THE JOURNAL OF PARASITOLOGY
Vol. 59, No. 2, April 1973, p. 396–399

DUNG BEETLES AS BIOLOGICAL CONTROL AGENTS FOR GASTROINTESTINAL PARASITES OF LIVESTOCK

G. Truman Fincher
Animal Parasite Research Laboratory, ARS, USDA, Tifton, Georgia 31794

ABSTRACT: Herbage samples from a pasture plot free of dung beetles had 14.7 times more *Ostertagia ostertagi* (Stiles) larvae than samples from a plot which contained an increased dung beetle population of about 5-fold above the natural population. Herbage samples from a plot with the natural dung beetle population had 3.7 times as many larvae as samples from the plot containing the larger beetle population. The reduction in numbers of *O. ostertagi* larvae available to grazing animals by the burying activity of the beetles was reflected in a similar reduction in the number of adults recovered from parasite-free calves which grazed the plots.

The incidence and severity of parasite infections of livestock are greatest in the southeastern United States although losses are sustained in all parts of the country. Parasitism is essentially a problem of sanitation arising from the changing agricultural practices, which concentrate animals in increasingly smaller areas for more economical production. Such crowding augments the transmission potential of internal parasites by effectively concentrating the hosts and their parasites in the same small area. Control of gastrointestinal parasites of livestock through the years has been largely by costly chemotherapeutic agents.

The prevention of parasite infections of livestock is primarily a problem of management based on the available knowledge of the parasite life cycles. It is logical to attempt to break the life cycle chain at its weakest link, which in most cases is the free-living stage. At present, however, there are no economical means of destroying parasite eggs and larvae on pasture and chemotherapeutic treatment of the host animal does not prevent reinfection. With the high stocking rates on pastures today, many fecal deposits remain on pasture surfaces for several months because the native dung beetles and other coprophagic organisms cannot cope with the increased feces production. A fecal deposit remaining on the pasture surface can be regarded as an incubator in which the larvae develop to the infective stage; as a shelter with a hard impervious outer covering baked by the sun; and as a reservoir for parasite larvae (Reinecke, 1970). The possible role of dung beetles in reducing the accessibility to livestock of the infective stages of parasitic worms has been casually mentioned by several authors (Bornemissza, 1960; Halfftner and Matthews, 1966; Ferreira, 1967). Reinecke (1970) stated that a highly efficient form of biological control could result from the stimulation of dung beetles; however, data confirming the reduction of livestock parasitisms by these beetles are lacking. If contaminated feces were buried by dung beetles before the parasites reached the infective stage, the parasitism potential of a fecal deposit would be greatly minimized.

Received for publication 1 August 1972.

This report describes a new approach for the control of gastrointestinal parasites of livestock, which involves rapid burial of feces from pasture surfaces by increasing the population of dung beetles.

MATERIALS AND METHODS

Three 14.6- by 7.3-m plots were marked off in a nearly level swine pasture that had not been used in 5 years. The adjoining plots A and B were completely enclosed with plastic screen (7 squares per cm) supported by a wooden framework. Plot C had only a screen top similar to the tops of the other 2 plots and was located 2 m from plot B. The distance from the ground surface to the top of the framework was approximately 1.7 m. The bottom of the sides of plot A extended 15 cm below the ground surface to prevent the escape of beetles. Plot B was enclosed similarly to plot A except that a strip of thin, galvanized metal was attached to the bottom frame and extended 76 cm into the ground to prevent beetles attracted to feces from digging in. Plots A and B had a screen side in common. Three strands of barbed wire were placed inside plots A and B and around plot C. Each plot was then subdivided by barbed wire into two 7.3- by 7.3-m subplots.

The plots were covered with vegetation consisting of about 80% common bermudagrass [*Cynodon dactylon* (Linnaeus) Pers] and the remaining 20% was composed of large crabgrass [*Digitaria* *sanguinalis* (Linnaeus) Scopoli], yellow woodsorrel (*Oxalis stricta* Linnaeus), and a few other grasses and herbs. The grass in each plot was about 8 cm high when the test began. A granular commercial fertilizer was applied to each plot 3 weeks before the test began at the rate of 1.5 kg per plot.

Cattle feces less than 24 hr old containing *Ostertagia ostertagi* (Stiles) eggs were collected from pens containing donor animals every 2 days and thoroughly mixed. A 1,000-g pat of mixed feces was placed on each subplot every other day from 21 June to 9 September 1971, for a total of 41 fecal pats in each subplot. Each pat was formed by letting a ball of feces drop from a height of 1.3 m above the pasture surface to create a naturally shaped deposit. The fecal pats were approximately 5 cm thick and 20 cm in diameter and were placed at least 60 cm apart. Wooden stakes were used to mark the location and date of deposit of each pat.

Dung beetles were captured in feces-baited pit traps about 5 km from the test site and were periodically released into plot A to maintain a population of beetles that would bury the feces within 96 hr. The beetle species used were *Phanaeus vindex* MacLeay, *P. igneus* MacLeay, *Dichotomius carolinus* (Linnaeus), *Canthon pilularius* (Linnaeus), *Copris minutus* Drury, and *Onthophagus* spp. (including *O. hecate* Panzer, *O. pennsylvanicus* Harold, *O. concinnus* LaConte, and *O. oklahomensis* Brown). The numbers and species of dung beetles used in plot A at the beginning of the experiment were: 300 *P. vindex*, 10 *P. igneus*, 60 *C. pilularius*, 10 *C. minutus*, 100 *D. carolinus*, and 1,000 *Onthophagus* spp. The total number of beetles was an increase of about 5-fold above the normal local population except for *C. pilularius* and *D. carolinus* whose numbers were increased about 10-fold. Approximately 10% of the original number of each beetle species was added every 2 weeks to compensate for beetle mortality.

Two pit traps were baited daily in plot B during the experiment to capture dung beetles which could have emerged from the soil from eggs deposited before the plot was enclosed and to test the effectiveness of the beetle guard around the plot. Swine feces were used as bait in the pit traps as a better attracter of dung beetles than cattle feces (Fincher et al., 1970). No dung beetles were captured in the pit traps and no burying activity was observed near the cattle feces indicating the absence of dung beetles in plot B. The natural dung beetle population had free access to the fecal pats in plot C.

Herbage samples, which included the matting, were taken from near the first 10 fecal pats deposited in each subplot for 10 weeks beginning 1 week after deposit. The sampling method consisted of alternating weekly collections from near fecal pats with the same deposit date in subplots of each plot. The sampled area extended 15 cm from the outer edge of the pats and equaled ⅛ of the total area surrounding each pat. Sample variability was

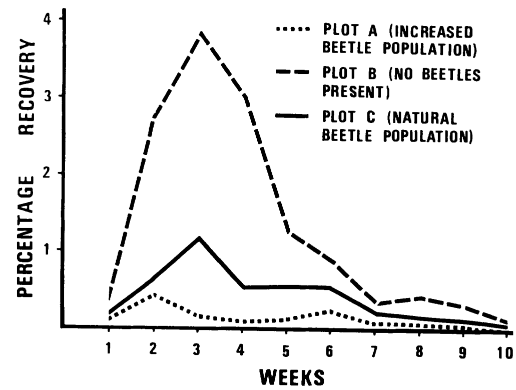

FIGURE 1. The effect of dung beetle activity on the percentage of recovery of *Ostertagia ostertagi* infective larvae on pasture.

minimized with the aid of a plywood disc, 50 cm in diameter, having a wedge-shaped cutout equivalent to ⅛ of the total area. The samples were taken near 9.00 AM and were baermannized overnight in plastic funnels 24 cm in diameter. The percentage recovery of *O. ostertagi* larvae in each plot was based on the average number of larvae from 10 herbage samples in each subplot × 8/the average number of eggs in the fecal pats × 10.

Six dairy bull calves were obtained when 3 to 4 days old, bottle-fed, and weaned at age 3 weeks. They were 54 to 64 days old when put singly on the subplots to graze on 16 September. Each of the calves was drenched 3 times with a broad-spectrum anthelmintic and fecal egg counts were negative for 26 consecutive days when the test began. The calves were allowed to graze for 3 weeks and were then placed in individual concrete-floored pens where daily fecal samples were taken and examined for worm eggs. The number of eggs per gram of feces (EPG) was determined by the salt flotation method. The calves were necropsied 25 to 28 days after removal from the plots and the abomasum contents were washed and screened through sieves to remove adult *O. ostertagi*. The abomasum was then artificially digested overnight for recovery of immature worms.

RESULTS

Approximately 80% of the feces placed in plot A, which contained the increased dung beetle population, were buried within 24 hr, 95% within 48 hr, and 100% within 72 hr. Infective *O. ostertagi* larvae were recovered from some of the herbage samples beginning 1 week after deposition (Fig. 1). Most of the larvae (72.3%) were recovered during the 2nd, 3rd, and 4th weeks. Percentage of recovery of larvae was lowest on plot A. Herbage samples from plot B, which did not contain

TABLE I. *Total number of* Ostertagia ostertagi *recovered from calves after exposure to contaminated pasture plots for 3 weeks.*

	Subplot	Calf number	Maximum EPG	Worm count
Plot A	1	1	218	570
	2	2	196	503
Plot B	1	3	577	1222
	2	4	481	1120
Plot C	1	5*	–	48
	2	6	378	901

* Died of undetermined causes after 2 weeks exposure to contaminated plot.

dung beetles, had 14.7 times more larvae than did those from plot A. Herbage samples from plot C, with the natural dung beetle population, had 3.7 times more infective larvae than did those of plot A.

Two recovery peaks occurred in plot A: the first peak during the 2nd week and the second peak during the 6th week (Fig. 1). The recovery of larvae in plot B sustained a lasting peak of recovery for weeks 2 to 4. None of the feces were buried in this plot and the results show an increase of larvae on herbage compared to the other two plots (Fig. 1). A recovery peak in plot C occurred during the 2nd week, followed by a reduced but stable percentage recovery through the 6th week. Approximately 40% of the feces in this plot were buried by the existing dung beetle population.

Calves 1 and 2 in plot A had high EPG's of 218 and 196, respectively, after grazing 3 weeks on the contaminated plot, whereas the highest EPG's of calves 3 and 4 in plot B were 577 and 481, respectively (Table I). The highest egg count of calf 6 in plot C was 378 EPG. Calf 5 in plot C died of unknown causes after 2 weeks exposure and during that time grazed very little. Post-mortem examination of the abomasum revealed 48 *O. ostertagi.* Calves in plot B had 2.2 times the average number of *O. ostertagi* recovered from the calves in plot A (Table I). The surviving calf in plot C had 1.7 times the average number of parasites recovered from the calves in plot A.

DISCUSSION

The screen enclosure of plots A and B reduced the air movement which resulted in temperatures of approximately 1 C higher than the temperatures of plot C during the afternoon and early evening hours. Dew was also present on the herbage of plots A and B longer than in plot C. Rainfall and temperatures were near normal during the length of the experiment.

The observations on larval recovery from the three plots cannot be compared directly since the physical conditions were different. However, plots A and B were generally alike and the differences in numbers of larvae recovered are attributable to the treatments of adding to or removing the normal dung beetle population. The function of dung beetles in burying feces and their effectiveness in reducing the number of free-living stages of an animal parasite nematode were demonstrated.

Beetles of the natural population did not bury the fecal pats at the same rate. One pat in plot C would be partially buried, whereas the replica pat would remain undisturbed. However, the weekly recovery rate in each plot was based on the average number of larvae from 10 herbage samples from replicas of each plot and the results show that plot A, with the increased dung beetle population, had the lowest recovery percentage. The reduction of parasite larvae available to grazing animals in plot A was reflected in a similar reduction in the number of *O. ostertagi* recovered from parasite-free calves which were allowed to graze in the plots.

The first recovery peak of plot A was probably caused by larvae developing from eggs remaining in the loose soil after the beetles had buried the feces. The second peak was probably caused by larvae developing from eggs buried a few cm below the soil surface. Preliminary studies indicate that cattle feces containing *O. ostertagi* eggs must be buried at least 15 cm below the soil surface to prevent migration of ensuing larvae through the soil to the surface. Under field conditions, the effects of climatic factors such as solar radiation and wind would probably eliminate the two peaks, except during a prolonged period of cool, wet weather.

Dung beetles are attracted to animal feces within minutes after deposition and individual pairs of some of our native species have been observed to bury up to 150 g of feces daily. Only a few pairs of such beetles are needed to bury entire cow pats within a few days. Rapid burial of livestock feces would also reduce populations of horn and face flies which breed only in fresh cattle feces. In Australia, the recently introduced Afro-Asian dung beetle, *Onthophagus gazella* Fabricius, buries bovine dung as food for its larvae so rapidly that, when beetle populations are of the order of four insects per 100 cm^3 of dung, entire cow pats are completely broken up and buried within 30 to 40 hr (Bornemissza, 1970). Dung disposal at that rate caused 80 to 100% reduction in numbers of the bushfly, *Musca vetustissima* Walker, emerging from the pats during insectary studies (Bornemissza, 1970).

Quick recycling of volatile nutrients in feces would increase pasture yields as a result of the incorporation of organic matter into the soil (Gillard, 1967; Bornemissza and Williams, 1970), with a concomitant increase in soil friability, aeration, and water-holding capacity. Rapid removal of feces would also reduce rank growth around deposits thereby increasing the effective grazing area (Bornemissza, 1960) and would minimize pasture surface pollution.

Forages are being continuously improved for greater yield per unit area and better nutrition for livestock. Even today, grazing at the stocking rate required to consume all of the forage that can be produced with heavily fertilized Coastal bermudagrass contaminates the grass with feces and results in poor animal performance (Burton, 1972). The native dung beetle population apparently has not increased in proportion to the increased production of livestock and feces. Widespread usage of insecticides, herbicides, fungicides, or anthelmintics and systemic insecticides in the feces on which the beetles feed may be responsible. New forages, chemical fertilizers, and intensive grazing along with other management innovations may also have had an effect on the dung beetle population.

Although food is available for the native dung beetles, it is not being fully utilized. Unless the dung beetle population can increase to a level that would assure rapid removal of livestock feces from pasture surfaces, other measures will have to be taken to solve the problem.

LITERATURE CITED

BORNEMISSZA, G. F. 1960. Could dung eating insects improve our pastures? J. Austral. Inst. Agr. Sci. **26:** 54–56.

———. 1970. Insectary studies on the control of dung breeding flies by the activity of the dung beetle, *Onthophagus gazella* F. (Coleoptera: Scarabaeinae). J. Austral. Entom. Soc. **9:** 31–41.

———, AND C. H. WILLIAMS. 1970. An effect of dung beetle activity on plant yield. Pedobiologia **10:** 1–7.

BURTON, G. W. 1972. Can the south become the world's greatest grassland? The Progressive Farmer, March **87:** 22–24.

FERREIRA, M. C. 1967. Os escarabideos de Mocambique. Revta. Entom. Mocamb. **10:** 778 p.

FINCHER, G. T., T. B. STEWART, AND R. DAVIS. 1970. Attraction of coprophagous beetles to feces of various animals. J. Parasit. **56:** 378–383.

GILLARD, P. 1967. Coprophagous beetles in pasture ecosystems. J. Austral. Inst. Agr. Sci. **33:** 30–34.

HALFFTER, G., AND E. G. MATTHEWS. 1966. The natural history of dung beetles of the subfamily Scarabaeinae (Coleoptera: Scarabaeidae). Folia Entomologica Mexicana, Nos. 12–14, 312 p.

REINECKE, R. K. 1970. Helminth diseases in domestic animals in relation to their environment. S. Afr. J. Sci. **66:** 192–198.