Role of the Poultry Manure Pad in Manure Drying and Its Potential Relationship to Filth Fly Control[1]

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ABSTRACT Experiments were conducted to determine whether and how a residual, dry poultry manure pad helped subsequent manure to dry faster after manure was cleaned out. A dry manure pad did not absorb enough moisture from fresh manure to be measurable after 1 wk. A simulated rough surface texture and increased surface area also did not reduce manure moisture. However, a 1-wk-old accumulation of manure elevated by 11 cm was 37% (summer) or 15% (fall) drier than manure accumulating on the ground. Elevated, drier manure would be expected to be less suitable for filth fly oviposition and development.

KEY WORDS Diptera, Muscidae, *Musca,* manure, moisture, cultural control

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Poultry manure is suitable for development of several pestiferous fly species. The problem has become more acute in modern high-density housing, where manure is concentrated in piles below the birds. The most important fly pest worldwide is the house fly, *Musca domestica* L. (Axtell 1986, Axtell & Arends 1990). In California, *Fannia canicularis* (L.) and *F. femoralis* Stein also are very abundant, and *F. canicularis* is a key spring- and early-summer pest (Anderson & Poorbaugh 1964, Legner et al. 1973, Meyer et al. 1987).

Manure management is critical to control of pestiferous Diptera. Optimizing manure drying lowers habitat suitability for pest flies while facilitating activity of their natural enemies (Axtell 1986). Pest flies in poultry systems develop best in fairly wet, but not liquified, manure. Stafford & Bay (1987) found house flies were abundant at moisture levels of 70% – 79% but were relatively rare at moisture levels below 60%. A drying, building, and aging manure mass also supports fewer flies, presumably due in part to an increasingly complex assemblage of natural enemies over time (Peck & Anderson 1970, Legner & Bowen 1973, Legner et al. 1973, Geden & Stoffolano 1988).

In dry climates common to the southwestern United States, many poultry producers leave a pad of dry manure as a base when the manure is cleaned out. This pad often is 10 to 20 cm deep and lessens the intensity of fly outbreaks, which

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often occur for 4 to 8 wk after a cleanout (Peck & Anderson 1970, Legner & Bowen 1973, Meyer et al. 1987). This effect is usually attributed to the pad serving as a natural enemy refugium, though possible physical and chemical effects, such as the dry manure acting as an absorbent pad, also are mentioned (Legner & Bowen 1973, Axtell & Arends 1990). Many of the predators and immature fly prey are most abundant in the upper levels of the accumulated manure (fresh deposition zone), which are removed at cleanout (Geden & Stoffolano 1988, Wills & Mullens 1991). It has been suggested that removal only of the upper manure layers might remove relatively more flies than natural enemies (Legner 1971). Given the importance of moisture for fly success in poultry manure, we conducted a series of experiments to determine the physical role of the pad in poultry manure drying.

Materials and Methods

Role of the manure pad in moisture absorption. Trials were conducted on two inland southern California caged-layer poultry ranches with typical open-sided housing. Hens were housed in long rows of single-tier wire cages (2 to 3 hens per 38 cm × 45 cm cage) suspended above the floor. The first ranch was near Lake Matthews, Riverside County, and the second ranch was near Redlands, San Bernardino County. Ranches were approximately 30 km apart but had similar climatic conditions.

Locations (blocks) were designated in the test house along each of the four rows of manure. Wet surface manure was scraped away from the manure accumulations, leaving a level, relatively dry (30%–40% moisture) manure surface about 20 cm high. In each location two pieces of 16-mesh aluminum window screen, 10 cm × 10 cm square, were placed on the manure surface 20 cm apart. One of the screens was bare (treatment 1); the second screen was fastened to a 10 cm × 10 cm base of plastic (treatment 2). Fresh manure could fall on the first screen and contact the dry manure base. The plastic below the second screen prevented contact between the fresh manure and the dry manure base.

The first test was conducted at the Redlands ranch in March (spring conditions), with 10 replications per treatment; the second test was conducted at the Lake Matthews ranch in August (summer conditions), with 20 replications per treatment. Screens remained on the manure surface for 7 d and then were returned to the laboratory. Manure was removed from approximately 25% of the surface area and weighed that day (wet weight). Samples were oven-dried at 50°C for 48 to 72 h and weighed again (dry weight). Percent moisture ([wet weight-dry weight/wet weight] × 100) was calculated. Treatments were compared by season by using a paired *t*-test (Minitab, Inc. 1992).

Role of manure surface texture and elevation. A second set of experiments was done after complete manure cleanout to the soil surface (no pad left). Any residual manure (0 to 2 cm) was removed from the soil surface beneath the hens in 10 blocks, each 1 m long. The experimental design was a randomized complete block using the 2 factors elevation and surface texture in combination (Fig. 1). Wooden blocks 10 cm × 10 cm in surface area and 11 cm tall elevated the manure-collecting surface. Glass marbles (1.4 cm diam) provided a rough surface texture approximating the size of poultry manure droppings. Hardware cloth trays (3 mm mesh, 10 cm × 10 cm across by 1 cm deep) fitted with plastic square bases collected the manure. A single layer of marbles could be placed into the tray before deployment. The four treatments thus were elevation with or without rough surface texture (marbles) and ground level with or without marbles (Fig. 1). Statistical analyses were done by using analysis of variance (Minitab, Inc. 1992).

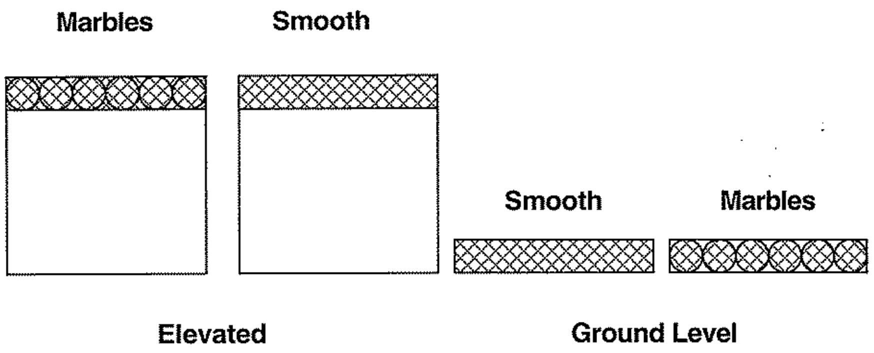

Fig. 1. Diagram of experimental treatments (side view) using elevation and surface texture (with and without marbles) as factors in poultry manure drying. Wood blocks elevated the collection surface; hardware cloth trays with a plastic base contained the marbles.

The trays were weighed individually before field deployment. After 1 wk, the trays plus manure were returned to the laboratory, where they were weighed before and after oven-drying as above. Moisture was calculated after subtraction of the tray weight. The experiment was conducted in September (summer conditions) and mid-November (fall conditions). Temperature and humidity for this set of experiments were recorded by using a hygrothermograph at ground level in the poultry house.

Results

Role of the manure pad in moisture absorption. Moisture content of a 1-wk accumulation of manure in the spring trial was 64.6 ± 8.8% (mean ± sd) for the screen plus plastic treatment and 64.1 ± 22.1% for the screen-only treatment (*t*= 0.142, *P*= 0.885). For the summer trial, moisture in the screen plus plastic treatment was 55.3 ± 37.8% and for the screen-only treatment was 58.7 ± 11.8% (*t*= 1.9, *P*= 0.07). Whether or not new deposits of manure made direct contact with a dry pad surface made no difference in dryness after a 7-d period.

Role of manure surface texture and elevation. Summer and fall trials differed significantly in moisture overall ($P = 0.016$), and there was a significant trial by elevation interaction ($P = 0.004$). The trials thus were analyzed separately.

Average daily high/low temperatures during the summer trial were 32.1°/16.1°C, with average daily high/low humidity levels of 87%/32%. Block effects ($P = 0.09$) and the elevation × texture interaction ($P = 0.434$) were not significant. The greater surface area resulting from the marble treatment (rough surface texture) also had no significant effect on manure moisture ($P = 0.815$). Average moisture was 49 ± 2% for the marbles and 49 ± 2% for the smooth surface. The effect of elevation, however, was highly significant ($P < 0.001$). Elevated manure had an average of 38 ± 2% moisture versus 60 ± 2% for manure on the ground (Fig. 2).

The fall trial had average daily high/low temperatures of 18.7°/5.9°C. Humidity data were not available. Block effects ($P = 0.479$) and the surface texture × elevation interaction ($P = 0.941$) again were not significant. The main effect of surface texture also was not significant; 53.3 ± 2.1% moisture with marbles and 55.7 ± 2.2% without marbles ($P = 0.433$). The effect of elevation, however, again was highly significant ($P = 0.008$). Elevated manure had a moisture level of 50.2 ± 2.2%, whereas ground-level manure had a moisture level of 58.8 ± 2.1% (Fig. 2).

Discussion

These experiments demonstrated several important physical effects of a dry manure pad on fresh poultry manure dropped subsequently onto it. The dry pad had no apparent role in moisture absorption, at least with a 7-d accumulation of manure. Fresh caged-layer poultry manure accumulates at a rate of approximately 0.7 to 1.1 cm/d (Legner et al. 1973). Wet, fresh manure (ca. 80%–85% moisture), dropped from a height of about 0.7 m, penetrated the screen and made thorough, direct contact with the dry pad beneath. Manure over an impermeable plastic barrier was equivalent in moisture to manure over a permeable screen.

Moisture movement in soil is categorized as unsaturated flow, saturated flow, and vapor equalizations (Brady 1974). The first two are probably most important in potential short-term movement of water away from a wet manure layer (analogous to saturated clay soil) above a drier, porous substrate (analogous to a sandy soil). Capillary movement of water in soils is a key factor, dependent on pore size and moisture gradient. The relatively large particle and pore size and entrapped air in the dry pad might actually limit the rate of capillary movement of water away from the fresh (saturated), dense manure layer above. Filth flies, especially *M. domestica*, are abundant in 1-wk-old manure (Peck & Anderson 1970). The moisture levels we observed on top of the screen, particularly in the spring trial, are sufficient for fly development (Stafford & Bay 1987).

The second series of experiments showed that a simulated rough texture and increased surface area also had no effect on manure dryness after 1 wk compared with a smooth surface. We used glass marbles similar in size to dry manure clumps, but they of course would not absorb moisture. By observation, accumulating manure initially splattered over the marble surface, but in ≤1 d, it had become as even as the smooth-surface treatment, negating the initially higher surface area.

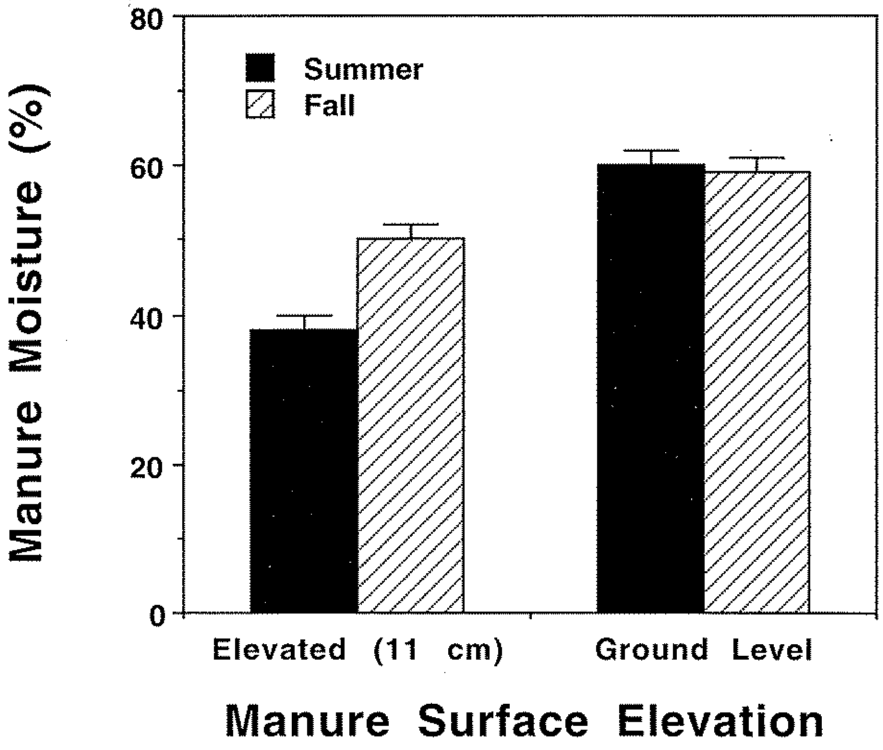

Fig. 2. Average moisture (% ± SD) in 1-wk accumulations of caged-layer poultry manure on the ground versus elevated (11 cm high) blocks in different seasons.

The most obvious potential effect of the manure pad was increased drying through elevation. Air flow is greater as distance from the ground increases and boundary layer effects are reduced. In this series of experiments, no absorption of water from fresh manure into the substrate was possible (plastic barrier). An elevation of only 11 cm resulted in a summer decrease in manure moisture of 37% relative to ground level. Air temperatures at this time were high (32°C) and probably enhanced manure drying. The effect of elevation was less significant in cooler fall weather, with a moisture reduction of 15%. The reduced moisture in summer rendered the elevated manure unsuitable for fly development; the fall reduction probably would decrease its suitability (Stafford & Bay 1987).

The initial trials on the manure pad in moisture absorption allowed fresh manure to fall on an elevated pad, but moisture levels were considerably higher than seen in our elevation experiments. Due to scraping off fresh accumulations to create a dry, level pad, the manure surface surrounding the test plots actually was higher than manure in the test plots themselves. This probably shielded and decreased air flow over the test plots and reduced manure drying potential. Typically, manure accumulates and dries somewhat irregularly over time, leading to peaks and valleys in the manure as it builds into cones. Our elevated blocks simulated these peaks and thus approximated an optimal drying scenario, with good air flow all around the manure accumulation being measured.

Early references to the role of the manure pad have emphasized its role as harborage for natural enemies (Peck & Anderson 1970, Legner & Bowen 1973, Legner et al. 1973, Axtell 1986). The number of natural enemies remaining after a cleanout would be expected to vary with the distribution of the particular natural enemy taxon, manure condition, and season. As discussed by Geden & Stoffolano (1988), older manure deposits also may inherently be more attractive (and subject to recolonization) than fresh manure alone to some natural enemy groups. Legner et al. (1973) noted that fly emergence declined markedly with manure accumulations higher than 20–30 cm. It is difficult to separate the effects of manure age and biotic complexity from physical factors such as height and manure dryness, but it is likely that at least some of the reduction in fly numbers resulted from better drying with height. Based on our experiments, residual dry poultry manure pads improve manure drying considerably through elevation alone. Given the critical importance of manure moisture for fly success, this is likely a primary reason for fewer flies following a cleanout where a pad is left.

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