Artículo Científico

# The role of *Digitonthophagus gazella* in pasture cleaning and production as a result of burial of cattle dung

*C. H. Behling Miranda**, *J. C. dos Santos***, and *I. Bianchin***

## Introduction

Probably between 85% and 95% of the total nitrogen (N) ingested by bovines return to the soil via dung and urine (Haynes and Williams, 1993). Most of this N may be lost from the soil-plant system by urea volatilization in a few days (Ferreira et al., 1995a; 1995b), unless it is incorporated into the soil organic or inorganic pool.

In this sense, coprophagous dung beetles play an important role, due to their capacity of incorporating fresh faeces to the soil. Usually, dung beetles dig a hole underneath the faeces patch carrying portions of dung to as deep as 30 cm and making dung balls in which eggs are deposited. On hatching, the larvae eat from the dung balls until they reach adult stage, when they leave the balls to fulfill their biological cycle. A large part of the buried material mineralizes in a short time, releasing significant amounts of N and P (Miranda et al., 1998).

The National Center for Beef Cattle Research (Gado de Corte) of the Brazilian Enterprise for Research on Agriculture (Embrapa) introduced, in 1989, as has been done in other countries (Doube et al., 1991; Kohlmann, 1994), the species *Digitonthophagus gazella* (formerly *Ontophagus gazella*; Barbero and López-Guerrero, 1992; Koller et al., 1999) to help in the biological control of gastrointestinal helminths and the horn fly, *Haematobia irritans* (Bianchin et al., 1992). Most of the biological cycles of such parasites are carried out in fresh cattle dung. When a dung patch is dismantled and buried by the beetles, the return of such parasites larvae to the soil surface is hampered, and this is a reliable and cheap form of parasite control.

*Digitonthophagus gazella* has an exceptional capacity both to disperse and colonize, being highly adaptable and with a high rate of reproduction (Oca and Halffter, 1995). Also, its exclusively coprophagous diet, with a marked preference for cattle dung, makes it appropriate for release in pasture areas.

The burial of dung has also other agronomic implications, positive for plant growth and pasture health. It is known that an area up to 12 times larger than the dung patch itself is not restrained from grazed for months or even as long as up to a year, first because of its strong odour, then because of plant lignification (Haynes and Williams, 1993). Such areas may correspond to up a third of a pasture's area, if it is used in rotational grazing (Afzal and Adams, 1992). If the dung patch is quickly buried, such areas of grazing rejection are not formed, and become part of the whole pasture. Also, dung is basically organic matter, and can stimulate soil biota activity and subsequent mineralization of essential nutrients (Elkins et al., 1984; Steinberger et al., 1984). Studies with *D. gazella* under controlled conditions have demonstrated such potential (Miranda et al., 1998).

In this paper, we present the results of an experiment conducted under field conditions to study the cleaning of an area and the contribution of cattle dung buried by *D. gazella,* to soil N and P contents and *Brachiaria decumbens* plant production.

## Material and methods

A 10-year-old pasture of *B. decumbens* established in a Purple Latosol of Embrapa's Beef Cattle Research Station, in Campo Grande, Mato Grosso do Sul (Brazil), was chosen for this experiment. Initially, the aerial plant growth was mechanically standardized at 10 cm height. After that, four treatments, with eight replications each disposed in a randomized design, were established, as follows:

* EMBRAPA-Gado de Corte, CP154, 79002-970, Campo Grande, MS, Brazil.
** Researchers, CNPq.

1. Control with no dung and no dung beetles.

2. Plot with 10 kg of fresh cattle dung, but no dung beetles.

3. Plot with 10 kg of fresh cattle dung, plus 30 pairs of *D. gazella*; and,

4. Plot with no cattle dung, but fertilized with the equivalent of 100 kg/ha of N (as urea), 100 kg/ha of $P_2O_5$ (as super simple phosphate), and 100 kg/ha of $K_2O$ (as potassium chloride).

Each plot was delimited by 1-$m^3$ iron cages. All cages were covered by a fine net to keep the beetles inside.

When adding fresh cattle dung in treatments 1 and 2, samples were taken to determine their moisture content (after drying at 45 °C to constant weight) to correct for dry matter added and N and P content. Nitrogen was determined in fresh samples, using the Macro-Kjeldahl method described by Bremner (1965). Phosphorus was determined in dry samples, using the methodology described by Adler and Wilcox (1985). Considering the dry weight of the samples in these treatments, 1952 g of dry dung were added, with 25 and 23 mg of N and P, respectively.

Ten days after adding the dung, the nets from all cages were discarded, as there were no more beetle activity. Fifty days later, at first harvest, the grass was cut at about 10 cm from the soil surface. The second harvest was cut 60 days later. Harvested plant material was separated into leaves, stems, and dead material. After separation, material was dried at 65 °C, weighed, milled, and analyzed for its N and P contents, as described above, except that the method used for N total determination was now the Micro-Kjeldahl, also as described by Bremner (1965). At the second harvest, all remaining dung in each splot was also collected and divided in two sub-samples. One sub-sample was burned at 600 °C for further corrections of soil contamination. The other was used to determine N and P contents, as described above.

## Results and discussion

Although care was taken to prevent invasion of native beetles in the control plot with fresh dung (treatment 2), there was a generalized intrusion of such beetles from underneath the net cover. Fortunately, most of them were *D. gazella*, given that as many as 37 species of dung beetles may occur in the research station area (Koller et al., 1999). Thus, the trend for treatment 2 was the same as for treatment 3. These beetles are therefore referred to in the tables of results as “local beetles”.

By the second harvest, about 90% of the added dung had disappeared from the soil surface. According to periodic visual evaluation, about 70% was a result of direct dung beetle action in the first 10 days after the dung was added. The remaining dung losses were due to rain and, most possibly, termites. Analysis of the remaining dung indicated that, from the added material, 22 g of N and 23 g of P were buried by the beetles, which is most of what had been first added.

Intense plant growth was seen at the first harvest, 50 days after treatments were established (Table 1), with no dead material. At the second harvest, however, there was some dead material was seen among the treatments.

Table 1. **Dry matter production of *Brachiaria decumbens* (g/$m^2$) during two harvests. Controls with or without fertilizer and with local or introduced beetles (*Digitonthophagus gazella*). (n = 8).**

| Treatments | Harvests (days) | Dry weight (g/$m^2$) Leaves | Tops | Dead material | Entire plant |
|---|---|---|---|---|---|
| Control | 50 | 84.5 c* | 88.8 d | – | 173.3 d |
| | 110 | 135.2 b | 100.7 cd | 28.4 | 264.3 bc |
| Introduced beetles | 50 | 96.7 c | 117.6 bcd | – | 214.3 cd |
| | 110 | 153.1 ab | 137.0 b | 28.0 | 318.1 ab |
| Local beetles | 50 | 87.6 c | 97.4 cd | – | 185.0 d |
| | 110 | 162.2 ab | 191.8 a | 29.2 | 383.2 a |
| Control plus fertilizer | 50 | 156.9 ab | 201.9 a | – | 358.8 a |
| | 110 | 173.4 a | 126.2 bc | 29.8 | 329.4 ab |

* Values followed by the same letter in the column are not significantly different (Duncan, $p < 0.05$).

There was a significant effect ($p < 0.05$) for all treatments in both harvests. The highest was the fertilized control (treatment 4), followed by treatments with beetles (2 and 3), which were all higher than the control without fertilizer or dung (treatment 1). Such results confirm what was previously measured under greenhouse conditions (Miranda et al., 1998), where fresh dung cattle was buried in a confined area (20 kg of soil) and its further mineralization was studied. A similar but stronger effect was observed. In the field, plant roots are not restricted from growing laterally and thus exploit a larger area of soil. The beetles also may bury the dung over a more dispersed area.

The burial of fresh dung had shown also a significant effect ($p < 0.05$) on plant P and N contents (Tables 2 and 3). Plant total N content of treatments with beetles was slightly higher than that of the control, although significant only for the second harvest (Table 2). A similar tendency was observed for plant total P (Table 3). In both situations, the fertilized control showed higher production than any of the other treatments. This is expected because of the immediate availability of nutrients from the fertilizers. The buried dung must be mineralized through activity of soil biota, taking time.

Such results show the potential of *D. gazella* in two important aspects for pasture production: (1) cleaning the pasture by burying the dung; and (2) favoring an effective recycling of nutrients in the dung.

Related to the first aspect, some considerations can be made, using West Central Brazil region as an example. This is the country's major beef-producing area, with a bovine herd of 51 million heads (Anualpec, 1998). Considering that grazing bovines produce excreta that cover an area varying from 0.3 $m^2$/day for steers 1 to 2 years old, and up to 0.8 $m^2$/day for bulls and cows, then an area of about 2731 ha of pasture is covered by excreta daily. Excreta is not spread evenly over the area, some of it being restricted to water and mineral salt supply points. Even so, if only 50% of the total is leaft directly in the pasture, the area covered is still large. It is known that areas from 5 to 12 times the diameter of the excreta are avoided by grazing animals

Table 2. **Total N content in the dry matter of *Brachiaria decumbens* (mg/$m^2$) during two harvests. Controls with or without fertilizer and with local or introduced beetles (*Digitonthophagus gazella*). (n = 8).**

| Treatments | Harvests | Total content (mg/$m^2$) | | | |
|---|---|---|---|---|---|
| | (days) | Leaves | Tops | Dead material | Entire plant |
| Control | 50 | 936.5 c* | 850.4 c | — | 1786.9 c |
| | 110 | 1831.9 ab | 985.0 bc | 140.8 | 2957.7 b |
| Introduced beetles | 50 | 1036.9 c | 1044.9 bc | — | 2081.8 c |
| | 110 | 1943.6 ab | 1291.8 b | 138.1 | 3373.5 ab |
| Local beetles | 50 | 1083.1 c | 955.6 bc | — | 2038.7 c |
| | 110 | 2032.4 ab | 1734.8 ab | 120.7 | 3887.9 a |
| Control plus fertilizer | 50 | 1596.5 b | 1765.8 a | — | 3362.3 ab |
| | 110 | 2261.3 a | 1158.1 bc | 149.9 | 3569.3 ab |

* Means followed by the same letter in the column are not significantly different (Duncan, $p < 0.05$).

Table 3. **Total P content in the dry matter of *Brachiaria decumbens* (mg/$m^2$) during two harvests. Controls with or without fertilizer and with local or introduced beetles (*Digitonthophagus gazella*). (n = 8).**

| Treatments | Harvests | Dry weight (g/$m^2$) | | | |
|---|---|---|---|---|---|
| | (days) | Leaves | Tops | Dead material | Entire plant |
| Control | 50 | 88 d* | 84 c | — | 172 e |
| | 110 | 180 c | 117 ab | 14 | 211 cd |
| Introduced beetles | 50 | 118 d | 138 bc | — | 236 de |
| | 110 | 237 b | 259 a | 18 | 514 a |
| Local beetles | 50 | 121 d | 146 b | — | 267 de |
| | 110 | 249 b | 208 a | 19 | 476 ab |
| Control plus fertilizer | 50 | 164 c | 231 a | — | 395 bc |
| | 110 | 306 a | 230 a | 27 | 563 a |

* Means followed by the same letter in the column are not significantly different (Duncan, $p < 0.05$).

(Haynes and Williams, 1993) for periods varying from 2-3 months as long as a year. If most of the dung is quickly buried by the beetles, even partially, such areas are greatly reduced or even eliminated, making the pasture better used. Such contribution from the beetles is highly important for the region's husbandry.

Considering the second aspect, similar considerations can be made. From Euclides (1995), we know that for every 100 kg of liveweight of Nelore Zebu cattle grazing in *Brachiaria* spp. or *Panicum maximum*, the commonest grasses in the area, on the average, 1.04 kg of dry dung is produced daily. Thus, we can say that 51 million heads in the region produce about 150 million tons of dung. Because, on the average, fresh dung contains 1% N, 1500 tons of this element is deposited daily in the region. Under these conditions, as Ferreira et al. (1995a) demonstrated, that about 10% of the dung N, as ammonium, is lost by volatilization. From the urine, the losses are even higher, reaching 76% in a bare soil or 30% in soil with plants (Ferreira et al., 1995b). Considering the total amount of produced dung, such losses are highly relevant. By burying the dung, the beetles help maintain such N in the pasture system, contributing to the production system's sustainability. Also, N in an available form is recycled more rapidly, as demonstrated by this paper and as previously reported by Miranda et al. (1998). Other beneficial aspects of the burial of fresh cattle dung by *D. gazella*, including the control of horn fly, are amply discussed by Bianchin et al. (1992).

## Resumen

En una pastura de *Brachiaria decumbens* de 10 años de establecida en un Latosol Rojo de la estación experimental de la Empresa Brasileira de Pesquisa Agropecuária (Embrapa) en Campo Grande, Mato Grosso do Sul (Brasil), se evaluó la contribución del coleóptero coprofago *Onthophagus gazella* en el ciclo del nitrógeno (N) y del fósforo (P) presentes en las heces frescas de bovinos. Las áreas de medición de 1 $m^2$ fueron aisladas con jaulas metálicas recubiertas con un cedazo para evitar la contaminación externa. Los tratamientos consistieron en: (1) control sin heces ni coleópteros; (2) adición de 10 kg de heces frescas sin coleópteros; (3) adición de 10 kg de heces frescas más 30 parejas de coleópteros; (4) aplicación equivalente de N (urea), $P_2O_5$ (superfosfato simple) y $K_2O$ (cloruro), a razón de 100 kg/ha de cada uno. Las plantas fueron cosechas 50 y 100 más tarde, separando hojas y tallos para análisis de N y P. En la segunda cosecha se analizó la composición de las heces para determinar su aporte a la biota del suelo. Debido a la contaminación de coleópteros nativos, la mayoría *D. gazella*, el tratamiento 2 se asimiló al tratamiento 3. Los resultados mostraron aumentos en la producción de materia seca en la parte aérea y en los contenidos totales de N y P de las plantas por la presencia de los coleópteros, especialmente en la segunda cosecha. Estos resultados confirman que la incorporación de heces frescas en el suelo por los coleópteros es benéfica para las plantas, además de la descontaminación de las pasturas en los sitios de deposición de ellas.

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