Leslie N. Carraway[1] and **B. J. Verts,** Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon 97331

Pattern and Color Aberrations in Pelages of *Scapanus townsendii*

Abstract

This study was undertaken to determine the prevalence of aberrantly marked pelages in *Scapanus townsendii* and to ascertain if the aberrant coloration was an additive as suggested by others. Among 663 museum specimens of *Scapanus townsendii* examined, 197 had aberrantly marked pelages and were classified according to the extent and color of the aberrantly pigmented splotches. We found 154 specimens with 1 to several small white spots; 33 with 1 to 3 large yellowish splotches that occupy from <1 to 100 percent of the pelage; 3 with yellowish splotches on predominantly grayish pelages; 5 with pelages mottled grayish, brownish, or yellowish in various combinations; 1 nearly white; and 1 with a uniquely variegated pattern. These colormorphs likely were not the result of additives, but possibly were of genetic origin; did not differ in prevalence among states within the geographic range of the species; and, in some instances, likely were selected against.

Introduction

Although records of occurrence of atypical colormorphs are common for talpids in Europe and eastern North America (Wilson 1860, Barrett-Hamilton 1910, Scheffer 1910, Jackson 1915, Cockrum and Meinkoth 1942, Cooper 1953, Husson and van Heurn 1959, Godfrey and Crowcroft 1960, Skoczeń 1961) reports of such variation in *Scapanus* are rare. A *S. latimanus* with a light cinnamon-yellow pelage (Miller 1921), 2 albino *S. orarius* (Svihla 1939, 1941), and albino (Klein 1944), piebald (Bachman 1839), and iridescent (likely a misidentified *S. latimanus;* Merriam 1885) *S. townsendii* have been described.

On the basis of a collection from a single locality of 25 *Scalopus aquaticus* that contained 18 atypical colormorphs, Jackson (1915:18) suggested that color variation was a dominant character inherited in a "Mendelian ratio"; however, Miller (1921) believed that coat-color inheritance in moles was more complex. Subsequently, Eadie (1954) suggested that some pelage color aberrations in *Parascalops, Condylura, Scalopus,* and possibly *Scapanus,* were the result of staining by products of sudoriferous glands and were related to age and breeding condition of individual specimens. He further indicated that these glands were larger and most abundant on the snout, chin, and wrist, sites at which atypical pelage coloration commonly was observed; glands were smaller and less abundant on the venter and least abundant on the dorsum and along the sides. In *Condylura,* products of the sudoriferous glands reportedly resemble "cerumi-

[1]Current Address: Department of General Science, Weniger Hall 355, Oregon State University, Corvallis, OR 97331.

nous wax of the human ear—both in texture and color" (Eadie 1954:187), and, under magnification, in intensely colored areas, were visible on hairs of fresh specimens as particles of dried colored material. Eadie (1954) further suggested that glandular stains in regions where normal pigments were reduced genetically might account for aberrant pelage colormorphs described in the literature on talpids. Seemingly, Eadie's (1954) report was interpreted to indicate that all pelage coloration in American moles splotched with orange or yellow was attributable to glandular secretions and was totally without genetic basis (Godfrey and Crowcroft 1960; Yates and Pedersen 1982). Being familiar with the bronze wash on the throat, chin, and wrists of some *S. townsendii,* we failed to comprehend how a translucent yellow or orange waxy material could mask the usual purplish-black coloration of other regions of the pelage.

Herein, we report on the types and relative frequencies of pelage color variations in *S. townsendii,* on seasonal and geographic distribution of aberrantly colored specimens, on other biological properties of a sample of aberrantly colored moles, and on our interpretation of the origin and significance of these color and pattern aberrations of the pelage.

Methods

We examined 663 *Scapanus townsendii* from throughout the geographic range of the species (Hall 1981); 197 had aberrantly colored pelage. Specimens examined are on deposit in the National Museum of Natural History (USNM); Oregon State University, Department of Fisheries and Wildlife mammal collection (OSUFW); Portland State

University, Department of Biology; University of British Columbia; University of California, Museum of Vertebrate Zoology (MVZ); University of Connecticut at Storrs; University of Kansas, Museum of Natural History (KU); University of Minnesota, J. F. Bell Museum of Natural History; University of Oregon (UO); University of Puget Sound, Museum of Natural History (PSM); University of Washington, Burke Memorial Museum. Curators of mammal collections at Humboldt State University, San Diego Museum of Natural History, and the American Museum of Natural History reported no specimens with abberrantly colored pelage on deposit at their institutions. M. Morrison examined 16 *S. townsendii* skins in the Los Angeles County Museum for us and reported none with aberrant pelage color.

Aberrant color patterns were sketched on outline diagrams of dorsal and ventral surfaces of moles or described in detailed notes. Colors of both the aberrantly colored patches and typically colored areas were obtained by comparison with Munsell Color Charts (Munsell Color 1975). Hue, value, and chroma were recorded directly on the diagrams or in notes, and are reported herein parenthetically in that order. Sex, and date and locality of collection, were recorded from specimen tags.

We removed 3 to 4 hairs from each of 3 specimens (OSUFW 712, OSUFW 6030, and OSUFW 6857) and, after mounting them on slids with Permount, examined them at 100X under a compound microscope. Hairs of selected individuals were examined *in situ* under a dissecting microscope. During preparation of one specimen (OSUFW 7111), the skin was washed in acetone to remove any glandular secretions present on the pelage.

Results

On the basis of pigmentation of individual hairs, and of extent and color of aberrantly colored areas of pelage, each specimen was classified into 1 of the following categories:

Type 1

Type 1 specimens (n = 154) were characterized by 1 to several small white (10YR 8/1; 10YR 8/2), pinkish white (7.5YR 8/2), or very pale-brown (10YR 8/3) spots, usually <5 mm in diameter, but often in close proximity to or touching to form irregular patterns or strings 6 to 12 mm long on black (10YR 2/1) dorsal and black or very dark-brown (10YR 3/1) ventral pelages (Figure 1). Individual hairs within the aberrantly colored spots appeared to lack black masses of pigment (Williams 1938) throughout their length. This type seems to correspond with "aberratio coloris *subpunctulata*" in the classification of colormorphs of *Talpa europaea* by Husson and van Heurn (1959).

Sixty-nine females, 82 males, and 3 of undetermined sex were included in Type 1. Female and male specimens with Type 1 markings were collected in all months of the year; the sex ratio was nearly even (1:1.19 in favor of males). The frequency of occurrence of this type was not consistent among portions of the geographic range of the species (X^2 = 22.69; $d.f.$ = 2; $P < 0.05$) as the pelage of 53 (18.0%) of 295 individuals collected in Washington, 13 (61.9%) of 21 individuals in California, and 82 (24.4%) of 336 individuals in Oregon exhibited the small light-colored spots. One male Type 1 specimen we examined (OSUFW 7576; Cloverdale, Tillamook Co., Oregon) was a nestling. In southwestern Oregon, 29.4 percent (n = 10 of 34) of the specimens were spotted, in the Portland, Oregon-Vancouver, Washington area, 22.7 percent (n = 15 of 66) were spotted, and in the Tacoma-Olympia, Washington area, 7.7 percent (n = 10 of 130) were so marked.

Type 2

Type 2 specimens (n = 33) had 1 to 3 pale yellow (2.5Y 8/4), yellow (10YR 7/6), reddish yellow (7.5YR 8/6, 7.5YR 7/6, 7.5YR 7/8), or very pale-brown (10YR 8/3, 10YR 8/4) splotches on black (10YR 2/1) dorsal and black or very dark-brown (10YR 3/1) ventral pelages. Splotches were irregular in shape, but commonly consisted of a blaze on the forehead, a larger stigma on the pectoral region, and occasionally a spot on the lower abdomen (Figure 1). The yellowish coloration covered from <1 to 100 percent of the pelage. Individual hairs in aberrantly colored regions either lacked masses of black pigments between medullary air cells or the size of the masses were reduced greatly; none had visible granules of pigments in the cortex as described for hair of normal-colored pelages (Miller 1921, Williams 1938). However, the yellowish coloration was somewhat more intense (increased chroma) on the expanded tips than on more proximal portions of hairs in the splotched regions.

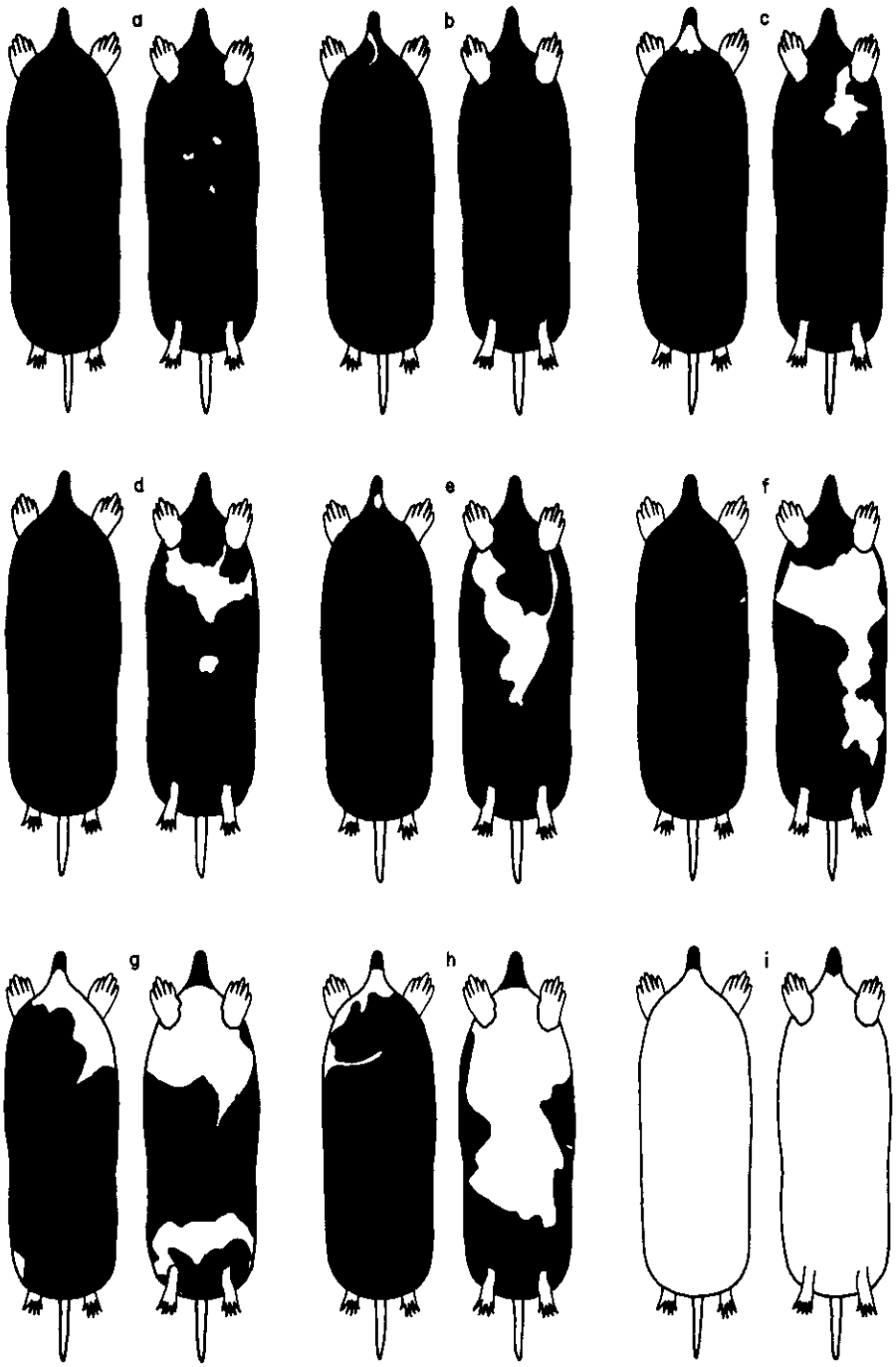

Figure 1. Diagrams depicting aberrant pelage-color patterns (black areas represent normal pelage color) in 9 *Scapanus townsendii:* a, Type 1 colormorph with three white spots on the venter, female, OSUFW 6038. b-i, Type 2 colormorph arranged in order of increasing amounts of yellowish pelage: b, female, OSUFW 6034; c, male, OSUFW 6042; d, male, OSUFW 6035; e, male, OSUFW 6040; f, female, USNM 262275; g, male, OSUFW 6857; h, male, OSUFW 3777; i, male, OSUFW 2618. Note that yellowish markings occur most frequently on the forehead, chest, and abdomen, and are larger and more conspicuous on the venter than dorsum.

Type 2 specimens probably conformed most closely with the "aberratio coloris *innominabilis*" classification of Husson and van Heurn (1959). One specimen (OSUFW 2618), entirely reddish yellow (7.5 YR 7/6) on the dorsum and very pale-brown (10YR 8/4) on the venter, was classified as Type 2 because it seemed to be the extreme in a graded series of moles with various amounts of yellowish pelage (Figure 1b-i). Husson and van Heurn (1959) likely would have classified the specimen as "aberratio coloris *cremea*." Because the splotches, although irregular in shape, occurred most frequently in the pelage of the forehead, chest, and abdomen, Type 2 specimens (except perhaps OSUFW 2618) correspond to the "piebald" condition described by Searle (1968). One Type 2 specimen (PSM 6823), a male collected in the Puyallup Valley, Washington, 28 March 1957, exhibited a molt line that bisected a triangular-shaped splotch left of midline on the venter in the pectoral region. The yellow (10YR 8/6) color on both sides of the molt line was identical.

Ten females, 20 males, and 3 of undetermined sex were included as Type 2. The sample of 30 of known sex was not biased significantly (X^2 = 3.33; $d.f.$ = 1; $P > 0.05$). Type 2 specimens were collected in January, May, June, July, September, October, and November. Geographic distribution of the aberrantly colored specimens tended to be clumped; 9 were collected in the vicinity of Tillamook, Oregon (KU 52686, 52687, 52692, OSUFW 6029, 6031, 6034, 6035, 6040, 6042), 5 in the Corvallis-Eugene, Oregon area (OSUFW 716, 3738, 6857, PSM 11960, UO no number), and only 1 in the southwestern part of the state (OSUFW 3777). In Washington, 9 specimens were from the Tacoma-Olympia area (PSM 881, 1134, 4636, 5991, 6823, 7652, 7653, 8380, USNM 288627). Other Type 2 specimens examined were OSUFW 2618, 7259, 7735, MVZ 19117, 58839, PSM 7288, 7291, 20566, and USNM 262275.

Type 3

The pelage of Type 3 specimens (n = 3) had yellowish-colored patches similar to Type 2 specimens, but on a gray (2.5Y 5/2, 5YR 5/1, 7.5YR 4/0, 10YR 5/1, 10YR 4/1) or brown (7.5YR 6/0) dorsum and gray (10YR 6/1) or light gray (10YR 7/1) venter. Three males (OSUFW 713, 6030, 6039), from the vicinity of Tillamook, Tillamook Co., Oregon, were included in this category. Individual hairs in aberrantly colored regions appeared to be somewhat more intensely colored (increased chroma) on the expanded tip. Hairs in grayish and brownish regions had reduced masses of black pigment, whereas masses were absent in the yellowish regions. Type 3 specimens of *S. townsendii* likely would be considered "aberratio coloris *innominabilis*" in the classification scheme devised by Husson and van Heurn (1959).

Type 4

Type 4 specimens (n = 5) had mottled pelage including gray (10YR 5/1, 7.5YR 5/0, 10YR 7/2, 10YR 6/2, 10YR 3/1, 10YR 6/1), brown (7.5YR 5/4, 10YR 4/3, 10YR 7/3, 10YR 8/3), grayish brown (10YR 6/2, 10YR 3/2), and yellow (10YR 7/6) in various combinations. The dorsum and venter were similar. Overall brownish-gray coloration was formed either by individual hairs with gray (10YR 3/1) or very dark-gray (7.5YR 5/0) bases and light brownish-gray (10YR 6/2) or light olive-brown (2.5Y 5/4) tips (1 male, OSUFW 6044, from Blaine, Tillamook Co., and 1 of undetermined sex, OSUFW 714, from Tigard, Washington Co., Oregon) or by individual hairs with white (10YR 8/1) bases and dark grayish-brown (10YR 4/2, 10YR 3/2) tips (1 male, OSUFW 7389, from 4.5 mi. S, 6.5 mi. W Albany, Linn Co., and 1 female, OSUFW 7898, from 3 mi. W. Monroe, Benton Co., Oregon). These specimens conformed most closely with those categorized as "aberratio coloris *cordida* and *nebulosa*" by Husson and van Heurn (1959). One female Type 4 specimen we examined (PMS 9735; from 2 mi. W. Tillamook, Tillamook Co., Oregon) possessed dark-tipped hairs of 2 lengths over the entire body producing an effect similar to that of agouti banding.

Type 5

Pelage of the single Type 5 (OSUFW 715, undetermined sex, from Noti, Lane Co., Oregon) specimen was white (2.5YR 8/2) on the dorsum and rump shading to yellow (10YR 7/6) on the head and white (10YR 8/2) on the venter shading to reddish yellow (7.5YR 7/6) in the pectoral and throat regions. We suspect that an albino *S. townsendii* referred to by Klein (1944) belonged in this category, but we were unable to locate this specimen for examination. Neither Husson and van Heurn (1959) nor Skoczeń (1961) reported examining predominantly white *T. europaea*.

Type 6

A male (OSUFW 7111) Type 6 specimen, from Tillamook, Tillamook Co., Oregon, exhibited the most garish pattern among the aberrantly colored *S. townsendii* examined. The head (except for a grayish-brown sigma-shaped blaze), the left shoulder, and most of the venter were reddish yellow (7.5YR 7/8) blending to very pale-brown (10YR 8/4) and yellow (10YR 8/6). The remainder of the dorsum posterior of a diagonal line from the right shoulder to the left lower thoracic region, flanks, and anal region were grayish brown (2.5YR 5/2). Individual hairs in the latter region had light gray (7.5YR 7/0) bases; about 90 percent of the hairs had yellow (10YR 8/6) tips and about 10 percent had dark brown (10YR 2/2) or black (10YR 2/1) tips. About half of the hairs with brown or black tips had a similar dark brown band midway along the shaft. The latter band was not sharply defined and seemed nearly to disappear with changes in the angle of illumination, so possibly was of structural rather than of pigmentary origin (Searle 1968). These characteristics remained the same before and after the skin of the specimen was washed in acetone.

Discussion

Because of the relatively restricted breeding season in *S. townsendii* (February to April, Moore 1939; January to April, Pedersen 1963), we believe absence of a strong seasonality in the occurrence of either Type 1 or Type 2 colormorphs in collections is evidence that the aberrancies are not related to the reproductive cycle. This, combined with evidence derived from the Type 2 specimen (PSM 6823) with identical coloration on both sides of a molt line that divided a yellowish splotch, and from those specimens possessing hairs with white or light gray bases interspersed with yellowish hairs and the Type 6 specimen (FW 7111) whose aberrant pelage-color characteristics did not change after being washed in a solvent, indicates that the color was not derived from waxy secretions from sudoriferous glands.

Searle (1968:215) suggested that described colormorphs in *T. europaea* provided ". . . evidence of mutation with respect to nearly all the major allelomorphic series and also the possibility of a sex-linked yellow. . . ." Because several similar colormorphs occurred among specimens in our sample, we believe that coat-color variants described for *S. townsendii* similarly represent mutations at various loci.

The significant differences in proportions of samples of *S. townsendii* collected in Washington, Oregon, and California with Type 1 aberrancy and the clumped distribution observed among Type 1 specimens in Oregon and Washington suggest that the frequency of the genotype differs among populations. Because white spotting in *S. townsendii* was overlooked easily even in good light, we doubt that "selection for the unusual" or "selection for the typical" by collectors would explain differences noted. However, the other colormorphs deviated markedly from the normal pelage coloration in *S. townsendii;* likely they would be preserved with much greater frequency by collectors than they occurred in populations. The relatively large number of aberrantly colored specimens collected near Tillamook, Eugene, Corvallis, and Portland, Oregon, and near Tacoma and Olympia, Washington, where collectors have been active for many years, may be explained by "selection for the unusual."

In *T. europaea*, the prevalence of aberrant colormorphs reportedly was about 1:1,000 in Poland (Skoczeń 1961), 1:1,600 in Italy (Stein 1950), and 1:300 in The Netherlands (Husson and van Heurn 1959). Similar information for *S. townsendii* is not available because, unlike *T. europaea*, it is not harvested for its fur. Only 1 of >1,200 (L. W. Kuhn pers. comm.) *S. townsendii* collected by Giger (1965*a*) and Pedersen (1963) in the vicinity of Tillamook, Oregon, was marked conspicuously (1 Type 3 specimen); however, 5 Type 1, 5 Type 2, 3 Type 3, 1 Type 4, and 1 Type 6 museum specimens we examined were from that locality. This supports our contention that specimens on deposit in museums are not representative samples of populations in regard to the prevalance of aberrant colormorphs.

Although Searle (1968:247) reported that ". . . white-spotting mutations abound in mammals, but most have adverse pleiotropic effects," the high prevalence (23.3%) of Type 1 colormorphs in our sample suggests that such effects in *S. townsendii*, if extant, are minor. Thus, the inconspicuousness of the white spotting in Type 1 specimens and the high prevalence of the colormorph in our sample suggest that the mutation does not confer a selective disadvantage; we cannot hypothesize a possible advantage. However, we suggest that the relatively low prevalance of Types 2, 3, 4, 5, and

6 colormorphs in our sample, the relative infrequency of yellowish splotches on the dorsum of Type 2 specimens, and the occurrence of remains of *S. townsendii* in regurgitated pellets of barn owls (*Tyto alba;* Giger 1965*b*) indicate that conspicuous markings in *S. townsendii* likely are selected against.

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