pair of *N. quadripunctatus* were released into the container. After confirming the burial and rolling of the meat piece three or four days later, I exhumed the meat piece, removed the beetles, and placed the meat piece on the soil surface. In experiment 3 (beetle burial and treatment, 14 replicates), I placed a meat piece on the soil in a container with a pair of *N. quadripunctatus* and allowed them to reproduce freely. In the control (10 replicates), a meat piece was placed on the soil in a container without beetles.

In all of the above settings, I checked the pieces seven days after the start of each experiment. I recorded whether mold colonies were present on the meat pieces (+), or not (−).

Table 1. Number of carcasses on which mold colonies were confirmed.

	Mold presence		Total
	+	−	
Control	8	2	10
Artificial burial	13	4	17
Beetle treatment	2	9	11
Beetle burial and treatment	1	13	14

Table 2. Comparison of each treatment.

	d.f.	χ^2	P
Control vs. Artificial burial	1	0.83	ns
Control vs. Beetle treatment	1	8.03	**
Control vs. Beetle burial + treatment	1	13.2	***
Artificial burial vs. Beetle treatment	1	9.12	**
Artificial burial vs. Beetle burial + treatment	1	14.9	***
Beetle treatment vs. Beetle burial + treatment	1	0.71	ns

Multiple comparison χ^2-test, **: significant at $P<0.01$, ***: $P<0.001$, ns: not significant.

Results

Results are shown in Table 1. Mold was confirmed on a large propotion of the meat pieces when they were placed on the soil or buried artificially. However, mold was found on only a small proportion of the meat pieces when they were treated by the beetles. The occurrence of mold was not significantly different between control and artificial burial, and between beetle treatment nor beetle burial + treatment. However, it was significantly different between the control and beetle treatment, between the control and beetle burial + treatment, between artificial burial and beetle treatment, and between artificial burial and beetle burial + treatment (Table 2, multiple comparison χ^2-test).

Discussion

Microbes including mold can compete with burying beetles for carrion because they decompose carrion and make it unsuitable for burying beetle reproduction. It is reported that carcasses buried and treated by burying beetles do not undergo the typical decomposing process (Eggert & Müller, 1997). This suggests that burying beetles can control the decomposition of the carcasses they possess.

However, how they control the decomposing process is still unknown. Burying beetles spread oral and anal secretions over the carrion and groom its surface with their mandibles. These secretions may prevent the growth of microorganisms (Pukowski, 1933). Rana *et al.* (1997) found phospholipase A_2, an enzyme that digests fatty acid, in the oral secretion, but the relationship between the existence of the enzyme and the management of decomposing process is unknown. On the other hand, Eggert & Müller (1997) speculated that microorganism growth in burying beetle chambers was inhibited due to low temperatures and high humidity.

It has been considered that carrion burial by burying beetles reduces intra- and interspecific competition (e.g., Eggert & Müller, 1997). However, carrion burial itself is only effective in reducing fly infestations (Suzuki, 2000). In this study, I demonstrated that the suppression of mold growth is not due to the carrion burial but to other treatments by burying beetles. Brood balls of dung beetles are quickly covered with fungi when the parents are removed (Halffter, 1997), whereas carcasses treated by burying beetles are less mold-covered even when the beetles are removed. This suggests that the suppression of mold growth is not due to its physical removal but to the chemical effects of secretions.

Acknowledgments

I thank Dr. H. Katakura for providing advice and help throughout this study, Mr. D. S. Sikes and Mr. M. Nagano for reading the manuscript and making a number of helpful suggestions.

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(Received March 26, 2001; Accepted September 3, 2001)