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Title: Observations of a Captive Kansas Least Weasel (Mustela nivalis)

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Mustela nivalis is an uncommon mustelid in Kansas. Collection records for the state reveal that only 25 specimens have been collected since the first record in 1964. A live specimen obtained from Ottawa County, Kansas was observed for 487 days. Study of this captive least weasel involved recording coat color changes, scat description, kill methods and food consumption. The captive weasel underwent a spring color change, an incomplete fall color change and a complete return to summer pelage. The study verified that Kansas specimens of M. nivalis exhibit individual variation in seasonal pelage change; all Kansas specimens do not change from summer brown to winter white pelage and an individual (the study specimen) varied in pelage from year to year.

OBSERVATIONS OF A CAPTIVE LEAST WEASEL (*Mustela nivalis*) FROM OTTAWA COUNTY, KANSAS

A Thesis
Submitted to
the Division of Biological Sciences
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In Partial Fulfillment
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Dwight L. Spencer
Approved for Major Department

Harold E Dirst
Approved for Graduate Council

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I especially appreciate the help and patience of my wife Katie, who helped run small mammal traplines, fed and helped to photograph the least weasel we called Tippy.

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INTRODUCTION

The least weasel, Mustela nivalis is an uncommon mustelid in Kansas. Collection records for the state reveal that only 25 specimens have been collected since the first recorded in 1964 (Jones and Cortner, 1965). Kansas is now considered a portion of the southern boundary for the species' distribution in North America (Choate et al., 1979).

Pelage color change is common in many species of the genus Mustela, family Mustelidae. In a few instances notes have been recorded concerning the pattern and dates of pelage change exhibited by M. nivalis (Swenk, 1926 and Easterla, 1970). Only Hall (1951) mentioned possible variations of patterns or dates due to latitude differences within the range of M. nivalis.

Recording the sequence of events involving pelage change in a captive M. nivalis from Kansas was the primary objective of this study. The study animal was captured 25 January '79 at a grain elevator in Ottawa County: Ada (T.10S, R.5W, Sec. 28). This is the only Kansas specimen known to have been maintained in captivity. A description and photographic record of scat were completed. Kill methods, food consumption and other behavioral activities were observed throughout the period of captivity. Although studying pelage change was the primary objective of this study, other factors have been included because of the scarcity of information concerning M. nivalis from Kansas.

Literature Review

Most studies concerning the least weasel, Mustela nivalis, have involved simple recording of capture data and compilation of these data into discussions of distribution. Bangs (1896) reported M. nivalis as

being first described, though misidentified, by Baird in 1857. Bangs (1896) described the species type from a few Canadian and Alaskan specimens and noted the white winter pelage. The least weasel in Nebraska was reported by Aughey in 1880 as being an infrequently seen species of weasel in that state (Swenk, 1926). Swenk (1926) reported in detail his efforts to substantiate Aughey's identification. The first positive identification by Swenk was of a single Nebraska specimen in 1905 and was followed with collection data on 17 additional least weasels in the next 19 years. Swenk (1926) also proposed the now accepted division of the species into four subspecies and provided a map showing North American distribution. The first Kansas specimen of M. nivalis was reported by Jones and Cortner (1965) and Kansas records have been brought up to date by Choate et al. (1979). The phrase "circumboreal species" was first applied to the least weasel by Allen (1933). Hall (1951) reviewed the structural characters, natural history and distribution, including a map for North America, for M. nivalis. Hall and Kelson (1959) published a North American distribution for M. nivalis. Jones (1964) reviewed the Nebraska distribution of M. nivalis and accepted Reichstein's opinion, based on skull characters, that the old world least weasels, M. nivalis, and the North American least weasels, M. rixosa, are the same species. This report follows Jones (1964), Heidt (1972), Ewer (1973) and Choate et al. (1979) in using Mustela nivalis for the North American least weasel.

Weasels have been described as possessing the characteristic of a seasonal color change in pelage from summer brown to winter white. Miller (1930 and 1931) described the spring and fall molts of a captive Mustela frenata. Hamilton (1933) stated that the spring and fall color changes

of M. frenata and M. erminea are the result of a molt and not a change in color of the existing hair. That the color changes are accomplished by molting was further substantiated by observations of both spring and fall molts of a captive M. frenata (Noback, 1935).

The factor or factors responsible for the spring and fall color variations in weasels have not yet been identified. Rothschild (1942) proposed that temperature is a modifying factor in that a number of captive M. erminea, but not all of even the same litter, exposed to cold exhibited a color change. Bissonnette (1944), working with M. frenata and M. erminea, reported that reductions or increases in day length are effective in inducing molt and a change of color, and that the photoperiod can be responsible for the intensity or completeness of color change from brown to white or white to brown. According to Rust (1962), temperature is not the major factor responsible for the spring color change. Rust (1962) experimented with M. erminea in environmental rooms with a constant 18-hour photoperiod. One group was maintained at a constant 70°F, the other at a constant 20°F, and it was found that cold temperatures did increase the speed and nature of the color change. However, both warm and cold groups did molt, hence, Rust's statement that temperature is not a "major" factor. Hewson (1979) associated snowfall and snow-lie duration, and the monthly minimum temperature, with the molt to winter white.

Sexual dimorphism of the color change in weasels (females appear to have a higher frequency of color change than do males of the same locality or even litter) was noted by Rothschild (1942), Hall (1951), Hutchinson and Parker (1978) and Hewson (1979). Hewson (1979) stated

that because of the smaller size of the females, and corresponding larger heat loss for the sex of smaller body weight, the speed and completeness of the fall molt might occur at a higher frequency in females than in males.

Hamilton (1933) stated that wide variations occur in time, manner of molt and the corresponding progress of molt for M. frenata and M. erminea. Hall (1951) and Hutchinson and Parker (1978) definitely correlated winter whitening as a genetic response (in the form of protective coloration) to seasonal characteristics and variation. Bissonnette (1942), reporting on anomalous seasonal coat color changes of a captive M. erminea, stated that the captive animal's change of habits in relation to his environment, rather than changes in that environment, conditioned the changes in pelage and coat color.

Killing behavior of the least weasel appears to be constant according to the methods described by Allen (1940), Llewellyn (1942) and Heidt (1972). Short (1961) proposed that a least weasel in the wild would eat approximately one half its body weight daily, computed as 1.6 Peromyscus maniculatus or 0.75 Microtus pennsylvanicus. Llewellyn (1942) also reported that a captive Mustela nivalis consumed about one half its body weight daily. Allen's (1940) data for four captive least weasels showed each weasel consuming approximately 1.3 Mus musculus per day.

The four sounds that least weasels produce were verbally described and analyzed with oscilloscope tracings and sonagrams by Huff and Price (1968). Heidt and Huff (1970) described the fifth known specific vocalization, produced only by immature least weasels.

Distribution

The least weasel in North America is represented by four subspecies.

Swenk (1926) published the first North American distribution map and differentiated between the subspecies as follows: Mustela rixosa eskimo, northern and western Alaska; Mustela rixosa rixosa, from north central Alaska east across Canada and south to northern Montana and northern Minnesota; Mustela rixosa allegheniensis, from western Pennsylvania through Ohio to southern and western Wisconsin, and south in the Alleghenies to western North Carolina; Mustela rixosa campestris eastern and central Nebraska. Hall (1951) and Hall and Kelson (1959) extended the range of the least weasel with records from North Dakota, South Dakota, the northern one half of Indiana and Illinois, north and east Iowa and southern Nebraska. Collection data provided by Easterla (1970), Choate et al. (1979) and Boyce (Mark Boyce, Museum Curator, University of Wyoming, personal communication) has changed the distribution boundaries in the United States (Fig. 1). Southwestern Iowa, northwest Missouri, northern Kansas and a first collection in northern Wyoming now represent parts of the southern boundary of the range of Mustela nivalis.

Twenty-five specimens of M. nivalis have been collected in Kansas (Table 1). The first Kansas least weasel, collected in Marshall County in 1964, was reported by Jones and Cortner (1965). Subsequent reports of least weasel collections in Kansas were made by Hesket and Fleharty (1966), Anderson (1971), Choate and Fleharty (1975), Swan (1978), and Choate et al. (1979). Twenty of the 25 records are authenticated and 21 of these specimens were observed during this study. The Saline County specimen has, unfortunately, been lost. Mike Little, Salina area game protector for the Kansas Fish and Game Commission collected the specimen, thought to be a victim of raptor predation, near Gypsum,

Figure 1. North American distribution of Mustela nivalis.

Table 1. Capture location, capture date and institution housing specimen for all known Kansas specimens of Mustela nivalis. (ESU) Emporia State University; (MHP) Museum of the High Plains; (KU) Museum of Natural History; (NA) not available.

LOCATION	DATE	INSTITUTION
Marshall Co.	3-13-64	KU
Smith Co.	4-28-66	KU
Smith Co.	5- 5-66	KU
Republic Co.	2- 8-67	NA
Smith Co.	3- -67	KU
Jewell Co.	2-16-68	KU
Republic Co.	5-14-68	KU
Jewell Co.	8- 8-68	KU
Brown Co.	10- 9-69	ESU
Smith Co.	1- -70	MHP
Lincoln Co.	3- -72	MHP
Republic Co.	5-16-72	MHP
Jefferson Co.	12-10-73	KU
Osborne Co.	4-17-75	MHP
Jewell Co.	1-16-75	MHP
Jewell Co.	1-16-75	MHP
Clay Co.	2-24-76	KU
Jackson Co.	3- 3-78	MHP
Jackson Co.	3- 3-78	MHP
Ottawa Co.	1-25-79	ESU
Pottawatomie Co.	NA	KU (NA)
Phillips Co.	NA	MHP (NA)
Marion Co.	NA	MHP (NA)
Cloud Co.	1967	ESU
Saline Co.	NA	DESTROYED

Kansas. The specimen was identified by George Carson, district game biologist for the Kansas Fish and Game Commission, and the specimen was donated to the Museum of the High Plains, Fort Hays State University (Mike Little and George Carson, personal communication). The specimen was placed in a freezer at that time but was not logged and has since disappeared. Choate et al. (1979) stated that the single Marion County specimen was the only one that had been saved out of eight or nine found dead beside a road.

The species has been found in the eastern two-thirds of the state, and probably occupies the northernmost tier of two or three counties except for a southward dip into the Flint Hills represented by the Marion County record (Fig. 2). Choate et al. (1979) suggested that dispersal of the species in Kansas has been through riparian habitats and across agricultural land located in floodplains. All Kansas locality records for M. nivalis are near reservoirs or watercourses associated with the tributaries of the Kansas River System except the specimen from Marion County which was collected on a tributary of the Neosho River (Choate et al., 1979). The Marion County specimen could represent a crossing of the narrow divide between the watersheds of the Kansas and Neosho rivers by means of mesic valleys of the Flint Hills (Choate et al., 1979). Choate et al. (1979) further suggested that the species might be expected to occur in the future in southeastern Kansas due to this movement.

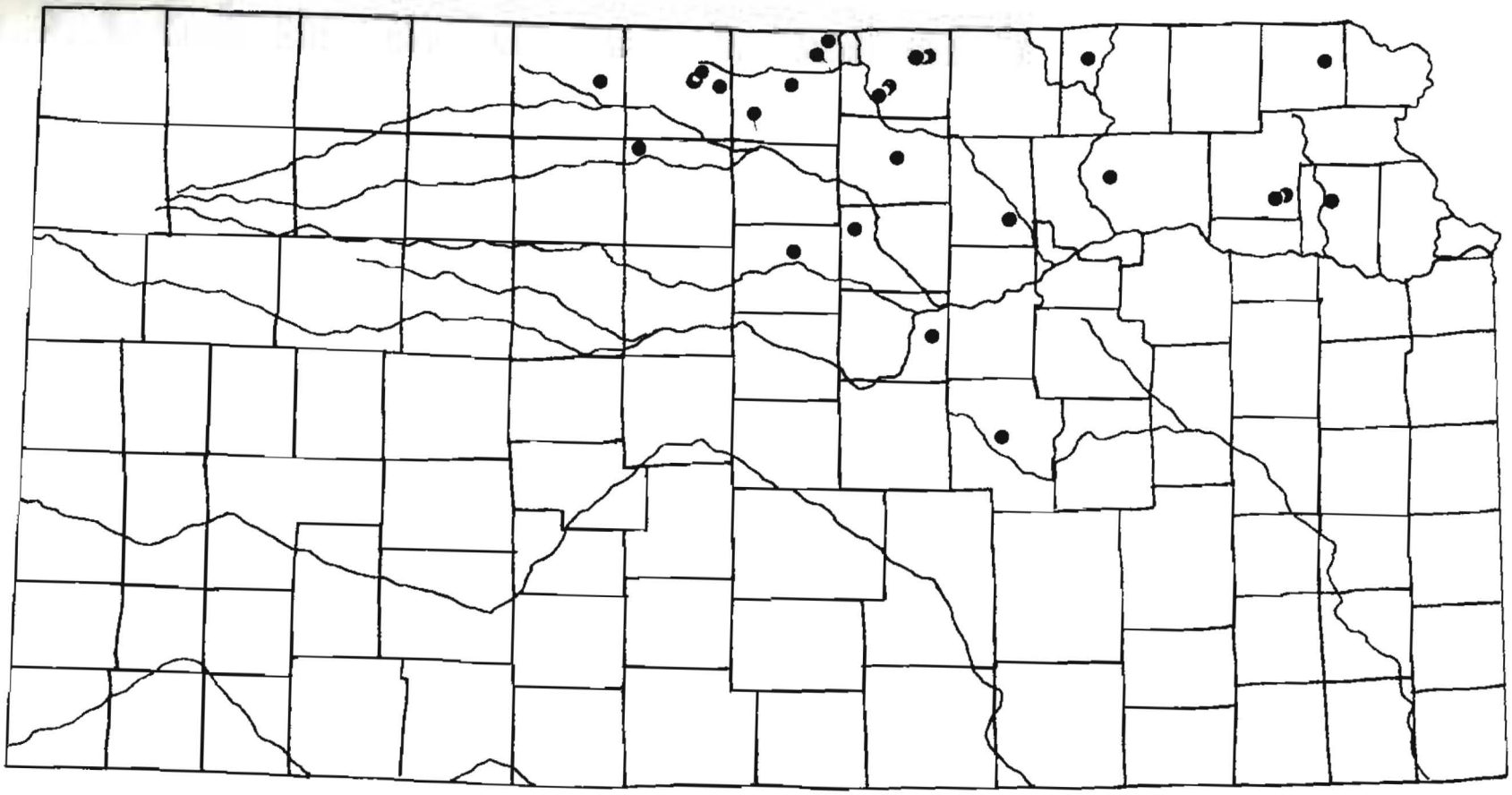

Figure 2. Kansas distribution of Mustela nivalis.
Black circles represent capture locations.

METHODS AND MATERIALS

The study animal was captured 25 January 1979 by Mr. Frank Shoyer at the Ada elevator, Ada, Kansas. Mr. Shoyer stated that while shoveling milo, a grayish-brown "ball" popped out of the auger chute into the milo bin in which he was working. The weasel, covered with dust, was simply scooped into a bucket (Frank Shoyer, personal communication). From 25 January 1979 through 12 February 1979 the weasel was kept in a small birdcage and kept alive on a diet of chicken liver and bologna. At the time of capture the weasel was in full white pelage, showing only a black tip on its tail.

The study animal was housed outdoors in an observation cage obtained from Emporia State University. The cage measured 48 X 39 X 18-inches and was constructed with a sheet-metal bottom, two glass sides and a 0.5-inch mesh wire screen on the remaining sides and top. The entire top was hinged for easy cleaning and a smaller hinged lid was built into the top for placement of food and water. A smaller nest box filled with cotton and straw was placed inside the cage until an exterior nest box was attached so that the animal could be isolated for photographing or cleaning either the nest box or cage. The cage bottom was covered with sand and gravel. Larger rocks, patches of grass and a fork shaped log were included for climbing and cover (Fig. 3).

Food consisted of rodents, beef liver and trial offerings of house sparrows, blacktailed jackrabbit and cottontail rabbit juveniles, lubber grasshoppers, a lined snake and a great plains rat snake. Rodents used as food items included Mus musculus, Sigmodon hispidus, Peromyscus spp., Neotoma floridana and Rattus norvegicus. One hundred and seventy-one wild rodents were trapped and used as food items. These rodents were

Figure 3. Observation cage in which the captive least weasel was housed.

obtained using Sherman live traps and homemade can traps. The remaining rodents were laboratory animals provided by Emporia State University. Food items were offered on a daily basis unless excessive wastage was observed and then the weasel would not be fed for a 24-hour period. Water was available at all times.

Throughout this study as little human contact as possible was made with the weasel in an attempt to avoid modifying the weasel's behavior. Contact was limited to photo sessions, cage cleaning and occasionally during feeding. Photographs were obtained at first by lifting the small lid on top of the cage and shooting downwards. Within a short period of time these photo sessions became increasingly difficult because the weasel would attempt to escape. The exterior nest box with trap door corrected the situation and the weasel could then be isolated in the observation cage to facilitate shooting photos through the glass sides. Line drawings were shaded in to depict coat color changes at intervals of a week to 10 days or when a change was thought to be significant. Photographs were taken of study skins housed at the Museum of the High Plains, Fort Hays State University and the Museum of Natural History, University of Kansas. These photographs were used to compare dates of the captive least weasel's color changes with specimens of wild Mustela nivalis.

RESULTS

Pelage Change

The least weasel was in white winter pelage when it was captured on 25 January 1979. The only hairs showing any pigment were in the black tip of the tail (Fig. 4). The spring color change was first noticed 17 February 1979 and was believed to be complete on 11 July 1979, a period of 145 days (Fig. 5).

The spring molt first observed on 17 February 1979 was mistaken for dirt, grease or blood stains. These marks appeared as splotches and streaks of brown on the dorsal, anterior one-third of the body in the right shoulder and neck region. On 26 February 1979 it was obvious that the color change was in progress as the shoulder areas on both sides of the body showed an increase in the portion appearing as brown. At this time it was also noticed that areas on the sides of the nose pad and at the base of the superciliary vibrissae had turned brown. By 10 March 1979 these spotty areas had become a solid, chocolate brown and were irregularly oblong in shape extending from the back of the shoulders up to the base of the ears. Facial coloration was only slightly more pronounced and flecks of brown appeared on the posterior of the hind legs at that time (Fig. 6). The solid shoulder patches extended down the forelegs, back to the middle of the flanks and continued posteriorly, as scattered spots, to the anterior portion of the hip region by 20 March 1979. The dorsal midline had become peppered with brown between the shoulder patches and between the ears except for a one cm^2 area on the dorsal midline of the neck which remained white. The posterior margins of the hind legs had become solid brown semicircles extending under the

Figure 4. White winter pelage of the captive least weasel on 28 January 1979.

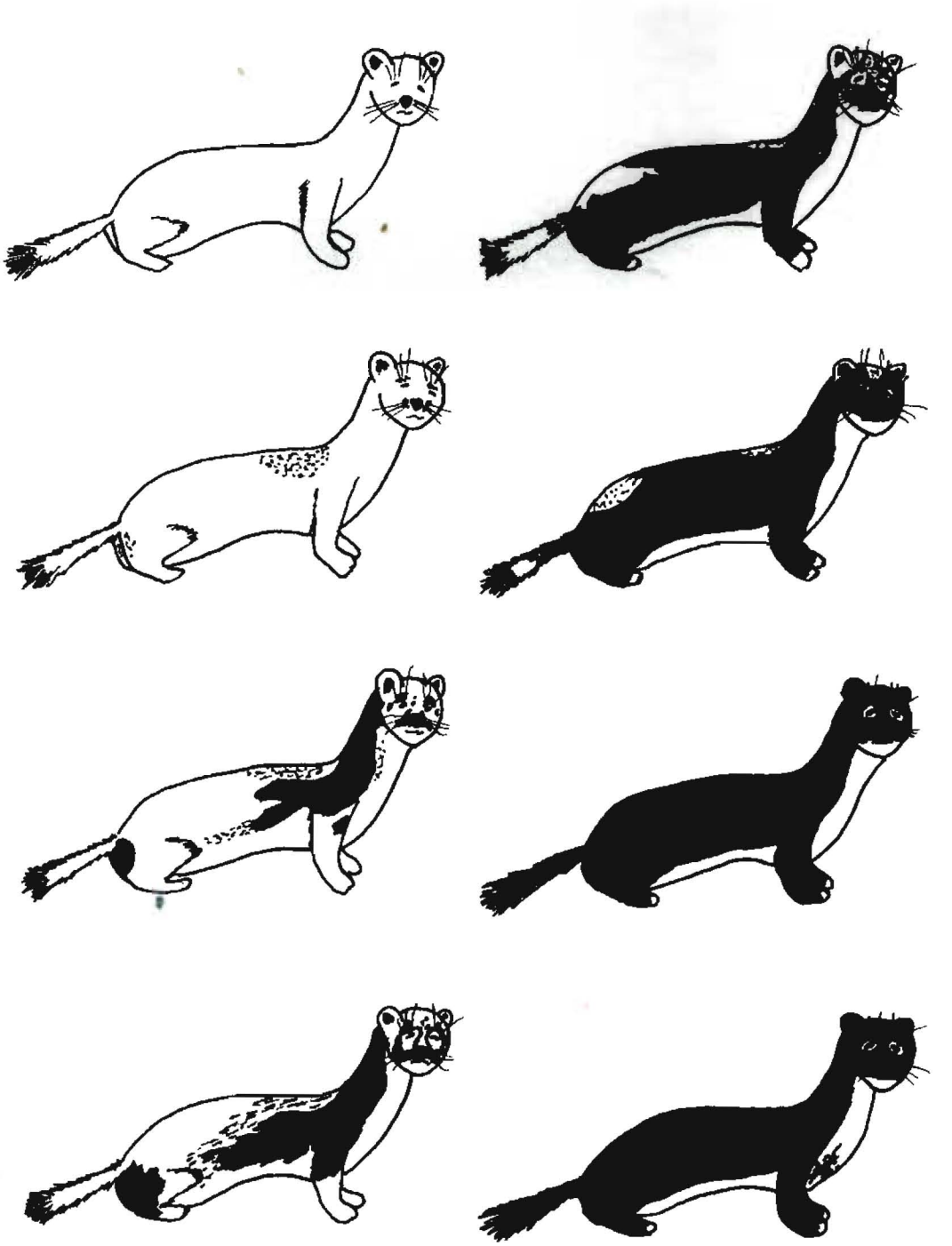

Figure 5. The spring of 1979 color change of the captive least weasel; 145 day duration.

Figure 6. Progress of the spring color change on 10 March 1979.

Figure 7. Progress of the spring color change on 20 March 1979.

tail across the anal region and had progressed laterally. The mystacial markings covered the entire upper lip back to the corners of the mouth and had begun to move upwards to the inside corner of the eyes. Small brown spots had appeared below and behind the eyes and one prominent spot was directly between the eyes. New brown hairs across the forehead and back to the anterior base of the ears produced a "dirty white" appearance when viewed closely and carefully (Fig. 7). Facial markings became striking by 1 April 1979 and gave a masked appearance to the face. Rings of brown encircled the eyes, having moved upwards from the brown upper lip and joined at the base of the superciliary vibrissae. Brown flecks had spread posteriorly and laterally from between the eyes. Shoulder patches became a continuous solid brown from the base of the ears, half-way down the lateral margin of the forelegs and thinned gradually to the anterior of the hind legs. Flecking, or scattered brown spots, had accumulated from the solid lateral markings at the hips up to the dorsal midline at about the middle of the back. The ventral portion of the weasel remained solid white except for the thin band across the anal region (Fig. 8). By 7 April 1979 the outsides of the forelegs and hind legs were a solid brown. The weasel's dorsum was brown except for a white rump patch and white between the shoulders and on the back of the head. The venter remained white and the tip of the tail remained black. The once white area of the tail was only sparsely covered with white hairs because most had fallen out and were being replaced with short brown hairs (Fig. 9). The brown continued to close in on the dorsal midline areas and on the face. The proximal one-third of the tail became filled with normal length brown hairs by 21 April 1979 (Fig. 10). The tail

Figure 8. Progress of the spring color change on 1 April 1979.

Figure 9. Progress of the spring color change on 7 April 1979.

filled distally with brown and was almost complete to the black tip by 28 May 1979. Also, by this date, the white dorsal portions had become peppered and the face was almost solid brown. The dorsal and lateral molt was practically complete by 21 June 1979. Only a few, small white splotches were present on the rump, tail and crown (Fig. 11 and Fig. 12). On 1 July 1979 brown spots were noticed on the ventral area between the forelegs. By 11 July 1979 this area had filled in with an irregular cross-shaped patch of brown hair. No new brown hair was observed after 11 July 1979.

To summarize, the spring molt occurred by the loss of white hair which was replaced by brown hair of a deep, milk-chocolate color. Easterla (1970) reported a similar pattern in the spring color change of a Missouri captive specimen. Progress of the spring color change in the study animal was characterized by these steps (Fig. 4):

1) Almost all areas that became brown first appeared as spotted brown and white giving a peppered appearance.

2) The shoulders, head and backs of the hind legs were the first areas to show brown.

3) Lateral extension and dorsal closing of the earliest shoulder patches filled in the bulk of the trunk as brown.

4) The tail, crown and rump were the last dorsal areas to fill in with brown hair.

5) The breast region was the last part of the body to change to the summer brown pelage.

The fall color change did not go to completion. The weasel was in full summer pelage on 22 September 1979. On 6 December 1979 it was noticed that the brown breast markings had entirely disappeared. By 26 December 1979 white hair had replaced brown hair on the anterior margin of the hind legs, the distal one-half of the tail and around the eyes,

Figure 10. Progress of the spring color change on 21 April 1979.

Figure 11. Progress of the spring color change on 21 June 1979.

Figure 12. Progress of the spring color change on 21 June 1979.

nose and lips (Fig. 13). With the exception of the black tip, the tail was fully white by 30 December 1979. At this time the margin along the neck and the margin between the flanks and belly were becoming broken with patches of white. The legs, flanks and face were the areas showing the greatest replacement of brown hair by white on 12 January 1980 (Fig. 14).

The neck, forelegs and hindlegs showed evidence of the return to summer pelage on 25 February 1980 and these areas were solid brown by 4 March 1980. The proximal section of the tail appeared brown on 15 March 1980. The dorsal two-thirds of the body seemed in full summer pelage by 12 April 1980 (Fig. 15). The brown ventral markings, again an irregular cross shape between the forelegs, was first noticed on 3 June 1980. No further brown appeared after 12 June 1980.

Comparison With Study Skins of Wild Specimens

Observations of Kansas Mustela nivalis specimens housed at the Museum of the High Plains, Fort Hays State University; Museum of Natural History, University of Kansas; and the Schmidt Museum of Natural History, Emporia State University, revealed that the color change characteristic of the least weasel in Kansas is highly variable among individuals. Dorsal and ventral photographs were taken of the Museum of the High Plains and the Museum of Natural History specimens for comparative purposes (Fig. 16, 17, 18 and 19). Capture locations and dates of capture are given in the corresponding tables; Figures 16 and 17 (Table 2) and Figures 18 and 19 (Table 3).

Specimens taken from Smith County, January, 1970; Jewell County, January, 1975; Clay County, February, 1976; Marshall County, March, 1964;

Figure 13. Progress of the fall color change on 26 December 1979

Figure 14. Progress of the fall color change on 12 January 1980.

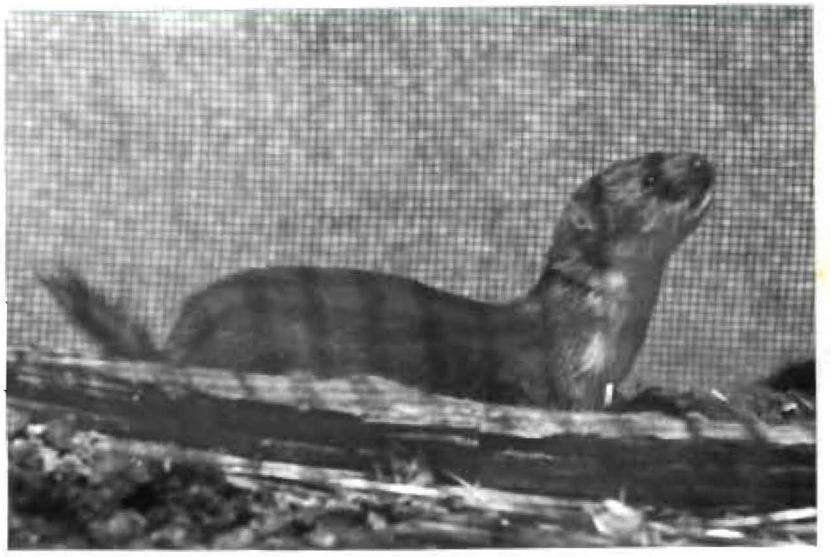

Figure 15. The return to summer pelage by the captive least weasel on 12 April 1980.

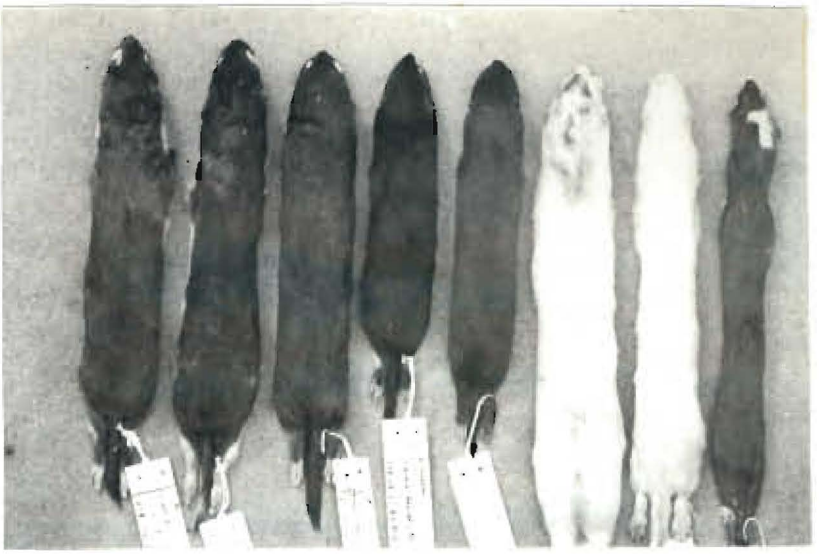

Figure 16. Dorsal view of specimens housed at the Museum of the High Plains, Fort Hays State University

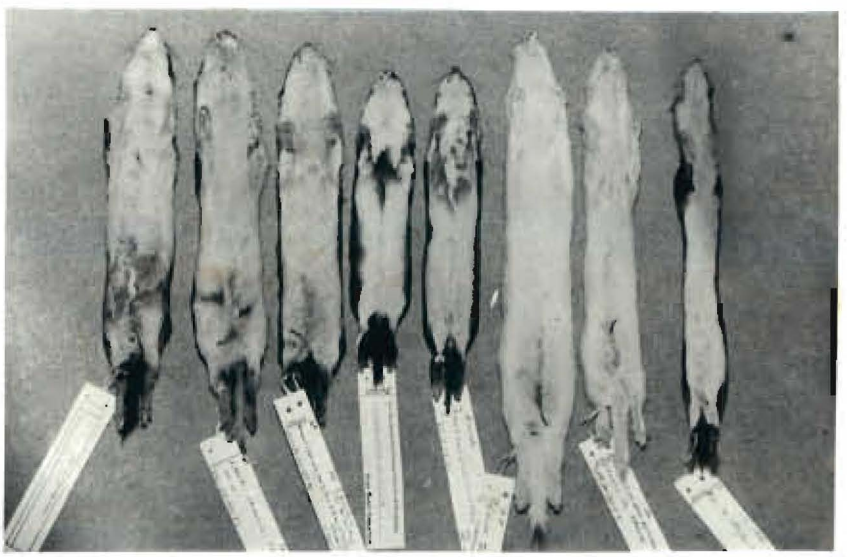

Figure 17. Ventral view of specimens housed at the Museum of the High Plains, Fort Hays State University.

Table 2. Capture locations and capture dates for the photographed specimens of the Museum of the High Plains (Fig. 16 and 17) numbered from left to right.

NUMBER	LOCATION	DATE
1	Jackson Co.	3- 3-78
2	Jackson Co.	3- 3-78
3	Osborne Co.	4-17-75
4	Republic Co.	5-16-72
5	Lincoln Co.	3- -72
6	Smith Co.	1- -70
7	Jewell Co.	1-16-75
8	Jewell Co.	1-16-75

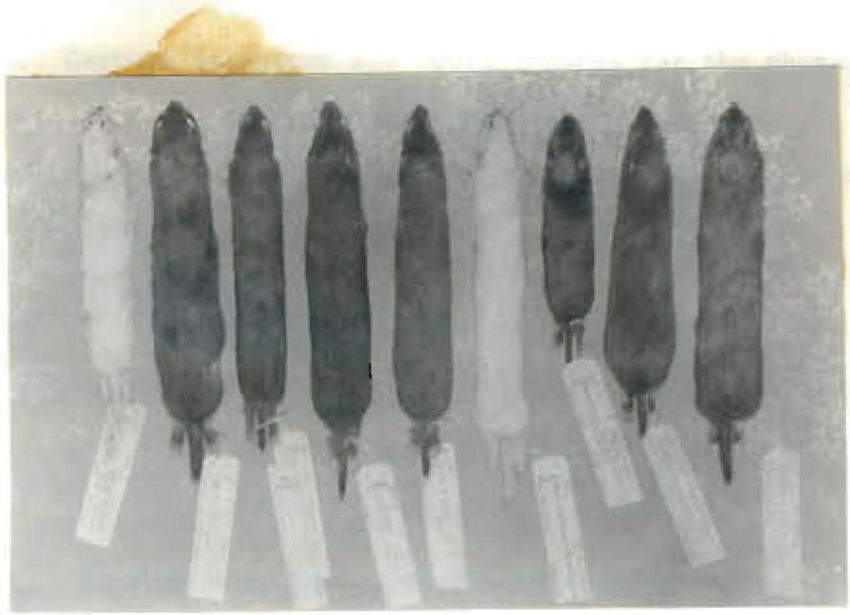

Figure 18. Dorsal view of specimens housed at the Museum of Natural History, University of Kansas.

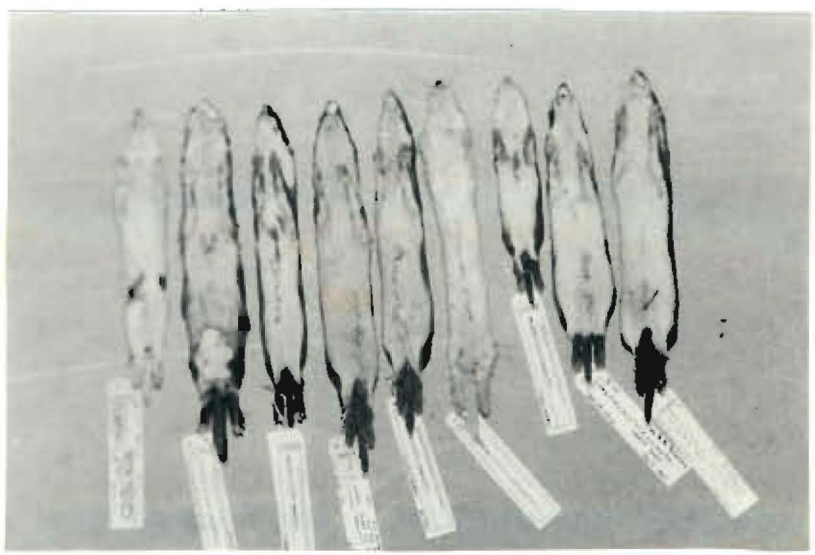

Figure 19. Ventral view of specimens housed at the Museum of Natural History, University of Kansas.

Table 3. Capture locations and capture dates for the photographed specimens of the Museum of Natural History (Fig. 18 and 19) numbered from left to right.

NUMBER	LOCATION	DATE
1	Clay Co.	2-24-76
2	Jefferson Co.	12-10-73
3	Jewell Co.	2-16-68
4	Jewell Co.	8- 8-68
5	Republic Co.	5-14-68
6	Marshall Co.	3-13-64
7	Smith Co.	4-28-66
8	Smith Co.	3- -67
9	Smith Co.	5- 5-66

Republic County, February 1967; Cloud County, no date available, and the study animal from Ottawa County, January 1979, were all in the white winter pelage when captured. This January through March period of white winter pelage is by no means a time during which all least weasels in Kansas are white. Specimens taken from Jewell County, January 1975; Jewell County, February 1968; Smith County, March 1967; Lincoln County, March 1972; Jefferson County, December 1973, and two specimens from Jackson County, March 1978, were all in the brown pelage. Specimens from Osborne County, April 1975; Republic County, May 1972; Smith County, April 1966, Jewell County, February 1968; and Jefferson County, December 1973, had the brown breast markings between the forelegs. This marking appeared in the captive least weasel between June and July. The specimen from Smith County, January 1970, was the only one with a pelage that was obviously undergoing a color change when captured and was mostly white with a tail tipped with black hairs. Mottled brown hair was present on the face, neck and shoulders of this specimen. All other specimens appeared solid in either white or the brown and white pelage, without evidence of mottling or other color patterns which would reveal that color changes were in progress when the animals were captured.

Scat

Scat of the least weasel is usually deposited as two or three short strings approximately 2.0 to 4.0 cm long and about 2.0 to 3.0 mm in diameter. The color is normally dark brown to black, drying to an ash grey (Fig. 20).

The defecation process follows a rather fixed routing. The weasel runs out of hiding to the latrine area, quickly pivots and backs two or

Figure 20. Scat of the captive least weasel.

three steps, lifts the tail and defecates. Swinging the rump out over a log or rock seems to be the preferred position but is not necessary. Only twice, during a period of heavy snow, was the weasel observed burying feces in a method similar to that employed by house cats.

The captive weasel used a definite latrine site throughout the study period. The northeast corner of the observation cage, farthest accessible point from the nest box, was the original latrine. As the sand in this corner became covered with a thin layer of fecal material, the weasel moved its deposits along first the west side and then the north side of the cage. When the fecal material in the northwest corner became dry and crumbly, that corner again became the major feces depository. The nest box was also used for deposition of feces, usually along the corner farthest from the nest. The shape, small size and possible latrine habits might make possible identification of least weasel presence in the wild.

Killing Method and Food Consumption

The least weasel displays a fairly stereotyped kill method and is well adapted for and efficient in the predator role (Heidt, 1972). Upon coming in contact with its prey, the weasel would grab the prey at the back of the neck and bite through the skull. If a chase was necessary the weasel would bite the prey any place on its body and then make the quick neck bite. The least weasel was agile and assumed a variety of contorted body positions. Often the weasel would wrap up the prey, using its body and feet to restrain movement until the prey animal was dead. The weasel did not always hang on to the prey until death occurred. Sometimes a mouse would be bitten and dropped, then "danced around" and "played with" before being eaten. Half-grown or smaller mice would simply be

picked up with the neck bite and carried back to the nest box to be eaten.

When more than one mouse was placed in the cage, usually each would be killed and the weasel would return to the first mouse to feed. Nine mice were placed in the cage during one feeding period. The time required to kill all nine mice was 5.5 minutes. This included carrying five of the mice back to the nest box and eight retreates to the nest box due to noise from a car. Larger prey were not always killed immediately. In many cases cotton rats would not be killed for three or four days and could even enter the nest box for hours at a time. Large adult cotton rats were close to three times the body size of the least weasel but would eventually be killed and eaten if no other food was presented. A juvenile wood rat, lab rats and young lagomorphs were also not killed immediately. When liver was the only food available the offered portions would sometimes be left for almost 24 hours before being eaten.

The brain and head were always eaten first. The nose, teeth and tails were usually not eaten and were often placed outside the nest box. When too much food had been made available the brain and chest cavities were eaten and the remainder would be left to decompose.

The weasel defended its kills with aggressive rushes at an intruding human hand, accompanied by sharp chirps, hissing and a baring of teeth. Even when a finger was placed outside the cage near a freshly killed mouse the weasel would strike, often hitting its teeth on the wire of the cage. To get the weasel into a smaller cage for transportation, a mouse was swung by its tail back and forth in front of the weasel until it struck and held on to the neck. The weasel was then physically swung through

the air and thrown into the open cage, still retaining its grasp on the mouse.

Rodents made up the bulk of the diet for the captive least weasel. One hundred and seventy-one wild rodents were eaten during the 487 day observation period. One hundred and thirty-nine adult and 159 juvenile laboratory mice and six laboratory rats were eaten during the captivity period. Two young cottontail rabbits and three young jackrabbits were also consumed. Forty-seven portions of beef liver, approximately 14 ounces each, were used to supplement the diet during the observation period (Table 4). Two house sparrows were killed but left uneaten. Six lubber grasshoppers were completely ignored for a period of five days and were then removed from the cage. A 21 cm lined snake and a 35 cm great plains rat snake induced flurries of activity by the weasel but neither snake was killed. Only three times during the entire observation period was the weasel observed drinking water from the bowl.

Some of the food items were half-grown or juvenile rodents that were given to the weasel two or three at a time. There were 51 days when the weasel was not fed for a 24-hour period because uneaten food was observed. These uneaten sections of prey, usually the trunk, were left in the nest box and would eventually be consumed by the weasel. Five hundred and twenty-seven food items were consumed over a period of 487 days, resulting in a diet of 1.1 food items per day. It was estimated that the diet was the equivalent of one adult mouse per day.

Behavior Notes

Some specific behaviors of the captive least weasel were of interest. Daytime movements outside the nest box were limited to only one or two

Table 4. Food items consumed by a captive least weasel during 487 days of captivity.

ITEM	NUMBER
Mus musculus (laboratory)	298
Mus musculus (wild)	14
Rattus norvegicus (laboratory)	6
Sigmodon hispidus	35
Peromyscus spp. (*maniculatus* and *leucopus*)	121
Neotoma floridana	1
Sylvilagus floridanus	2
Lepus californicus	3
Liver (approximately 14 oz. per packet)	47
Total	527

periods of searching activity usually accompanied by defecation. There were many days when a careful watch was kept on the cage and no daytime activities were noted. Nighttime observations using a flashlight or red light revealed that many short trips were made outside the nest box. Night activities were irregular and consisted of searching, defacation, grooming and playful activities.

In the early stages of captivity the slightest noise or motion would cause the weasel to scurry back to the nest box. Photo sessions, when the weasel was isolated from its nest box, appeared to induce hyperactivity. During these sessions the weasel would bite at the door to the nest box and run and climb around the cage floor, sides and top. Shrill chirps and hisses were issued if the observer approached within a few feet. At these times a strong musk odor would be detected. After the weasel had resumed normal activity, a soft chortle or trill, much like a high pitched house cat's purr would be given. Exposure to bright light during photo sessions had a pronounced effect on the animal. During one photo session in direct noon sunlight the weasel actually had muscular convulsions accompanied by rapid blinking of the eyes; followed by eventually curling into a ball and appearing asleep.

House cats often perched atop the weasel cage following introduction of live food items. The weasel usually remained in the nest box while a cat was present. When rodents were not immediately killed by the weasel, the cats would sit for long periods of time on the cage. The weasel eventually became accustomed to the cats and would enter the observation cage during their presence. A few instances occurred when the weasel would climb upside down on the wire cage top and try to bite the cats'

tails. Any movement of a cat would send the weasel back to the nest box until the cat was again immobile.

Thunderstorms always brought an increase in weasel activities outside the nest box. The weasel would run, jump and climb over the entire observation cage during these storms. Each corner of the cage would be checked in a searching fashion. Somersaults, climbing upside down, bouncing from wire screen to log and a reckless racing about clearly demonstrated the agility and speed of the least weasel. These "playful" activities were often followed by long periods of grooming with the tongue and teeth. The weasel was observed, apparently asleep, outside the nest box during a period of steady rain. It was constantly parasitized by fleas during the observation period and exposure to the rain might possibly have provided some relief from flea bites.

One interesting observation occurred about 1100 hours on 7 February 1980 after placing an adult cotton rat in the cage. Dry snow had fallen since about 0500 hours and approximately 10 to 12 inches had accumulated in the observation cage. The weasel was not out of the nest box prior to introduction of the cotton rat. For a period of 30 minutes the weasel "played" with the cotton rat. Snow tunnels were formed by digging with the front paws and the weasel would confine the cotton rat between the two tunnel openings at opposite ends of the glass sides. The weasel would nip at the rat from one end of the tunnel. The rat would run to the opposite end of the tunnel and the weasel would be waiting there, ready to nip at the rat again. The cotton rat eventually entered the nest box and the weasel remained in the snow creating new tunnels which extended around the entire observation cage.

The weasel covered its scat with snow after defecating at two different times. This was the only time that fecal material was observed to be covered during the observation period of 487 days. After 40 minutes the cotton rat was chased out of the nest box and the "cat and mouse" activity was resumed for an additional 20 minutes until the weasel retired to the nest box. The cotton rat was not killed until after dark that evening.

The "cat and mouse" behavior was observed infrequently when large quantities of food had been made available. This behavior consisted of chasing a mouse for a short period of time while making occasional nips to cause the mouse to jump or run. The weasel's head and shoulders were sometimes rubbed in the sand either before or after a kill. Bouncing back and forth around a dead mouse, running to all corners of the cage and climbing upside down on the wire screen top of the cage were often associated with post-kill activity.

DISCUSSION

Pelage color change of mustelids is not fully understood. A molt is necessary for a weasel to change color, although an individual may molt without changing color. Duration of the photoperiod appears to be of primary importance in initiating the color change. Temperature is a modifying factor which can affect the rate at which the color change occurs. Both of these environmental factors may be altered by an individual weasel by varying the amount of time spent in the warmth and darkness of the den and the time spent exploring outside the den. Individual weasels from different areas within the species' range do not follow the same pattern of color change; dates of initiation and completion of the change also vary. It is likely that through genetic heterogeneity, environmental stimuli for initiating and controlling color change are not the same for all members of a species throughout its range (Ewer, 1973).

Specimens of Mustela nivalis taken in Kansas at the same time of the year exhibit coat color variation. The captive least weasel underwent a complete color change from winter white to summer brown, an incomplete change from summer brown to winter white and then became brown with the following spring molt. It must be noted that throughout the entire observation period this animal was maintained outdoors with an exposure where the nest box and observation cage were always under the influence of the complete daily photoperiod. Hall (1951) gave examples of a few captive Mustela frenata kept outdoors under similar conditions. Long-tailed weasels were captured in an area where all were known to become white

during the winter. Following immediate transportation to the south where local long-tailed weasels remained brown during the winter, the northern weasels would molt to white. Hall's (1951) investigations of coat color of study skins revealed that there exists a belt across North America from coast to coast in which M. frenata from any single locality may be either white or brown in winter. He did not note color change variations from year to year in any single specimen. Rothschild (1942, 1944) reported a similar situation for Mustela erminea in England, however, the line of demarcation between populations exhibiting habitual whitening and those that remain brown in winter was more irregular than in North America. Rothschild (1944) stated that variation occurs between individuals and also from year to year in the same specimen. Hutchinson and Parker (1978) suggested that there must be introgression from both the north and south which maintains a genetically polymorphic population in the zone where whitening occurs irregularly. There is no southern population of North American least weasels that remains brown in the winter year after year. Hall (1951) described the incomplete or delayed fall molt of specimens of the subspecies M. nivalis allgheniensis from the southeastern part of M. nivalis range. These specimens were taken in winter with either brown or white pelage and the time of molt into winter pelage was irregular. Each of 11 specimens taken in January, February and March from Pennsylvania, Michigan and Ohio was mostly white with brown on the head and along the midline of the dorsum. Hall (1951) considered this brown hair as the remains of the summer pelage. In the captive least weasel these areas of the body were ones in which new brown hair of the spring molt occurred. It is possible that specimens that Hall

examined had molted to white earlier than Hall suspected and that the skins were taken when in the early process of the spring molt. Easterla (1970) reported specimens of northwestern Missouri and southwestern Iowa were captured in either brown, white or a transition pelage during primarily winter months over a period of six years. These weasels, like those from Kansas, represent a portion of the southern boundary for the species in North America.

Causes for the incomplete fall color change from brown to white in the study animal are unknown. The animal was maintained outdoors so the 1979-80 winter photoperiod would have been similar to the previous winter when the least weasel was captured in full white pelage. The season of the incomplete color change (1979-80) was milder in many respects than the 1978-79 winter. Temperatures did not remain at extreme lows over long periods as they had the previous year; snowfall and corresponding snow-lie was also less. It is not possible to state that seasonal variations of temperature and snow were totally responsible for the incomplete color change. Modifications of the weasel's behaviors imposed by captivity could have altered or controlled actions of the pituitary gland in response to day-length stimuli received through the eyes. Bissonnette and Bailey (1944) experimented with M. frenata and M. erminea and demonstrated that photoperiod does affect the time of molt. Hall (1951) accepted studies of the ferret by Bissonnette and the varying hare by Lyman as showing that the stimulus required to initiate molting is received through the eyes, and those of Wright using M. erminea and M. frenata to illustrate that a gonadotrophic hormone produced by the pituitary gland can be responsible for the molt and color change of weasels. Temperature was considered by Rust (1962) as a

modifier of M. erminea color change. Although temperatures did not determine whether or not Rust's weasels exhibited a color change, it did alter the speed at which the change occurred. Bissonnette (1942) and Bissonnette and Bailey (1944) suggested that a lowering of temperature could change the habits of a weasel, resulting in reduction of activities, and therefore reduction of exposure to normal daylight. Rothschild (1944) agreed with these views on the basis of her experiments with manipulation of both photoperiod and temperature on captive M. erminea specimens.

The recent range extension of M. nivalis into Kansas, Missouri and southern Iowa is documented (Easterla, 1970 and Choate et al., 1979). Hall (1951) expressed the opinion that M. nivalis was a later arrival to the United States than was M. erminea. M. erminea was thought to have invaded the western United States prior to M. nivalis and acquired a reduction in body size during its southward extension; this would have placed the two species in competition for similar food items. M. nivalis and M. erminea are sympatric in northern North America, yet in these areas there is sufficient difference in body size to substantially reduce any competition for food. M. nivalis followed the movements of M. erminea southward, was stopped short at the northern boundary of the region in which M. erminea was of small size, and continued eastward and southward into the Appalachian region of the eastern United States where M. erminea was not present, and no other small carnivore existed to offer competition (Hall, 1951). The recent range extension of M. nivalis into the midwest and great plains regions of the United States where M. erminea is absent serves to reinforce Hall's

line of thinking. It may be inferred that irregularity of the M. nivalis color change along its southern range boundary may be associated with Hall's (1951) proposals for the southward extension of the species from more northern areas.

The southern boundary for the North American range of the least weasel, M. nivalis, (Hall and Kelson, 1959) is quite similar to the zone where M. frenata could be found in either brown or white winter pelage as shown by the map of Hall (1951). The southern range boundary of M. nivalis could therefore be considered quite similar to the zone of introgression in populations of genetically polymorphic M. frenata as applied to Hall's (1951) findings by Hutchinson and Parker (1978). Pelage information concerning M. nivalis from Kansas, Missouri and southern Iowa, all a part of the southern range boundary, shows much variation in the winter whitening characteristic. Hutchinson and Parker (1978) stated that environmental changes influencing a polymorphic population could change selection for or against whitening. Rapid changes in selection for the whitening character in this case could be controlled by dominant or recessive genes. As long as the alleles of both genes are present in the population there would always be some less well-adapted phenotypes available for an environmentally determined change in selection. Hutchinson and Parker (1978) maintained that for this mechanism to be effective the rate of selection must not be so great as to cause complete removal of one allele from the population before another environmental change can take place.

It appears possible that the zone of introgression between winter white and winter brown populations of M. frenata in North America and M. erminea of England are similar to the southern boundary for the

North American distribution of M. nivalis. There is no southern population of winter brown M. nivalis to substantiate this. At present, the southern boundary population is composed of individuals that may be brown or white during the winter, or even vary between brown and white from year to year. It is reasonable to assume, however, that the winter whitening characteristic of M. nivalis may be subjected to varying selection pressures imposed by the variable winter conditions present in the great plains and midwest.

SUMMARY

1. A study of a captive Mustela nivalis was conducted from 25 January 1979 through 12 June 1980. The study was undertaken to increase the information concerning Kansas least weasels, in particular the sequence of pelage color change exhibited by an individual representing the southern range boundary population in North America.

2. The least weasel was maintained outdoors in a large observation cage exposed to ambient daylength and weather conditions. A nest box was available at all times for shelter. Human contact with the study specimen was restricted to avoid modifying behavior.

3. The least weasel underwent a complete color change from white to brown, an incomplete color change from brown to white and a complete change back to brown during the observation period.

4. It was concluded that the captive least weasel showed seasonal variation of pelage color change. Study skins of other Kansas M. nivalis specimens showed that variation exists among individuals of the population. M. nivalis of Kansas may represent a genetically polymorphic population for which the characteristic of coat color change is subjected to changes of selection for whitening due to the environmental stresses imposed by the variable climate of the great plains.

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