Some Ecological Aspects Of Animal Excrement

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ANIMAL EXCREMENT is, to many persons who are not science oriented, a rather unmentionable, even repulsive product cast to earth as a completely useless substance. Persons with a knowledge of gardening or agriculture may realize the important place animal waste has in the overall biological cycle, but the general public and even students of science may not be aware of some of the very unique and fascinating aspects of the relationships of animal solid waste to both the animal and the plant kingdoms. The ecology of excrement should not be neglected when other ecological relationships are studied. There are many complex factors which contribute to the environmental quality in a given habitat, and one very important factor is the nature of and the relationships involving the animal wastes entering this environment (see Dahlberg 1973).

Some scientists make very careful analyses of animal waste to determine their biochemical and physiological significance. There is even a science of the study of animal feces—scatology, the name being derived from the Greek words "skatos" meaning feces or dung and "logos" meaning science or knowledge. The root word for feces is found in a number of biological terms and scientific names. Another such word is the Greek word "kopros" meaning dung; thus coprophilous means dung loving. In like manner a coprophyte (phyton, plant) is a dung-inhabiting plant and a coprozoite (zoon, animal) is a dung-inhabiting animal.

Coprophagy and Mutualism

Some authorities consider certain relations such as coprophagy to be cases of mutualism, a division of symbiosis that includes a number of types of various associations or partnerships. Odum (1971) states that the reingestion of feces by some coprophagous animals can be viewed as mutalism because feces contains microorganisms that can aid in the utilization of food energy. This relates to examples of internal microorganisms that aid in the breakdown of food for animal nourishment.

A similar situation is created by fungus-growing ants who fertilize the leaves they cut and carry to their nests with their own excreta. Weber (1966) mentions that some ants may add broken caterpillar excrement to the original leaf sections. The feces of the ants contain certain enzymes which the fungus lacks. The ants eat the fungus to complete this food energy cycle. Using the feces accomplishes for the ants much the same thing as the intestinal symbionts of wood-eating termites (Odum 1971). Unlike the common wood-eating termite, fungus-growing termites have no intestinal symbionts and thus use their fecal material as do ants to grow fungi for food.

Still another example is the betsy beetle, *Popilius.* This beetle lives in decaying logs and feeds upon a combination of fecal pellets and chewed wood which has become enriched by fungi (Odum 1971). Certain mammals such as rats habitually practice coprophagy by reingesting their own feces.

When moulting, young nymphs of wood cockroaches (Cryptocerus) lose their symbiotic protozoa. To reestablish their intestinal fauna they must eat some fresh excrement from the other members of the colony (Knight 1965: 139).

Dung as a Microhabitat

Many organisms live by feeding exclusively on the solid wastes of other animals. Anyone familiar with cattle must have noticed that a manure pile is actually a small living environment of organisms that are totally dependent upon this organic material. Ecologists have studied these microhabitats and found that there is even a pattern of succession. Each stage is associated with a characteristic community of animals (Brady 1965; Mohr 1943). Some organisms are present in the freshly deposited moist dung. Other appear later, and still others, certain beetles for example, appear when the pile is almost dry. Microscopic organisms such as bacteria (coprophytes) and protozoa (coprozoites) are very numerous, especially in moist piles. Bacteria help to decompose organic substances, thus returning the elements to the earth. Gradually, after the action of not only biotic agents but also such climatic factors as heat, sunlight, wind, and rain, the temporary microenvironment disappears. We see then that the cattle dung has provided not only food but a habitat for these small organisms. All organisms do not simply "die" with the pile; some are transported actively or passively to new piles. There is a similar fungal succession involving the dung fungi to be discussed later in this paper.

Fig. 1. Paine College students, Alana Faye Hill (*left*) and Loise Pinkston examine parasites that are transmitted via animal feces. (Photo courtesy of the Paine College Public Relations Office.)

Many organisms which do not actually live as adults in the dung use it for reproductive purposes. Certain flies lay their eggs exclusively in dung just as others lay eggs in carrion. The larvae then live and feed in the feces. Dung beetles carefully roll portions of manure of large mammals into balls, bury them below the soil, and then deposit an egg in each dung ball. After hatching, the young have a ready source of food. One large dung beetle of Africa (Family Celonidae, genus *Goliathus*), known as the Goliath beetle, may roll dung balls as large as small apples (Essig 1942: 586).

As is often true of food or habitat selection by organisms, there may be host specificity in some of the dung beetles. One author lists *Dialytes* spp. of the family Scarabaeidae as feeding by preference on deer droppings (Arnett 1968: 397). Others, not so particular, will even substitute rotting organic materials for the dung roll.

Symbiosis among Dung Organisms

Some of the dung-inhabiting beetles have specific biotic relations with other dung-associated organisms. For example, one of the dorbeetles is reported to have small mites on its body. These clean the dung from the bodies of the beetles. This is a relationship that could be called cleaning symbiosis. In addition, the mites are also transported from place to place (hitch hike) on the body of the dung beetle. This type of relationship is called phoresy. Certain flies (borborid fly, *Limosina sacra)* are also transported from one manure pile to another on the body of dung beetles (Frost 1959: 255). This traveling not only insures distribution of the species but also enables the individual to leave a pile before it gets too dry and reach another pile more suited to its environmental needs.

There are a number of additional cases of scatophagy or coprophagy. These relationships sometimes are referred to simply as scavenging. Some noncoprozoites seem to feed only on the feces of certain species of animals. The case of dung beetles and deer droppings has already been discussed. Another rather unique example is young sticktight fleas (*Echidnophaga gallinacea),* who eat the feces of their parents (George 1971: 49). Scavengers are frequently associated with specific organisms, living in their nests or burrows. Commensal insects live in the burrows of moles and feed on the parasites or excreta of their hosts and there are numerous insects found in the nests of hornbills, which participate in nest sanitation by feeding upon the feces of the host birds.

Hinwood (1951) reports of several moths associated with birds' nests as scavengers. Chisholm (1952: 526) writes of a moth that is associated with the golden-shouldered parrot, a bird which builds its nest in termite mounds. The name of this moth *Neossiosynoeca scatophaga,* means new social scavenger (or as seen earlier, "feces feeder") and refers to the nest cleaning which the caterpillar of the moth effects by feeding on the feces of the parrot. This example further illustrates that in the biotic world partnerships do not necessarily involve two members; there is often a "web" of entanglement of a number of organisms interdependent upon one another for food, shelter, reproduction, companionship, protection, or other purposes.

Van Beneden (1876: 79) states, "Fishermen affirm that the *Cyclopterus lumpus* feeds on nothing but the excreta of others fishes." When hard-pressed for food in the winter of the North Country, the ravens, *Corvous corax,* follow the dog teams and feed upon the freshly dropped dung (Bent 1946: 190). The sheathbill bird is associated with the dung of colonies of gentoo penquins. They follow along with the colonies of penguins to eat the numerous parasitic worms that have passed in the droppings of the birds (Friedmann 1967: 297). House sparrows, *Passer domesticus,* associate with large herbivorous mammals such as horses to feed upon the seeds in the droppings of their hosts (Friedmann 1967: 293, 294). Bent (1946: 150) reports on the magpie's habit of frequently keeping company with horses, elk, and buffalo for the manure upon which they feed.

A Variety of Uses

Food is not the only motive that brings organisms into some association with dung. An African bird, the thickknee or water dikkop *(Burhinidae vermicularis),* frequently lays its eggs in a heap of dried dung of a large mammal such as an elephant, hippopotamus, or buffalo (Thompson 1964: 816).

Another bird, the Florida burrowing owl (*Speotyto cunicularia floridana)*, uses dried cow dung and horse manure to line its underground burrow. The Argentine or Rufous oven bird (*Furnarius rufus*) builds its nest by mixing the dung of cattle or other large mammals with sand to make surprisingly excellent building material. In Headstrom's (1970) field guide to nests, there is mention of pieces of dried cow and horse manure being used as building material in the nests of numerous birds. The nest or burrow of packrats also contains cattle dung. The hornbill uses its own excrement as part of the material for sealing up the cavity which is its nest and in reinforcing the plastering. And the common termite plasters its tunnel with a grayish mortar-like substance made of excrement (Headstrom 1970).

Perhaps the most intiguing animal behavior involving dung is that of the black rhinoceros. Goddard (1973) notes that after defecating, the black rhinoceros kicks the dung pile with its hind legs, thus scattering the droppings. Goddard surmises that this behavior serves to establish a home range for the animals through scent recognition of the dung along their trails and that which clings to the feet. The adults have a definite home range and usually remain in this area throughout life.

Many intestinal parasites (bacteria, protozoa, and worms) are spread by the agency of the hosts' feces. There have been some marvelous evolutionary adaptations to insure that the species continues and the method via feces is a most effective one. Helminth parasites lay millions of eggs in the digestive tract and these are passed in the feces. Under proper conditions for the parasite, these eventually find their way into the digestive tract of a new host in contaminated food and water.

A totally different relation to dung is the remarkable aspect of dung mimicry by animals. This may be more properly referred to as protective resemblance. A number of organisms actually "mimic" dung to appear distasteful to predators. Several adult moths "copy" bird droppings to camouflage themselves, and the organge-dog butterfly caterpillar also imitates bird droppings (Wheeler 1901). One tiny tropical frog closely resembles the droppings of a bird, and certain leaf beetles resemble the droppings of caterpillars; this for them is more convincing because of their size than would be bird droppings. The oleander hawk moth *Daphnis nerii* is camouflaged by spots on its body that resemble its own droppings (squarish, drum-shaped pellets). Mimicry, camouflage, or protective resemblance is an entire study within itself but this is one small segment that adds to the puzzling examples that have, through years of little-understood evolution, resulted in animals' ability to cope with an everchanging environment.

Plant-Dung Relationships

Plants too have important relationships to dung. A familiar function of animal waste is to recycle elements useful to plant life, especially nitrogen, which is abundant in the excrement of birds. The earth is covered with examples of such dependencies, but there are several close relations that serve exceptionally well to illustrate the point.

On the South Atlantic island of Tristan da Cunha, the tall tussock grass depends on the droppings of the rock-hopper penguins *(Eudyptes crestatus)* for fertilizer to produce its vigorous growth. The heavy growth of the grass in turn provides shelter for the penguins (Welty 1962: 379). A dung-plant relationship of a most unusual type is found in dung fungi. Jensen and Salisbury (1972: 381) note that dung would seem to be "an almost ideal substrate" for many fungi, yet there are only a few that are adapted to grow on it.

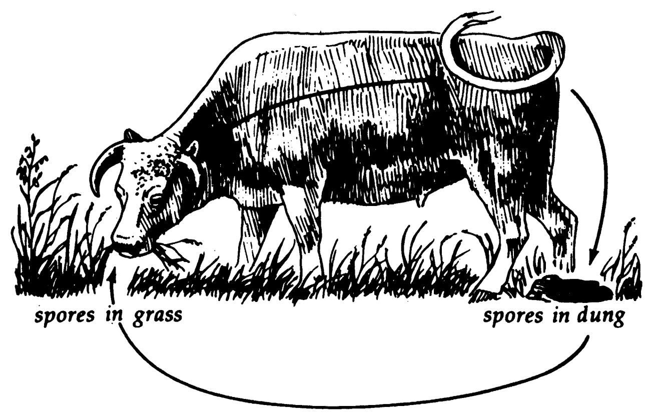

Fig. 2. The pathway of spores of dung fungi. (From *Botany; An Ecological Approach,* by Willaim A. Jensen and Frank B. Salisbury. ©1972, by Wadsworth Publishing Co., Belmont, Calif. Reprinted with permission of the publisher.)

An herbivorous animal, usually a cow or a horse, eats leaves with dung fungal spores attached. These are able to pass through the digestive tract unharmed. The most unusual of the dung fungi is *Pilobolus* (see Coble and Bland 1974). It is provided with a sticky substance which enables it to adhere to leaves of plants where it falls. A cow or horse eats the vegetation, and the cycle begins anew.

Pilobolus appears in freshly deposited dung. Its presence, plus the changes that occur in the substrate, result in creating a habitat more suitable for another kind of dung-inhabitating fungus such as *Sordaria. Sordaria,* in turn, leaves a fairly dried out heap that is suitable for a third group of fungus which includes the genus *Sphaerobolus.* This relationship serves as yet another illustration of ecological succession in a microhabitat. The sporangia of the fungus *Basidiobolus rararum* are eaten by beetles, which are in turn eaten by frogs or lizards (Alexopoulos and Bold 1967: 99). This fungus then lives and grows in lizard or frog excreta.

Dung—A Medium of Dispersal

The stinkhorn fungus, *Phallus impundicies* attracts carrion flies by the carrion-like odor of its slimy cap. The spores are dispersed by the feces of the flies who have fed upon the fungus spores. Truffles (*Tuber aes-*

tirum) is another fungus that depends on feces for dispersal. These plants emit a strong odor that attracts rodents. The rodents dig up the ascocarps—fruiting bodies—and eat them. The spores pass through the animals' digestive tracts unharmed and are deposited with the feces (Jensen and Salisbury 1972: 356).

The feces of animals serves in many cases in the dispersal of higher plants. For instance, certain mistletoes are quite dependent on birds for their spread and germination. A nearly obligate interdependence exists between the American Euphonia, called the mistletoe bird, and certain mistletoe. Its diet is believed to be exclusively mistletoe fruits. Kuijt (1969: 45) states that the Germanic name for mistletoe may have come from the association of seeds with bird excrement. The German word for manure is "der mist" and for mistletoe "die mistel."

The seeds of many other plants are reported to be dependent on birds or other animals for germination. The tough-coated seed of a certain African plant must be scarred by the teeth and pass through the gut of the wild boar before it can germinate. The seeds of the sausage tree *Kigelia* and those of the boabab *Adansonia digitata* will not successfully germinate unless passed through the digestive tract of large animals such as baboons. The passion flower *Passiflora* has the same problem. Owners of haciendas in Ecuador desiring these plants solve the problem of special treatment of seeds by having the laborers eat the ripe fruit and then defecate in certain spots in the fields (Wickler 1968: 154).

Excrement—A Link in the Chain of Life

Man himself has made many uses of dung. Probably most importantly, he takes advantage of the fertililizing aspects of dung, purposely applying it to the plants he cultivates. For that reason there is an economic value in such animal wastes. Dried dung has another use to man: fuel. Buffalo "chips" were a very important source of fuel in the days of the Old West. Through the years there have probably been various other uses made of animal wastes. Some perhaps were associated more with superstition than with actual benefit. Havemann (1967: 24) reports that Egyptians used barrier-like contraceptives similar to the modern diaphragm. Various types were employed, but a 4,000-year-old papyrus advises the use of "a plug made from the droppings of crocodiles."

Hopefully , the numerous examples that have been given prove that animal waste does not establish a single link but many links in the intricate chain of life. Its complex relationships to the environment might be best expressed by John Muir's statement, "When we try to pick out anything by itself, we find it hitched to everything else in the universe" (Brainerd 1971: 330).

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The worst miser is the learned man that will not write.

Austin O'Malley