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### Coat Color and Survival of Displaced Wild and Laboratory Reared Old-field Mice

[With 1 Table and 4 Figures]

Wild and laboratory reared mice from central Florida and South Carolina were released into enclosures on the significantly darker South Carolina soils. The lighter southern mice disappeared at the same rate as the darker northern form, as did the males and females from both localities. Prior experience with field conditions was associated with a large selective advantage; the laboratory reared mice disappeared much faster than the wild mice. The correlation between soil and pelage color implies a selective advantage for mice to match the soil, but this advantage must be relatively small because the light form did not disappear at a higher rate than did the darker mice. The relationship between reflectivity and wavelength was linear for both pelage and soil samples. This probably means that the evolution of the dorsal pelage color in this species takes place by modifications in the slope or the intercept of the pelage line.

#### I. INTRODUCTION

The old-field mouse, *Peromyscus polionotus* Wagner, shows considerable morphological variation throughout its range (Smith, 1966). The adaptive significance of many of these variations has been implied by correlational techniques, but no attempt has been made to experimentally determine under field conditions the selection coefficients for any of these traits. Despite a lack of data, it can still be argued that the observed polymorphisms are not random but rather represent evolutionary responses to differences in the local environments. Following this reasoning, we would expect mice currently living in one locality to be better adapted for survival in this particular area than mice that are taken another area and released at the first site. Of course, it is necessary to assume that the areas are separated to such an extent

that genetic exchange between the populations is negligible, the environments at the two sites are significantly different, and finally that the populations have persisted in these areas for a sufficient length of time for selection to produce differences between them. Under these conditions, two populations would normally be expected to differ in more than one way. For our purposes in this paper, we will concentrate only on differences in coat color of the old-field mouse in relation to the color of their soil background.

## II. MATERIALS AND METHODS

Old-field mice were captured in the field or reared in the laboratory and then released into two outdoor enclosures. The enclosures, each containing approximately two acres, were adjacent to one another in field 3-412 on the Savannah River Plant in Aiken County, South Carolina, USA. The vegetation in area 3-412 is typical on an old-field (Odum, 1960; Golley & Gentry, 1965), and *P. polionotus* occurs abundantly in this area (Caldwell, 1964; Davenport, 1964). Caldwell & Gentry (1965) described an enclosure similar to the ones used in this study.

The wild mice were collected from other fields on the SRP and also from Citra in Marion County, Florida. Laboratory reared mice were taken from two different colonies; one was located at the University of Georgia and the other at the Savannah River Ecology Laboratory (see Carmon, Golley & Williams, 1963, and Smith, 1966 for details concerning the maintenance of the colonies). The University of Georgia colony, which was in its seventh generation in the laboratory, was derived from a wild stock collected in the 3-412 area. The other colony came from stock collected in the Ocala National Forest just east of Citra, Florida and was in its fifth to seventh generation in the laboratory. The laboratory animals were from three to six months of age.

Each experiment consisted of releasing 10 adult males from each area into one of the enclosures and 10 adult females from each area into the other enclosure. Pregnant females were excluded from all experiments. The wild mice were held in the laboratory for about 10 days before their release. Experiments consisted entirely of wild mice or of laboratory reared mice; the two types were never released in the enclosures at the same time. Two experiments were conducted with laboratory reared mice and two with the wild mice; a total of 160 mice, 80 wild and 80 reared in the laboratory, were released. The order of the experiments was randomly selected; it was laboratory, wild, wild, laboratory. Sex, locality, and wild versus laboratory origin were the three factors being tested. The various types of mice were placed into the enclosures in a random order with the restriction that each factor must be tested twice in each enclosure.

Each mouse was toe clipped and then released. Populations were censused by live trapping for one day each week for a month. At the end of this time the survivors were removed and another experiment started. The first experiment was started on January 12, 1967 and the last one on May 2, 1967. There were 134 traps per enclosure, and they were distributed in a grid with 30 feet between the traps.

Reflectance was recorded for the mid-dorsal pelage and for the surface and subsurface soil where the mice were captured. Reflectance was measured between 400 to 700 m $\mu$  (violet to red) using the Bausch and Lomb Spectronic 505 Recording Spectrophotometer with its visual reflectance attachment in a way similar to the method used by Sealander, Johnston & Hamilton (1964). Flat skins were used in determining the reflectance of the pelage. The mice used in this part of the work were collected at the same time and areas at those released in the enclosures. Soil samples were taken from areas alongside the burrows in which the mice were captured. The reflectance at eight equally spaced points from 400 to 700 m $\mu$  was used for the statistical analyses. Reflectivity is given as a percentage of the amount of light reflected from a pressed white magnesium carbonate standard.

### III. RESULTS

There was a linear relationship between wavelength ( $X$ ) and amount of light ( $Y$ ) reflected from each soil sample or from the pelage of each mouse. Each sample was analyzed separately, so a series of values for

**Table 1.**

Results of linear correlation and regression analyses of the relationship between reflectivity and wavelength between 400 to 700 m $\mu$  for individual soil and pelage samples from Florida and South Carolina.

Statistical Parameters	FLORIDA SOIL			SOUTH CAROLINA SOIL		
	Pelage	Surface	Subsurface	Pelage	Surface	Subsurface
Sample Size *	12	10	10	19	15	15
Range of $r$ **	.907—.995	.992—.998	.990—.998	.968—.990	.956—.994	.951—.991
Range of $a$ ***	4.49—11.94	16.27—20.99	12.66—18.68	2.68—8.53	9.98—14.99	8.03—14.88
$\bar{a} \pm \text{S.E.}$	6.75 $\pm$ .75	17.17 $\pm$ .44	14.12 $\pm$ 1.64	4.36 $\pm$ .37	11.41 $\pm$ .32	11.07 $\pm$ .46
Range of $b \cdot 10^{-4}$	1.30—2.68	3.71—7.55	8.43—10.72	1.89—5.32	3.08—6.87	3.35—8.72
$\bar{b} \pm \text{S.E.} \cdot 10^{-4}$	1.67 $\pm$ .01	4.61 $\pm$ .03	9.33 $\pm$ .02	2.88 $\pm$ .02	4.63 $\pm$ .02	5.48 $\pm$ .04

\* The number of observations for each regression equals 8,

\*\* All  $r$  values were significant at the 0.01 level,

\*\*\*  $a$  is given in per cent reflectivity at 400 m $\mu$ .

the correlation coefficient ( $r$ ), the intercept ( $a$ ) and the slope ( $b$ ) were generated (Table 1). A linear model accounted for the majority of the variability in all cases (82.3 to 99.6%).

The pooled data for reflectivity of the pelages and surface soils are given in Figs. 1 and 2, respectively. Surface soils from Florida and South Carolina are obviously different in reflectivity at the various

wavelengths but the same is not true for the pelages. However, it would be an error to conclude from Fig. 1 that the relationship between reflectivity of the pelage and wavelength is necessarily the same in the two areas, since the pooled data consists of a series of independent straight lines. In South Carolina  $b$  is larger for a given  $a$  than in Florida. In other words, the ratio of reflected red to violet light is larger for a given amount of reflected violet light in South Carolina than in

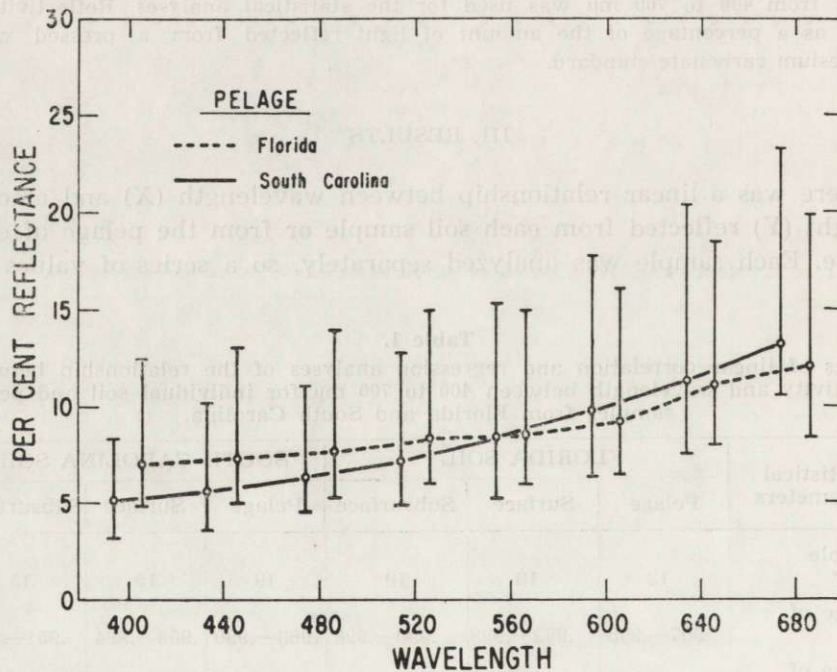


Fig. 1. The range and mean reflectance values for the mid-dorsal pelage of *Peromyscus polionotus* from Florida and South Carolina as a function of wavelength from the violet (400 mμ) to the red (700 mμ) end of the spectrum. Reflectance is given as a percentage of the amount of light coming off a pressed white magnesium carbonate standard.

Florida. The distribution of the  $b$  and  $a$  values for the pelages, surface soils, and subsurface soils from South Carolina and Florida is given in Fig. 3. The relationships between  $b$  and  $a$  differs in each case for the two areas.

The disappearance rates of the four groups are given in Fig. 4. There were no significant differences between the disappearance rates of Florida and South Carolina mice ( $\chi^2 = 0.18$ ), or of males and females ( $\chi^2 = 0.18$ ), or in the two enclosures ( $\chi^2 = 2.2$ ), but wild mice survived better than laboratory reared mice ( $\chi^2 = 12.84$ ).

## IV. DISCUSSION

The linear mathematical model accounted for more than 82 per cent of the variability between reflectivity and wavelength for every soil and pelage sample. The similarity of the relationship for the two types of samples was most likely the result of selection for the mice to match their background. Dice (1947) showed that mice that contrast with their background were captured by owls more often than those that blended in with their background. However, the exact way in which

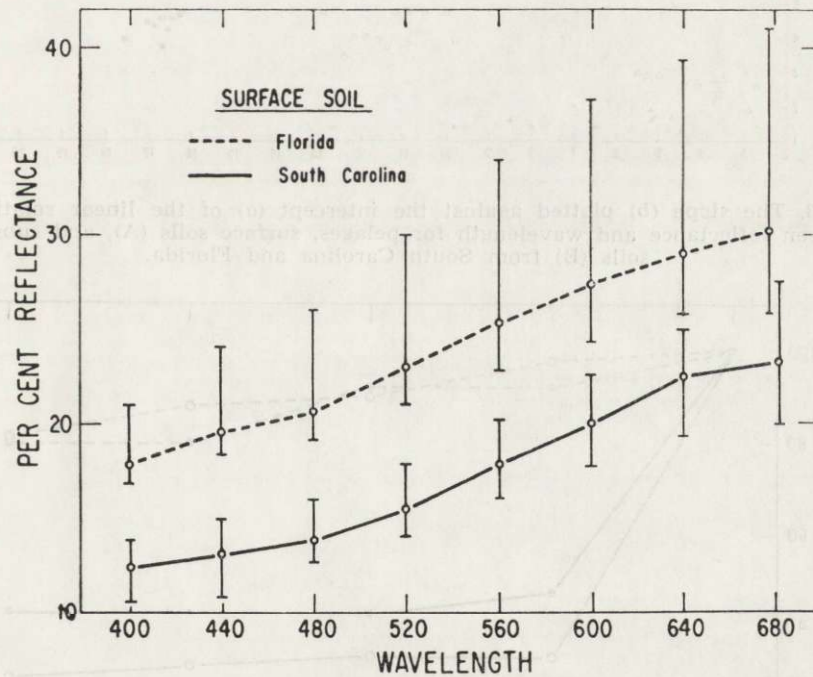


Fig. 2. The range and mean reflectance values for dry surface soils from Florida and South Carolina as a function of wavelength from the violet (400  $m\mu$ ) to the red (700  $m\mu$ ) end of the spectrum. Reflectance is given as a percentage of the amount of light coming off a pressed white magnesium carbonate standard.

populations respond to selection of this kind was not known. It now appears that there are only two parameters that are subject to modification by selection. These are the slope ( $b$ ) and the intercept ( $a$ ) of the reflectance line. This statement probably has general applicability for many, if not all, species of small mammals; we recently found a significant linear correlation between reflectivity and wavelength for six species picked at random from the University of Georgia's museum (manuscript in preparation).

The gross similarity of the mathematical relationships goes beyond mere linearity. Slopes and intercepts were positive for all samples. The largest intercepts for the pelage lines were associated with the largest

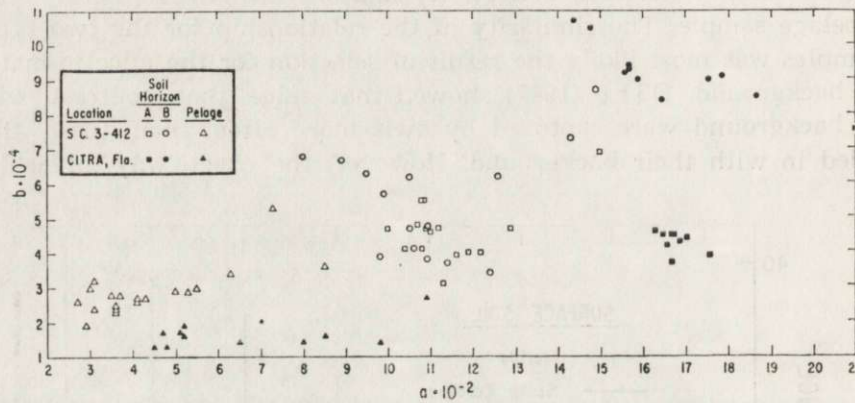


Fig. 3. The slope ( $b$ ) plotted against the intercept ( $a$ ) of the linear relationship between reflectance and wavelength for pelages, surface soils (A), and subsurface soils (B) from South Carolina and Florida.

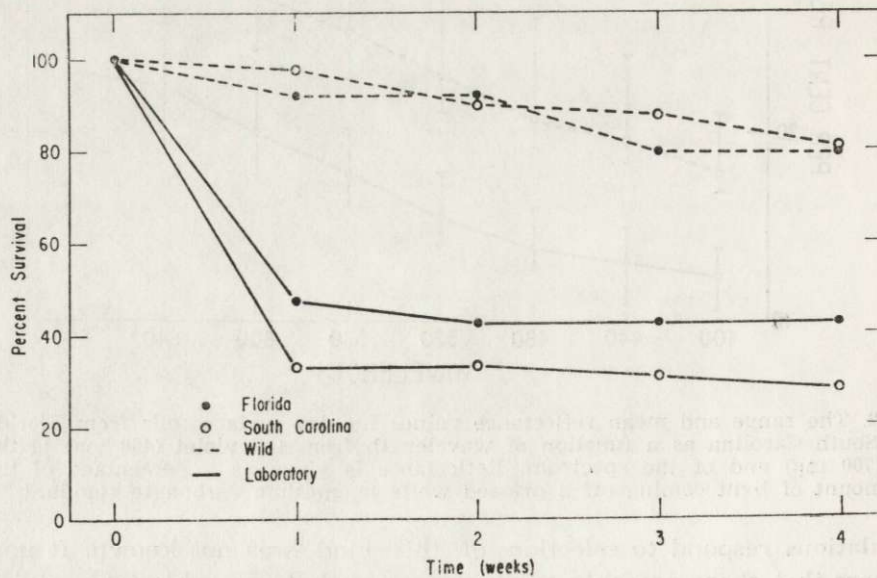


Fig. 4. Disappearance rates of wild and laboratory reared old-field mice from Florida and South Carolina released in South Carolina.

intercepts for the soil lines. Despite these similarities there were differences in the reflectivity of the pelages and soils at the two localities. The differences include the slopes of the pelage and subsurface soil lines and the intercepts of the surface soil lines. Both the mice and the

backgrounds upon which they occur are different in the two areas, and thus there is reason to expect the light Florida mice to disappear faster than the dark South Carolina mice when released on the darker northern soils. The Florida and South Carolina mice did not disappear at different rates. Since the reason(s) for this contradiction is not readily apparent from the data, it is necessary to examine some of the assumptions underlying our reasoning concerning differential survival.

First, we must assume that there was sufficient selection pressure to cause an observable difference in the survival rates of the various groups during the study period of one month. The relatively high disappearance rate of the laboratory reared mice was probably the result of a high selection pressure. Most of the mice disappear during the first week after introduction, and the survival curves are almost horizontal after this time even for intervals longer than one month (Schneil, 1964; Golley & Gentry, in press). Second, predators must use the visual cues associated with the dorsal pelage to locate the mice. There is no way to test this assumption with the available data. However, considering the relatively high survival rate of the wild mice, it seems unlikely that many of the mice escaped from the enclosures. Thus, their disappearance is probably synonymous with their death by predation or disease. The latter is not probably since none of the mice appeared to be sick when captured in the traps.

Potential predators include several species of large mammals, raptorial birds and snakes. Large snakes do go in and out of the enclosures over the sheet metal fence, and many of these species are known to eat *Peromyscus* on the Savannah River Plant (Deever, 1967). Since the relative importance of each of the potential predators and of the various senses used in their hunting behavior is not known, it could be concluded that the predators of the mice in the enclosures were not using the visual cues associated with the dorsal pelage to locate their prey. This conclusion is inconsistent with the overall correlation between soil and pelage color found in this species by ourselves and Hayne (1950). It seems more likely that there is only a slight selection pressure for modifying the slope and intercept of the reflectivity-wavelength relationship of the dorsal pelage in relation to similar values for the soil. Under these conditions it would take a relatively long period of time to produce the differences in the dorsal pelage that are used to distinguish between the various subspecies (Schwartz, 1954).

As the selection coefficient ( $s$ ) approaches 0, the sample size needed to adequately estimate  $s$  approaches infinity. Our sample size was probably too small to detect a slight difference in the survival rates of the mice from the two localities. Prior experience with field conditions was

associated with a large selective advantage. Thus learning is apparently very important to the survival of mice under natural conditions. Smith (1967) presented evidence for a different disappearance among the sexes based on sex ratios among young and adult mice, but the difference would have been slight and accordingly undetectable considering our sample size. These data are consistent with the conclusions made above.

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#### REFERENCES

1. Caldwell, L. D., 1964: An investigation of competition in natural populations of mice. *J. Mammal.*, 45: 12-30.
2. Caldwell, L. D. & Gentry, J. B., 1965: Interactions of *Peromyscus* and *Mus* in a one-acre field enclosure. *Ecology*, 46: 189-192.
3. Carmon, J. L., Golley, F. B. & Williams, R. G., 1963: An analysis of the growth and variability in *Peromyscus polionotus*. *Growth*, 27: 247-254.
4. Davenport, L. B., Jr., 1964: Structure of two *Peromyscus polionotus* populations in old-field ecosystems at the AEC Savannah River Plant. *J. Mammal.*, 45: 95-113.
5. Duever, A. J., 1967: Trophic dynamics of reptiles, in terms of the community food web and energy intake. M. S. thesis, Univ. Georgia, 89 p.
6. Dice, L. R., 1947: Effectiveness of selection by owls of deer mice which contrast in color with their background. *Contrib. Lab. Vert. Biol. Univ. Mich.*, 34: 1-20.
7. Golley, F. B. & Gentry, J. B., 1965: A comparison of variety and standing crop of vegetation on a one year and a twelve year abandoned field. *Oikos*, 15, 2: 185-199.
8. Golley, F. B.: Response of rodents to acute gamma radiation under field conditions. *Proc. Sec. Nat. Symp. Radioecology*, Ann Arbor, Mich. [in press].
9. Hayne, D., 1950: Reliability of laboratory-bred stocks as samples of wild populations, as shown in a study of variation of *Peromyscus polionotus* in parts of Florida and Alabama. *Contrib. Lab. Vert. Biol. Univ. Mich.*, 46: 1-56.
10. Odum, E. P., 1960: Organic production and turnover in old field succession. *Ecology*, 41: 34-49.
11. Schnell, J. H., 1964: An experimental study of carrying capacity based on the disappearance rates of cotton rats (*Sigmodon hispidus komareki*) introduced into enclosed areas of natural habitat. Ph. D. diss., Univ. Georgia, 46 p.
12. Schwartz, A., 1954: Old-field mice, *Peromyscus polionotus*, of South Carolina. *J. Mammal.*, 35: 561-569.
13. Sealander, R. K., Johnston, R. F., & Hamilton, T. H., 1964: Colorimetric methods in ornithology. *Condor*, 66: 491-495.



14. Smith, M. H., 1966: The evolutionary significance of certain behavioral, physiological, and morphological adaptations of the old-field mouse, *Peromyscus polionotus*. Ph. D. diss., Univ. Florida, 186 p.
15. Smith, M. H., 1967: Sex ratios in laboratory and field populations of the old-field mouse, *Peromyscus polionotus*. *Researches Population Ecology*, 9: 108—112.

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UBARWIENIE FUTERKA A PRZEŻYWANIE DZIKICH I LABORATORYJNYCH  
*PEROMYSCUS POLIONOTUS*

Streszczenie

Dziki i hodowane w laboratorium *Peromyscus polionotus* (Wagner, 1843) były wpuszczone do zagród w Południowej Karolinie. Chociaż gleby w Karolinie są ciemniejsze niż na Florydzie (Fig. 2), to jednak kolor futerka badanych populacji myszy nie różnił się (Fig. 1). Zależność pomiędzy zdolnością odbijania światła a długością fali była liniowa zarówno dla skórek jak i dla próbek gleby (Tabela 1). Myszy z Florydy wydawały się na oko jaśniejsze i miały mniejszy kąt nachylenia prostej regresji przy danej stałej wielomianu w porównaniu do myszy z Południowej Karoliny (Fig. 3). Naprzekór tym różnicom, jaśniejsze osobniki ginęły w takim samym tempie jak ciemniejsze z południa. Dotyczy to zarówno samców jak i samic z obu miejscowości (Fig. 4). Wcześniejsze doświadczenia w warunkach terenowych były związane z dużym zróżnicowaniem w selekcji; hodowane w laboratorium myszy ginęły znacznie szybciej w porównaniu z dzikimi (Fig. 4).

Korelacja między barwą gleby a barwą futerka zwierzęcia sugeruje istnienie selektywnej dominacji myszy przystosowanych do gleby. Dominacja musi być względnie mała, ponieważ jasne formy nie giną w większym stopniu niż ciemne. Ewolucja w ubarwieniu grzbietowej strony futerka u tego gatunku zachodzi prawdopodobnie poprzez modyfikację kąta nachylenia linii obrazującej zależność pomiędzy zdolnością odbicia światła od powierzchni futerka a długością fali lub też przez zmianę stałej wielomianu równania regresji.