ENVIRONMENTAL IMPACTS OF POWDERTRACKING USING FLUORESCENT PIGMENTS

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Tests revealed long-term persistence of pigments and the potential for environmental contamination. Primary persistence of pigments falling from animals lasted through the melting of 3-m-deep snowpacks, summer rains, and winds for at least 2 years. Secondary persistence included transfer of pigments to non-test animals, and concentration and incorporation into scat and woodrat middens. Feces persist in middens extending potential contamination up to 40,000 years. Since the potential for long-term, environmental contamination exists, researchers should carefully consider initial application techniques, clean up methods, and residual visual and ultraviolet visual contamination.

Key words: Fluorescent pigments, environmental contamination

Powdertracking consists of dusting live-trapped small mammals with fluorescent pigments by gently shaking them in a plastic bag full of the powder (Lemen and Freeman, 1985). Animals covered with the pigment leave a trail that can be followed at night with a longwave ultraviolet-light source. Powder trails reveal objects manipulated, plants climbed, burrows entered, and items eaten. Thus, powdertracking provides detailed and accurate information by which mammal activities can be traced. Since powdertracking was introduced (Lemen and Freeman, 1985), it has become an important method for the study of mammals; it has gained rapid and wide acceptance (Jike et al., 1988). However, because the use of pigments is so new, little information exists about their long-term impacts to the environment. This study documents the problem of visual and black-light visual contamination by long-term persistence of pigments. Researchers should be aware of potential problems, and carefully consider pigment use where the size of the study area is limited (biological preserves and field stations) or where repeated studies are possible.

MATERIALS AND METHODS

Permanent plots were established to test persistence under differing climatic regimes. One site at 3,535 m elevation on Niwot Ridge, Boulder Co., Colorado, was established 16 August 1988. It consisted of a 1-m-long line (0.5-cm wide) of fluorescent pigment (Radiant Color—Lemen and Freeman, 1985) sprinkled on the ground. The concentration of pigment in the line was slightly less than the amount dropping off a captured animal in the 1st m of travel following marking and release. The line was located in a moist-meadow, alpine-tundra community and was perpendicular to the hydrologic-flow line. Pigment was exposed to strong solar (including ultraviolet) radiation because of the low stature of alpine plants, but covered by snow for 6–7 months/year. Precipitation averages 930 mm/year with 72% falling as snow at the site. Mean annual temperature is −3.7°C (Greenland, 1987).

At Niwot Ridge, the maximum depth of the snowpack over the study plot was ca. 180 cm in 1989 and 300 cm in 1990. For several days during snowmelt each spring, up to 10 cm of water/day flow freely across the study plot. The plot was checked following snowmelt and before the seasonal initiation of plant growth (26 June 1989 and 11 July 1990), and at yearly intervals since the initiation of the study (16 August 1989 and 19 August 1990). Each time the plot was checked, a visual examination was made under bright, morning sunlight for the pigment, and 35-mm slides were taken. During August, examination also was done at night using a UV-light source. Pigment particles located down slope from the initial line were flagged and later mapped in the daylight.

A second series of plots was established at the Paisano Baptist Camp, ca. 16 km southwest of Alpine, Brewster Co., Texas. At this site, the initial release points and trails of two white-throated woodrats (*Neotoma albigula*) were permanently marked on 23 April 1989. The trails were located under large overhangs that provide complete or nearly complete shading from sun on a year-round basis. Mean annual temperature is ca. 18°C for this location in the Davis Mountains, which is not near a weather station.

Results

The test line at Niwot Ridge was still discernible during the daylight and immediately following snowmelt in 1990, 2 years after its establishment. Once plant growth was initiated each year, it became necessary to do a careful search among the plants to find the line. Mapping using the UV-light source revealed that pigment particles had moved an average of 46.7 cm down slope (range, 15.0–87.1 cm; $SD = 20.81$) 1 year later. In 1990, the visible, downslope front of the test line averaged 44.5 cm (range, 11.5–79.0 cm; $SD = 24.0$) and fewer particles were located. Down-slope movement of particles was highest in the initial year, and by 1990, particles that were not eroded away appeared to be more fixed in place. Powder removal by rain made it possible to separate older trails from new trails, but did not entirely remove the pigment from the environment.

Marked trails were checked at Paisano on 5 December 1989. Visual examinations were made in the morning, but under the normal shaded conditions. After dark, an examination was made with a UV-light source. Dry, fine dust on the floors under the overhangs indicated that no moisture had reached either test plot since it was established.

At Paisano, 226 days after the test was initiated, release points, evidence of primary persistence, were strongly evident in the daylight. UV lighting revealed 3–5 m of the initial trail. Secondary persistence effects discovered using a UV light included the incorporation and concentration of pigments in scat that were found laying on the ground, and incorporation of pigmented scat into packrat middens. Another secondary effect was the transfer of pigments to animals other than the one marked. At Paisano, mutual grooming by *Peromyscus eremicus* from another experiment passed pigments from marked adults to juveniles that had not been captured.

Discussion

It is concluded that fluorescent pigments are highly persistent in the environment because they are resistant to movement and degradation. Melting of two annual snowpacks of up to 3 m in depth and summer rains failed to wash away pigments at Niwot Ridge. Ten to 12 months of solar radiation over two summer seasons failed to break down pigments. Pigments were still visible 2 years after application and pigments placed in shady, protected environments were more persistent than those placed out in the open.

Pigments persisted longer in Texas, although winds did pick up some powder and move it up to 2 m onto nearby rocks. Moister conditions at the Colorado site and protection provided by the low plant growth reduced wind movement of pigment. Rain and melt water moved some pigment at the alpine location, but the majority remained at the point of original deposition. Downslope movement by water contaminated lower areas.

Secondary incorporation of pigments into biological materials may enhance their persistence. Based on records of packrat middens up to 40,000 years (Betancourt et al., 1990), scat that concentrates pigments and is incorporated into middens may be evident thousands of years later. Pigments also may be incorporated into abiotic media by yet-to-be documented mechanisms such as sedimentation and may insure pigment persistence well into the future.

Since the largest concentration of pigments usually is within 1 m of the point of release, it may be possible to reduce contamination by releasing animals onto a protected surface. I have found that a long cardboard box, with one end cut out allows the initial heavy load of pigments to fall off before the animal touches the ground. Hand-held vacuum cleaners have been used to clean up trails.

Researchers should carefully consider both the effects of environmental contamination when designing studies and the potential impact that residual powders may have on later, unrelated studies. Although powders may not be normally visible, the use of black lights for later studies may be influenced. However, the persistence of pigments might also have beneficial uses. Secondary persistence may allow the pigments to be used for long-term studies when designed properly, and even as markers that may be passed between animals. Besides visual and black-light visual contamination, research is needed on persistence for periods >2 years, identifying potential clean-up techniques, the persistence time for different colors, potential inclusion of pigments into different trophic levels, and potential toxic effects throughout the food chain.

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