Comparison of Chemical Attractants against Dung Beetles and Application for Rangeland and Animal Health

Author(s): J. A. Goolsby, N. K. Singh, D. B. Thomas, A. Ortega-S. Jr., D. G. Hewitt, T. A. Campbell, and A. Perez de Leon
Source: Southwestern Entomologist, 42(2):339-346.
Published By: Society of Southwestern Entomologists
https://doi.org/10.3958/059.042.0203
URL: http://www.bioone.org/doi/full/10.3958/059.042.0203

Comparison of Chemical Attractants against Dung Beetles[1] and Application for Rangeland and Animal Health

J. A. Goolsby[2]*, N. K. Singh[2,3], D. B. Thomas[2], A. Ortega-S. Jr.[4], D. G. Hewitt[5], T. A. Campbell[4], and A. Perez de Leon[6]

Abstract. Dung beetles (Coleoptera: Scarabaeidae) play a major role in nutrient cycling, soil aeration, and biological control of pests and parasites that breed in manure. Habitat fragmentation, pesticide usage, and conventional agricultural practices threaten dung beetle diversity, and their conservation is of growing concern. This study from August to October 2016 on the East Foundation, Santa Rosa Ranch, Kenedy County, TX investigated the comparative effectiveness of three chemical attractants, viz., screwworm lure, volatile fatty acids, and citronella oil to attract dung beetles. The screwworm lure attracted large numbers of beetles, but the other two attractants were not attractive to dung beetles. Morphological identification of 16 adult specimens confirmed *Phanaeus vindex* MacLeay, family Scarabaeidae (eight); *Canthon pilularius* L., family Scarabaeidae (five); and *Nicrophorus carolinus* L., family Silphidae (three), indicating the dung beetles were very attracted. Screwworm lure might be used to efficiently attract large numbers of dung beetles for relocation to areas where the species have been impacted.

Introduction

Dung beetles (Coleoptera: Scarabaeidae) are a relatively small group with approximately 7,000 species worldwide, prevalent on every continent except Antarctica, and most diverse in Africa where more than 2,000 species occur (Hanski and Cambefort 1991). Dung beetles are a major component of biological control of dung (cattle feces) and livestock pests that use dung as a breeding ground (Fincher 1973). Dung beetles cause 95% fewer horn flies, *Haematobia irritans* (L.), 80-100% fewer bush flies, *Musca vetustissima* Walker, and nine times fewer cattle parasite loads (Bornemissza 1970), along with reduced numbers, resurgence, and migration of biting fly larvae in livestock feces (Fincher 1973). Besides benefiting cattle production, they also efficiently cycle nutrients into the soil and create healthier rangelands (Halffter and Matthews 1966, Kirk 1983, Walters 2008). With beef

---

[1]Coleoptera: Scarabaeidae

[2]United States Dept. of Agriculture, Agricultural Research Service (USDA-ARS), Cattle Fever Tick Research Laboratory, 22675 N. Moorefield Rd, Edinburg, Texas 78541 United States. John.Goolsby@ars.usda.gov
[3]Guru Angad Dev Veterinary and Animal Sciences University, Dept. of Veterinary Parasitology, Ludhiana, Punjab, 141004, India
[4]East Foundation, 200 Concord Plaza Drive, Suite 410, San Antonio, TX 78216, United States
[5]Texas A&M Kingsville, Caesar Kleberg Wildlife Research Institute, 700 University Blvd, Kingsville, TX 78363, United States
[6]USDA-ARS, Knipling-Bushland U.S. Livestock Insects Research Laboratory and Veterinary Pest Genomics Center, 2700 Fredericksburg Rd., Kerrville, TX 78028, United States

production being one of the most valuable industries in the region, dung beetles are of great economic value, estimated at $380 million annually in the United States (Losey and Vaughan 2006).

Individual cattle daily produce approximately 10-20 dung pats that may last as long as 4 years without dung beetle activity (Walters 2008). While dung may be broken down by weathering and by other organisms such as earthworms, ants, and termites, dung beetles significantly increase the rate of decomposition (Wratten and Forbes 1996). Cattle do not graze in close proximity to their own feces, and nondegraded dung can prevent growth of vegetation, resulting in an area that will remain ungrazed by cattle for as long as 2 years (Anderson et al. 1984).

Presently, as much as 56% of cattle in the United States are treated with antiparasitic agents aimed at controlling dipterans, internal parasites, and ticks (Losey and Vaughan 2006, Scholtz et al. 2009). In pastures, most antiparasitic agents are excreted to some extent in the feces of treated animals, creating concern for the effect on organisms that feed and/or breed in animal excrement. As the spectrum of activity of antiparasitic agents has enlarged, the potential for affecting non-target organisms also has increased (McKellar 1997). Dung beetles that breed in herbivore dung in which antiparasitic agents are used can be adversely affected. Recolonization of dung beetles in affected areas is often recommended, but in practice can be difficult and labor intensive (McCracken 1993). Successful recolonization depends on the availability of large numbers of dung beetles. In this regard, use of chemicals to attract beetles could be useful for efficient collection from pastures and reintroduction into impacted areas. Therefore, the current study was undertaken to evaluate three chemical attractants for collection of dung beetles in South Texas.

Materials and Methods

The study from August to October 2016 was at the East Foundation, Santa Rosa Ranch, a 7,545-ha ranch in Kenedy County, near Riviera, TX (26°55'N, -97°42'E). The ranch has an active cattle herd and is managed to support wildlife conservation and other public benefits of ranching derived from stewardship of private land.

The study used screwworm lure, volatile fatty acids, and citronella oil to investigate comparative effectiveness for attracting dung beetles. The research was part of a larger study evaluating the compounds to attract nilgai antelope, which are exotic hosts of the cattle fever tick, *Rhipicephalus microplus* (Cannestrini), in South Texas (Goolsby et al. in review).

Screwworm lure was developed to mimic rotting flesh to the screwworm fly, *Cochliomyia hominivorax* (Coquerel), a pest of livestock. The lure was selected for testing because of its strong odor and similarity to the smell of rotting offal. The lure was prepared according to the method of Mackley and Brown (1984) with slight modification. Butanol, iso-butanol, and acetic acid (each 187 ml) were mixed with butyric acid and pentanoic acid (62 ml each). Phenol (50 g), *p*-cresol (50 g), benzoic acid (12 g), and indole (12 g) were added and mixed properly. Dimethyl disulfide (187 ml) was added, and the lure was aliquotted in 50-ml graduated tubes from a translucent, plastic carboy and stored in an air-conditioned chemical storage shed until used in the field. All chemicals for the lure were purchased from Sigma-Aldrich, St. Louis, Missouri, USA.

Synthetic volatile fatty acid compound was selected because it mimics the smell of entrails, which are part of offal, and has a strong odor. The volatile fatty acids in the lure approximated the volatile fatty acids in the rumen of a bovine heifer and were prepared using methods described by Paul Reimer (USDA-ARS, Madison, WI). The lure mixture consisted of 100 mM acetic acid, 24 mM propionic acid, 14 mM butyric acid, 1.7 mM valeric acid, 0.2 mM caproic acid, 1.7 mM iso-butyric acid, 1.2 mM 2-methyl-butyric acid, and 1.2 mM iso-valeric acid. The lure was stored in an amber-glass bottle at room temperature until further use.

Natural citronella oil is an insect repellent and produces a pungent and long-lasting odor. It is derived from lemongrass, *Cymbopogon* spp., native to India, and was purchased from Sigma-Aldrich, USA. Although citronella is a known insect repellent instead of an attractant, it was included in the nilgai lure study, and thus the data were presented. A 20-liter lure bucket was recessed into a hole (0.5 m deep) 100 m wide at each of five sites (1 km apart). Each bucket received 100 ml of lure. At each screwworm lure site, a screw-cap vial fitted with a dental wick and 50 ml of lure was added (Fig. 1). The vial with dental wick was developed to extend the life of the lure because of its high rate of volatility in warm weather. Trapped beetles were collected after 1 week, and data were visually recorded by volume. The test was repeated twice starting on 8 August and 19 September 2016.

Fig. 1. Lure bucket with screwworm lure and wick at the East Foundation, Santa Rosa Ranch, near Riviera, TX.

Results and Discussion

Examination of buckets after 1 week revealed the screwworm lure attracted large numbers and a diversity of dung beetles (Fig. 2). On average, 10 liters of beetles (lure bucket halfway filled) were collected in each screwworm lure bucket. In some cases, the beetles filled the bucket and spilled out of the vent slits. It might be possible to collect even greater numbers with a deeper bucket. The other two attractants failed to attract any beetles. Representative samples of adult beetles were removed from the screwworm lure bucket and identified by DT. In total, 16 adult specimens were identified as rainbow scarab, *Phanaeus vindex* MacLeay, family Scarabaeidae (eight); common tumblebug, *Canthon pilularius* L., family Scarabaeidae (five); and *Nicrophorus carolinus* L., family Silphidae (three), indicating these dung beetles were very attracted.

Fig. 2. Bucket full of dung beetles 1 week after deployment of screwworm lure.

Rainbow scarabs, *P. vindex*, are members of the subfamily Scarabaeinae, most of which are dung beetles (Bertone et al. 2004). The rainbow scarab has a bright exterior of metallic green, blue, and red interspersed with golden reflections. The rainbow scarab is native to and found extensively in, the eastern United States, from Massachusetts to South Dakota in the north and Arizona to Florida in the south (Woodruff 1973). The common tumblebug, *C. pilularius* is generally dull black and widespread in the eastern half of the United States including Texas (Matthews 1963). The species feeds on cow dung in pastures, and is rarely attracted by decaying carcasses.

The carrion beetles (Coleoptera: Silphidae) are among the most conspicuous insects that scavenge on vertebrate carcasses. They are ecologically beneficial as decomposers and are important for maintaining ecosystem health and productivity; both larvae and adults feed on carrion, but a few species might be phytophagous or feed on fungi or fly larvae (Mullins et al. 2013). Mullins et al. in a survey of carrion beetles of Texas reported the prevalence of *N. carolinus*. *Nicrophorus* species bury small vertebrate carcasses they use as food for their young and typically, both male and female beetles provision developing larvae after burial of a carcass. However, it was interesting to record their attraction to screwworm lure developed to mimic the smell of decomposing liver (Mackley and Brown 1984).

Based on nest construction behavior, there are three types of dung beetles: tunnelers (paracoprids), dwellers (endocoprids), and rollers (telecoprids). *P. vindex* is an example of a tunneler (Ratcliffe et al. 2002), whereas, *C. pilularius* is a roller beetle (Matthews 1963). In tunneling species, both sexes create a tube by excavating soil underneath the dung pat, culminating in a chamber below the surface, and produce a brood ball beneath the dung pat (Ratcliffe et al. 2002). The brood ball consists of moist dung coated with soil to serve as food for the larva and young adult (Bertone et al. 2004). The ball of dung is pulled into the tunnel a few centimeters below ground and formed into brood or feeding balls (Kirk and Feehan 1984). Because tunnelers bring dung underground, they are the most sought-after dung beetles for dung degradation (Kaufman and Wood 2012). Roller beetles make and roll dung balls to transport dung away from the dropping and bury it to be eaten underground where it is protected from desiccation. The dung ball serves as food either for the beetle rolling it or for the future larva. Two types of dung balls made are a food ball and a brood ball. The former are made, rolled, and buried as food by a single beetle of either sex; the latter are made, rolled, and buried by a male, accompanied by a female, to serve as food tor a single larva (Matthews 1963).

Dung beetles play a vital role in the processes of dung dispersal and are crucial for maintaining pasture hygiene, nutrient cycling, soil aeration, humus content, water percolation, and pasture productivity (Lumaret and Kirk 1987, Lumaret and Errouissi 2002). In addition, they also ensure the livestock grazing area is not drastically reduced by accumulation of dung (Herd 1995) and also decrease wastage of herbage through rejection of fouled herbage and smothering of pasture leaf area (Lumaret et al. 1993). In the cow dung community, dung feeder flies, coprophagous beetles, and annelid worms are the most important organisms. Under warm and dry weather conditions, dung beetles seem to be the most important organisms to degrade dung pats, while earthworms are dominant in activity and biomass under temperate and more mesic conditions (Putman 1983). Beetles rapidly colonize and oviposit in dung pats the first few days after they are dropped, facilitating initial breakdown of dung and allowing subsequent entry of earthworms that continue to degrade the dung (Wall and Strong 1987). When beetles utilize dung pats, they dig small tunnels that weaken the pats and, at the same time, beetles that carry spores of telluric fungi and microorganisms on the integument inoculate the heart of pats with microorganisms (Lumaret and Errouissi 2002). Dung beetles efficiently cycle nutrients into the soil and create healthier rangeland and reduce greenhouse gas emissions (Halffter and Matthews 1966, Walters 2008). If dung is not removed by the beetles, about 80% of the ammonia released from dung pats is lost during the first 5 days, but when sufficient numbers of beetles are present for quick burial, the loss is reduced to 5-15% and permits the use of this nitrogen by plants for as long as 2 years (Gillard 1967). Tunnels made by beetles improve the oxygen supply to coprophagous flies but also provide runways so predatory staphylinids can access the flies (Valiela 1969). Furthermore, harmful fly species such as the horn fly might be outcompeted by populations of dung beetle larvae (Bertone et al. 2004).

Screwworm lure could be used as an efficient way to attract large numbers of dung beetles for relocation to areas where the species are depleted. Plastic buckets similar to those in the study could be used to collect dung beetles and other associated insects. More than 10 liters of insects were routinely collected in the traps each week. Buckets might need to be serviced daily to prevent death of dung beetles. This new tool for redistribution of dung beetles in their environment could significantly benefit rangeland and livestock health.

Acknowledgment

The authors thank University Grants Commission, New Delhi, India for granting funds to Nirbhay K. Singh through Raman Fellowship for Post-Doctoral Research in the USA for 2016-2017. We acknowledge the contributions of Drs. Steve Skoda and Muhammad Chaudhry (USDA-ARS Knipling Bushland U.S. Livestock Insects Research Laboratory, Screwworm Research Unit, Kerrville, TX) for advice on formulating the screwworm lure; and Dr. Alan Kirk (USDA-ARS, Montpellier, France) for information on dung beetles. The authors wish to thank Reyes Garcia, III (USDA-ARS, Cattle Fever Tick Research Laboratory, Edinburg, TX); Matthew Rector, Eric Bautista, (Texas A&M Agrilife Research, Weslaco, TX), for field assistance and maintenance of the cameras. We wish to thank two anonymous reviewers for helpful edits of the manuscript. This article reports the results of research only. Mention of a commercial or proprietary product in this article does not constitute an endorsement by the U.S. Department of Agriculture. The USDA is an equal opportunity provider and employer. This is manuscript number 015 of the East Foundation.

References Cited

Anderson, J. R., R. W. Merritt, and A. C. Loomis. 1984. The insect-free cattle droppings and its relationship to increased dung fouling of rangeland pastures. J. Econ. Entomol. 77: 133-141.

Bertone, M. A., W. Watson, M. Stringham, J. Green, S. Washburn, M. Poore, and M. Hucks. 2004. Dung beetles of central and eastern North Carolina cattle pastures. North Carolina Cooperative Extension, North Carolina State University, Raleigh, NC.

Bornemissza, G. F. 1970. Insectary studies on the control of dung breeding flies by the activity of the dung beetle, *Onthophagus gazelle* F. (Coleoptera: Scarabaeidae). Austral. J. Entomol. 9: 31-41.

Fincher, G. T. 1973. Dung beetles as biological control agents for gastrointestinal parasites of livestock. J. Parasitol. 59: 396-399.

Gillard, P. 1967. Coprophagous beetles in pasture ecosystems. J. Austral. Inst. Agri. Sci. 33: 30-34.

Halffter, G., and E. G. Matthews. 1966. The natural history of dung beetles of the subfamily Scarabaeinae (Coleoptera, Scarabaeidae). Fol. Entomol. Mex. 12-14: 1-312.

Hanski, I., and Y. Cambefort. 1991. Dung Beetle Ecology. Princeton University Press, Princeton, NJ.

Herd, R. 1995. Endectocidal drugs: ecological risks and counter-measures, Int. J. Parasitol. 25: 875-885.

Kaufman, P. E., and L. A. Wood. 2012. Indigenous and exotic dung beetles (Coleoptera: Scarabaeidae and Geotrupidae) collected in Florida cattle pastures. Ann. Entomol. Soc. Am. 105: 225-231.

Kirk, A. A. 1983. The biology of *Bubas bison* (L.) (Coleoptera:Scarabaeidae) in southern France and its potential for recycling dung in Australia. Bull. Entomol. Res. 73: 129-136.

Kirk, A. A., and J. E. Feehan. 1984. Method for increased production of eggs of *Copris hispanus* L. and *Copris lunaris* L. (Coleoptera: Scarabaeidae). J. Aust. Entomol. Soc. 29: 293-294.

Losey, J. E., and M. Vaughan. 2006. The economic value of ecological services provided by insects. BioScience 56: 311-323.

Lumaret, J. P., and F. Errouissi. 2002. Use of anthelmintics in herbivores and evaluation of risks for the non target fauna of pastures. Vet. Res. 33: 547-562.

Lumaret, J. P., and A. A. Kirk. 1987. Ecology of dung beetles in the French Mediterranean region (Coleoptera:Scarabaeidae). Acta. Zool. Mex. (ns) 24: 1-55.

Lumaret, J. P., E. Galante, C. Lumbreras, C. Mena, M. Bertrand, J. L. Bernal, J. F. Cooper, N. Kadiri, and D. Crowe. 1993. Field effects of antiparasitic drug ivermectin residues on dung beetles. J. Appl. Ecol. 30: 428-436.

Mackley, J. W., and H. E. Brown. 1984. Swormlure-4: a new formulation of the swormlure-2 mixture as an attractant for adult screwworms, *Cochliomyia hominivorax* (Diptera: Cal- liphoridae). J. Econ. Entomol. 77: 1264-1268.

Matthews, E. G. 1963. Observations on the ball rolling behaviour of *Canthon pilularius* (L.) (Coleoptera, Scarabaeidae). Psyche 70: 75-93.

McCracken, D. I. 1993. The potential for avermectins to affect wildlife, Vet. Parasitol. 48: 273-280.

McKellar, Q. A. 1997. Ecotoxicology and residues of anthelmintic compounds, Vet. Parasitol. 72: 413-435.

Mullins, P. L., E. G. Riley, and J. D. Oswald. 2013. Identification, distribution, and adult phenology of the carrion beetles (Coleoptera: Silphidae) of Texas. Zootaxa 3666: 221-251.

Putman, R. J. 1983. Carrion and dung: the decomposition of animal wastes. Inst. Biol. Stud. Biol. 156: 62.

Ratcliffe, B. C., M. L. Jameson, and A. B. T. Smith. 2002. Family 34. Scarabaeidae Latreille 1802. In R. J. Arnett Jr., M. C. Thomas, P. E. Skelley, and J. H. Frank [eds.], American Beetles, Vol. 2: Polyphaga: Scarabaeoidea through Curculionoidea. CRC Press, Boca Raton, FL.

Scholtz, C. H., A. L. V. Davis, and U. Kryger. 2009. Evolutionary Biology and Conservation of Dung Beetles. Pensoft Publishers, Sofia, Bulgaria.

Valiela, I. 1969. An experimental study of mortality factors of larval *Musca autumnalis* DeGeer. Ecol. Monogr. 39: 199-225.

Wall, R., and L. Strong. 1987. Environmental consequences of treating cattle with antiparasitic drug ivermectin. Nature 327: 418-421.

Walters, C. 2008. Dung Beetles: The greatest invention and a cowman's profits. Acres U.S.A. Austin, TX.

Woodruff, R. E. 1973. Arthropods of Florida and neighboring land areas. The Scarab Beetles of Florida, Vol. 8. Florida Department of Agriculture and Consumer Services, Contribution No. 260, Bureau of Entomology, Gainesville.

Wratten, S. D., and A. B. Forbes. 1996. Environmental assessment of veterinary avermectins in temperate pastoral ecosystems. Ann. Appl. Biol. 128: 329-348.