Arthropods Associated with Bovine and Equine Dung in an Ungrazed Chihuahuan Desert Ecosystem[1]

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ABSTRACT Arthropods associated with bovine and equine dung were studied in the Chihuahuan desert from June to July 1981 in a *Yucca-Prosopis* habitat. Community structure, trophic relationships, and arthropod succession were examined by using traps baited with standardized samples of dung. Trap collections revealed at least 30 species of arthropods, but no difference between bovine and equine dung treatments was found. Ants (five species) were numerically and taxonomically dominant; they comprised 74% of all individuals captured. Muscoid flies, histerids, spiders, scarabs, tenebrionids, moths, crickets, and staphylinids (in order of decreasing frequency) were collected in smaller numbers. Community structure of dung arthropod populations was similar in regard to species richness, diversity, and evenness. Taxa were separated based on their probable trophic position in the community: coprovores (17 species), omnivores (5 species), and predators (8 species). Trophic structure showed a pyramidal progression of arthropod dry-weight standing crop: dung (305 g), coprophages (143 mg), omnivores (80 mg), and predators (40 mg). Ants and scarab beetles were the most important dung reducers, whereas histerid beetles were important predators in the community. Arthropod succession showed a general decrease in numbers and biomass with increasing age of the droppings. These results are compared with patterns of dung utilization by coprovores in other ecosystems.

Use of dung by arthropod consumers has been investigated extensively in temperate, pastoral ecosystems (e.g., Wilson 1932, Hafez 1939, Mohr 1943, Snowball 1944, Lawrence 1956, Valiela 1969, 1974, Legner et al. 1975); however, community ecology of desert coprophages is poorly understood. Several authors have examined components in deserts of dung arthropod assemblages including scarab beetles (Gordon and Howden 1973, Gordon and Cartwright 1974, Matthews 1976), dipterans (Legner and Olton 1971), and subterranean termites and microarthropods (Ferrar and Watson 1970, Johnson and Whitford 1975, Spears and Ueckert 1976, Ettershank et al. 1980), but there have been few analyses of dung arthropod faunas in natural desert habitats. During 2 months in summer 1981, I investigated arthropod communities that utilized horse and cattle dung at a locality in the Chihuahuan desert near El Paso, Tex.

Major objectives of this study were to: (1) determine if arthropods frequenting bovine and equine droppings were similar in community composition, (2) define feeding roles and quantify trophic relationships of the dung arthropod community, (3) relate age of droppings to succession and dynamics of dung arthropod populations, and (4) compare results of this desert analysis with those conducted in other regions.

Materials and Methods

Study Area

Dung arthropods were studied in an ungrazed, relatively unperturbed area 5 km E of the Hueco Mountains (9 km E by road) in El Paso County, Tex. (106°04'N, 31°44'W). The site is in the Chihuahuan desert and averages 1,300 m in altitude. The substrate comprises sandy and gravelly soils. Vegetation was composed primarily of *Yucca elata* Engelm., *Prosopis juliflora* Torr., and *Salsola kali* L., with *Chilopsis linearis* (Cav.) Sweet occurring in shallow arroyos. Average annual precipitation is 211 mm, and extreme temperatures range from −8.9°C in February to 42.7°C in June (National Oceanic and Atmospheric Administration 1980).

Field Methods and Traps

Fresh cow and horse manure was obtained from a cattle feedlot and a small horse corral in midmorning (0800 to 0900 h) or early evening (1700 to 1800 h). Dung collected from two to three animals of each species was placed in separate buckets and mixed to uniform consistency. Standardized dung samples were prepared by placing measured portions of fresh manure (mean = 305 ± 55 g) into cardboard hoops (3 cm high by 15 cm in diameter) supported underneath by round pieces of dacron marquisette cloth (Valiela 1969). The cloth circles prevented loss of dung through the hoops.

Baited and unbaited collection traps were used to sample arthropod populations. Each trap consisted of an upper cone trap (Didonis and Miller 1980) to collect aerial arthropods, and a modified pitfall trap to capture nonvolant taxa (Fig. 1). Traps were charged with a water-ethylene glycol-detergent mixture (Morrill 1974) to preserve specimens. In each baited pitfall trap, dung hoops were suspended on a nylon cord "X" secured to the inside edge of a 20-cm plastic funnel positioned at ground level. Upon entering the trap, ground arthropods fell between the dung enclosed hoop and the funnel wall—a space 5 cm wide. The unbaited control traps were like the baited traps, but contained no dung.

Eighteen hoops and two unbaited control traps were arranged in a grid (4 by 5). Nine samples of each dung treatment (bovine, equine) were spaced alternately 15 m apart to form a 2,700-m² "checkerboard" grid. Six samples, three from each of the two dung treatments, were

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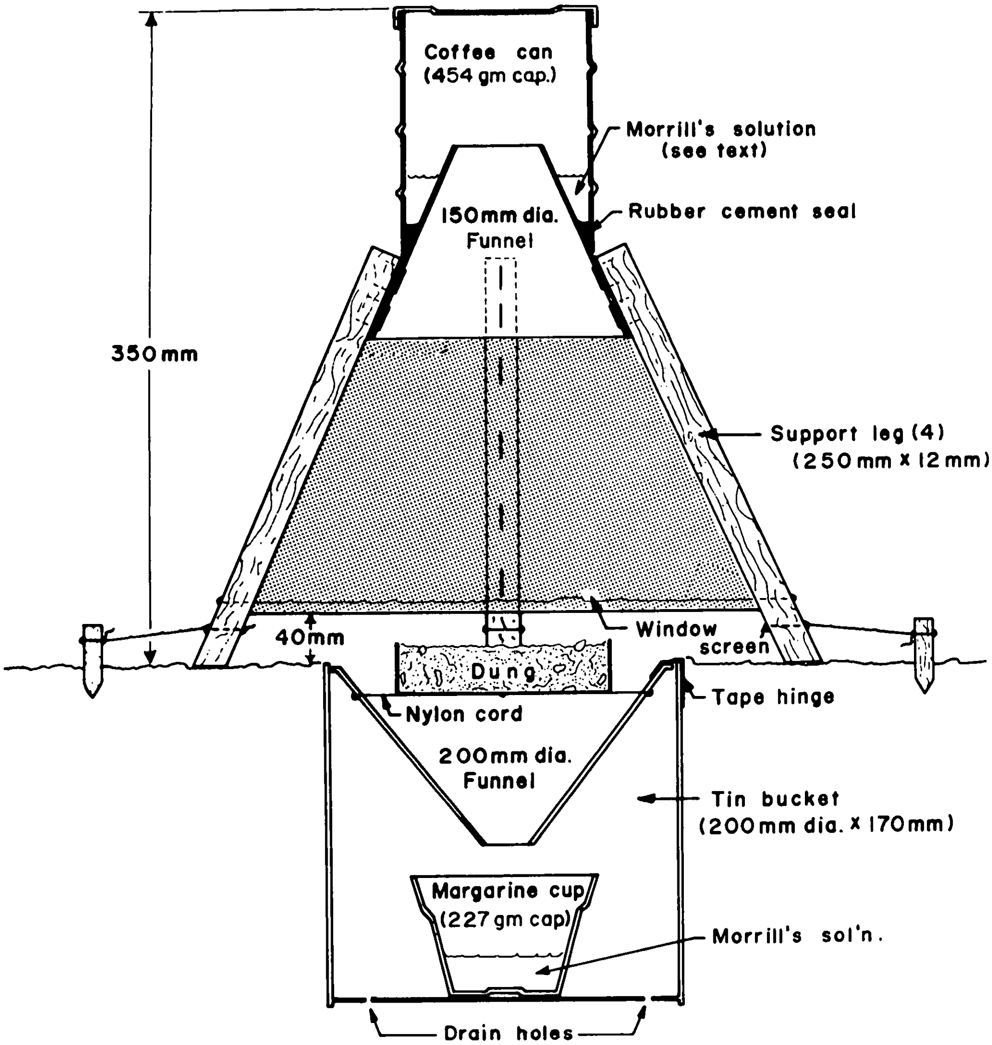

FIG. 1. Half-section of the bait trap designed to capture aerial and ground arthropods attracted to dung.

selected randomly in the grid and enclosed by traps. Accordingly, six traps, representing two dung treatments of three replicates each, collected arthropods during any one collection interval. Weight loss and community-wide trophic relations were recorded from the 12 unenclosed dung samples. Weight was recorded daily by lifting a dung sample with a Pescola spring scale attached to a string bridle stapled to the cardboard hoop.

Dung arthropods were sampled in the summer of 1981 during each of four intervals: 14 to 16 June (a preliminary trial), 30 June to 2 July, 15 to 17 July, and 26 to 28 July. Traps were emptied daily at 0800 to 0930 h for up to 3 days. After 3 days, only ants, crickets, spiders, and tenebrionid beetles were collected from baited traps. Specimens were brought to the laboratory and weighed, and representatives were sent to appropriate authorities for identification. Voucher specimens were deposited in the Resource Collections at Angelo State University.

Numerical Analysis

Composition of dung arthropod assemblages was characterized by using several community parameters: (1) species richness (S); (2) number of individuals (n); (3) Shannon-Weaver dominance diversity index ($H' = -\sum_{i=1}^{s} p_i \ln p_i$ [Shannon 1948]), which considers both species richness and relative dominance in a sample; and (4) species evenness index ($J' = H'/H_{max}$, where $H_{max} = \ln S$ [Pielou 1966]). Measures of association were used to evaluate possible differences in community composition between arthropods associated with equine and bovine dung samples. A modified t test (Hutcheson 1970) was used to test significance of association in species diversity estimates between dung arthropod treatments. A modified Sorenson coefficient ($C_n = 2_jN/aN + bN$, where aN and bN are total individuals in communities a and b, respectively, and $_jN$ is the sum of individuals for species common to both communities [Southwood 1978]) was used to determine the degree of similarity between dung communities. Data from the 13 June preliminary trial were not included in the analysis.

Results and Discussion

Species Composition and Community Structure

At least 30 arthropod species representing 16 families and 8 orders (Table 1), were collected. Three orders accounted for 20 species: Coleoptera (9 species), Hymenoptera (7 species), and Diptera (4 species). Within these three orders, the Formicidae was the dominant family with five species, followed by Scarabaeidae and Tenebrionidae with at least three species each. The same three orders accounted for 93% of the individuals collected: Hymenoptera (811), Coleoptera (68), and Diptera (25). All other orders were represented by 20 or fewer individuals.

Community structure of arthropods in the two types of dung was similar with regard to species richness (24 vs. 22 species for bovine and equine dung, respectively), species diversity (t = 0.533, P = 0.590), and evenness (0.408 and 0.400), and differed only in total individuals (Table 2). The community coefficient value (C_n = 0.790) showed the two communites were very similar. Species diversities differed significantly between dung-baited (B or E) and unbaited (C) traps (t = 3.130 and 3.540, P < 0.01 for B × C and E × C, respectively). There were more species and more individuals in dung-baited traps than in control traps (15 species, 127 individuals). Community coefficient values showed arthropod composition of dung-treated traps differed from that of control traps (C_n = 0.270, and 0.330 for B × C and E × C tests).

Trophic Dynamics and Feeding Roles

Arthropods were separated based on their probable trophic position in the community: coprovores (17 species), predators (8 species), and omnivores (5 species). Coprovores included scarabs, tenebrionids, sarcophagids, crickets, moths, and sand roaches. Histerids and spiders were predators. Ants were omnivorous, feeding on insects and dung. Trophic structure showed a pyramidal progression of biomass standing crop typical of many terrestrial communities: dung (305 g), coprovores (143 mg), omnivores (80 mg), and predators (40 mg). Over the 3-day period of succession, ants and tenebrionids made the largest contribution to dung arthropod biomass (mean = 88 and 85 mg per pad, respectively). Ants and histerids were important predators (histerids: mean = 12 mg per pad). Because of their nocturnal habits and low capture frequencies (< 3 per trial), the feeding relationships of certain taxa are inferred from studies by other authors.

Ants were dominant (mean = 74%), and are omnivorous feeders in the community. They swarmed over the fresh pads within seconds after placement. The most common species on the pads were *Pogonomyrmex maricopa* Wheeler and *Conomyrma bicolor* (Wheeler). The

Table 1. Percent frequency of arthropods collected from bovine (B) and equine (E) dung-baited traps and unbaited, control (C) traps during each of three trials and one preliminary trial from 1 June to 28 July 1981 in the northern Chihuahuan desert (number of species within each family in parentheses)

Taxon	13–16 June		29 June–2 July			14–17 July			25–28 July			Avg (baited traps only)
	E	C	B	E	C	B	E	C	B	E	C	
Hymenoptera												
Formicidae (5)	78.4	82.5	41.0	96.0	85.2	82.7	64.3	93.6	92.6	63.6	80.0	74.0
Mutillidae (2)	0.2	1.6	0.0	0.0	0.0	0.5	1.8	2.1	1.0	3.0	8.0	0.9
Coleoptera												
Scarabaeidae (3)	0.3	0.0	5.3	1.0	1.8	2.6	5.4	0.0	5.0	6.0	4.0	3.6
Tenebrionidae (3)	0.2	1.6	7.1	1.1	1.8	0.0	9.0	0.0	0.0	3.0	0.0	2.9
Histeridae (1)	0.9	0.0	10.7	0.0	0.0	5.2	5.4	0.0	0.5	3.0	0.0	3.7
Staphylinide (2)	3.2	0.0	3.6	0.0	0.0	3.1	1.8	0.0	0.5	0.0	0.0	1.7
Diptera												
Sarcophagidae (2)	2.1	0.0	3.6	0.4	0.0	3.1	5.4	0.0	1.0	3.0	0.0	2.7
Tachinidae (2)	2.3	0.0	0.0	0.0	0.0	2.6	0.0	2.1	0.5	9.1	0.0	2.1
Lepidoptera												
Geometridae (1)	0.9	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	1.1
Noctuidae (1)	8.3	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	1.3
Orthoptera												
Gryllacrididae (2)	0.3	9.5	5.3	0.0	1.8	0.0	0.0	2.1	0.0	0.0	0.0	1.1
Gryllidae (1)	0.0	0.0	1.8	0.4	3.7	0.0	5.4	0.0	0.0	0.0	0.0	1.1
Dictyoptera (2)	0.5	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Araneida												
Pholcidae (1)	0.3	0.0	7.1	0.4	1.8	0.0	0.0	0.0	1.0	6.1	4.0	2.1
Lycosidae (1)	2.0	1.6	9.0	0.7	1.8	0.0	0.0	0.0	0.0	0.0	4.0	1.7
Solpugida (1)	0.0	0.0	1.8	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.5

Table 2. Summary statistics for bovine and equine dung arthropod communities in the Chihuahuan desert

Statistic	Bovine	Equine
Total individuals	451	366
No. of species	24	22
Diversity (H')	1.298	1.236
Evenness (J')	0.408	0.400
t Test	0.533 791 df (ns)	
Community coefficient (C_n)	0.790	

former repeatedly burrowed into the fresh dung in large numbers (30 to 50 per pad). Within 2 days after placement, several pads were reduced to dry, fibrous hulks riddled with tunnels. Less frequently, ants fed on dung fluids and preyed on a miscellaneous array of insects. *Pogonomyrmex* workers are conspicuous seed harvesters in the deserts of western North America, but are also saprotrophs and predators on arthropods (Cole 1968) and important consumers in desert carrion communities (McKinnerney 1977). Other formicid species in the pads included *Iridomyrmex pruinosis* (Roger), *Myrmecocystus romainei* Cole, and *Pheidole militicida* Wheeler.

Four Coleoptera families were collected from the traps (Table 1). Scarabaeidae and Tenebrionidae (three species each) accounted for 59% of the beetles. Two dung-rolling scarabaeids, *Canthon ebenus* (Say) and *C. melanus* Robinson, were collected. The larger of these, *C. ebenus* (mean = 10 mg, n = 4), forms and rolls heavier dung balls than the smaller (mean = 4 mg, n = 7). Consequently, two sizes of dung balls were found in the traps (mean = 40 mg and 20 mg, dry weight, n = 3 and 5). Dillon and Dillon (1972) stated that adult *Canthon* beetles form and roll dung balls at least double their size. The third scarab collected, *Phanaeus difformis* LeConte, was represented by a single specimen. This beetle is not a dung roller, but instead excavates a shallow burrow in the soil beneath a decaying dung mat (Dillon and Dillon 1972).

Three tenebrionids, *Eleodes carbonarius* (Say), *E. fusiformis* LeConte, and *Eusattus reticularis* (Say), were collected. Darkling beetles of genus *Eleodes* principally inhabit desert regions and are known from a variety of decaying materials (Crawford 1979, 1981).

Saprinus pennsylvanicus (Paykull), the only histerid collected, was predacious. Other studies report this genus as a predator on maggots in carrion (Reed 1958, Schoenly and Reid, in press) and dung (Balduf 1935, *fide* Reed 1958), and *Saprinus* spp. may be controlling agents of the horn fly, *Haematobia irritans* (Summerlin et al. 1982). Staphylinid beetles were represented by two genera, *Philonthus* and *Aleochara*. *Philonthus* spp. are predators on mites and fly larvae, whereas *Aleochara* spp. feed on fly pupae (D. H. Kistner, personal communication). Both beetles are common in bovine excrement (Valiela 1974, Legner et al. 1981).

Dipterans were the third most numerous group of dung arthropods (Table 1). Twenty-five specimens (4.8% of the total fauna) represented four species and two families (Sarcophagidae, Tachinidae). Very soon after dung placement, coprophilous flies were active on the surface of the pads, utilizing available moisture for feeding and larviposition. The most common taxa were the sarcophagids *Ravinia l'herminieri* (Robineau-Desvoidy), *R. planifrons* (Aldrich), and *Oxysarcodexia conclausa* (Walker). The tachinids *Micromintho melania* Townsend and *Chetogena "claripennis* (Macquart)" were collected in fewer numbers. Valiela (1974) described *R. l'herminieri* as a large feeder on bovine dung. McKinnerney (1977) indicated that larval forms of *Oxysarcodexia* spp. are generalists, feeding as detritivores and insect parasitoids. Tachinids, in general, are larval parasitoids.

The five remaining orders included 10 species and 9% of the total count of individual arthropods. Moths (2.4% of the total fauna, Table 1) were represented by two species, *Semiothisa* sp. (Geometridae) and *Bulia deducta* (Morrison) (Noctuidae). Both species fed on fluids during the early evening on days 1 and 2.

Orthopteran use of dung was dominated by gryllid crickets (*Gryllus integer* Scudder) and gryllacridids (*Ammobaenetes phrixocnemoides* [Caudell]). One specimen of the Jerusalem cricket, *Stenopelmatus fuscus* Haldeman (Gryllacrididae), was collected. The feeding habits of desert gryllids and gryllacridids are poorly known and should be studied, because their biomass contribution is potentially quite large for both this dung microcosm (48 mg) and the greater detritivore ecosystem (Crawford 1981). The Araneida were represented by web spiders (*Psilochorus imitatus* Gertsch and Mulaik: Pholcidae) and wolf spiders (*Lycosa coloradensis* Banks: Lycosidae). Spiders have been reported from a variety of decaying materials (Walker 1957), and prey on dipterans found on carrion (Reed 1958, Cornaby 1974, Schoenly and Reid in press). Each of the following comprised less than 0.5% of the total fauna (Table 1): sun spiders, *Eremochelius bilobatus* (Muma) (Solpugida: Eremobatidae), and sand roaches, *Arenivaga* sp., *Eremoblatta* sp. (Dictyoptera: Polyphagidae).

The arthropod fauna sampled from unbaited traps included ants (86%), spiders (4%), crickets (2.5%), and tenebrionid beetles (2.5%), and others. This group of general detritivores and predators represented the dominant fauna associated with the desert floor.

Arthropod Successional Patterns

Considerable variation in arthropod biomass was recorded among dung pads and sampling trials during the 3-day period of succession observed (Fig. 2). Valiela (1974) attributed such fluctuations to density-independent influences (e.g., season and local climate) rather than to density-dependent factors (competition and predation). In spite of this variation, arthropod populations from all three trophic categories in this desert study generally displayed similar patterns in dung succession. On day 1, the pads were fresh and moist, and activity peaked for all taxa. After day 1, population densities of most taxa showed a marked reduction in numbers and biomass as the age of the droppings increased (Fig. 2). Only

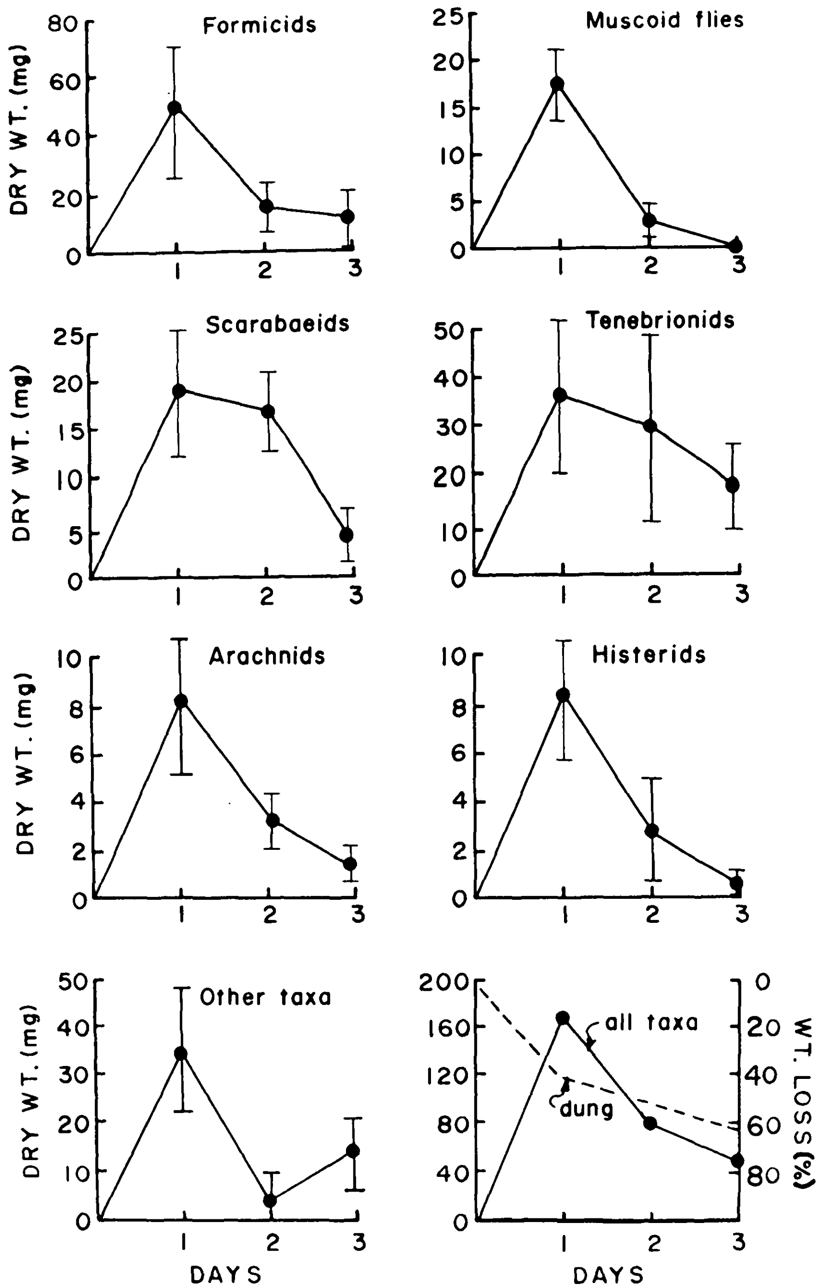

FIG. 2. Standing crops (mg, dry weight) of dung arthropods for each of 3 days of ecological succession. Vertical lines represent SEs of the mean. The lower right figure shows mean weight loss of dung (percent) through time. "Other taxa" refers to staphylinids, moths, crickets, mutillids, and solpugids.

scarab and tenebrionid beetles displayed some evenness of distribution during the 3-day period. After 3 days, arthropods were few, and species composition was similar to that of unbaited traps.

Successive daily estimates of arthropod standing crop totalled for all taxa averaged 165, 78, and 45 mg per pad for days 1, 2, and 3, respectively. Patterns of succession of dung arthropods in temperate climates generally show the reverse sequence (Mohr 1943, Valiela 1974). Valiela (1974) found that, as time increased, so did both species diversity and the number of feeding interactions in the dung community after invasion. Twenty-four taxa appeared on the pads on day 1, increasing to 44 taxa on day 5. In my desert study, fluid loss from dung and activities by ants and scarabaeids contributed substantially to pad reduction. Up to 40% of the dung mass was lost on day 1, followed by 55 and 63% on days 2 and 3 (Fig. 2). Moisture content appears to strongly influence the quality and quantity of arthropods attracted to dung during summer.

Matthews (1976) reports that coprophagy is accomplished by invertebrates in three ways: immediate use of moisture in fresh dung by coprophilous flies for feeding and reproduction, removal of dung for subsequent burial by scarab beetles, and feeding on dry feces by termites and tenebrionids. This sequence agrees generally with my findings, with the following exceptions. In my study, ants (particularly *P. maricopa*) were important reducers of dung and are major predators in the community, although flies rivalled ants as major dung colonists. Matthews (1976) understated the role of scarab beetles in arid Australia, but in my Chihuahuan desert site these beetles were important dung reducers. I estimate that scarabaeids (*Canthon* spp.) in a single 3-day interval remove 40 mg of dung per pad (a calculated mean density of 1.3 beetles per pad). Dung as a patchy and ephemeral resource does not appear to be either food limiting or habitat limiting to desert coprovores.

Because this study addressed only arthropods on feces up to 3 days old, the effect of termites was not examined. They might be the most important coprovores on dry feces in deserts (Johnson and Whitford 1975, Matthews 1976).

Dipteran larvae and pupae rarely were encountered. Only two droppings within a single sampling period (2 July) contained larvae (15 to 30 per pad). Perhaps the others became too dry to support larvae and failed to provide adequate time for pupation. Evidence from larval development studies corroborate this conclusion. Hafez (1941, *fide* Valiela 1974) and Valiela (1974) reported increased larval mortality with increased ambient temperatures above 40°C, particularly in 1st and 2nd instars. In addition, Bruce (1964) reported that summer populations of the horn fly, *Haematobia irritans* (L.), a common inhabitant of cow dung, have larval development periods lasting up to 4 days, as do larvae of other species (*Ravinia l'herminieri, Sarcophaga* spp., *Musca* spp.) (Valiela 1969, 1974).

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