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## IDENTIFICATION OF MAMMAL TRACKS FROM SOOTED TRACK STATIONS IN THE PACIFIC NORTHWEST<sup>1</sup>

CATHY A. TAYLOR

Pacific Southwest Forest and Range Experiment Station  
1700 Bayview Drive  
Arcata, California 95521

and

MARTIN G. RAPHAEL

Rocky Mountain Forest and Range Experiment Station  
222 South 22nd Street  
Laramie, Wyoming 82070

Sooted aluminum tracking stations were used to investigate distribution patterns of medium and large mammals in Douglas-fir forest in northwestern California. Track stations consisted of two adjacent aluminum sheets covered by a thin layer of kerosene soot with a central bait. Stations were located at 166 sites and monitored for eight-day periods between 1 July and 15 September in 1981, 1982, and 1983. Tracks from 23 species were preserved with transparent tape and up to seven measurements were recorded. We found track impressions on the hard surface to be much smaller and more detailed than those in soil or snow; available measurements and drawings in field guides were useless for identification purposes. Therefore we present a standard method of measurement and a key to distinguish the tracks of medium to large sized mammals from sooted track stations in the Pacific Northwest.

### INTRODUCTION

Wildlife biologists have used various tracking techniques to assess mammal populations. The most common method is to attract animals to a baited station where tracks are detected in fine soil or snow (Cook 1949; Wood 1959; Linhart and Knowlton 1975; Lindzey, Thompson, and Hodges 1977). However, this technique is infeasible in areas where soils are rocky and fine soil cannot be easily transported (Barrett 1983). A sooted surface was first used by Mayer (1957) to track small mammals. Further modifications were made by Justice (1961) and Lord et al. (1970) to investigate small mammal populations. Barrett (1983) expanded the use of a sooted aluminum surface to determine the distribution of martens, *Martes americana*, and other carnivores in the Sierra Nevada. This method was used on a larger scale in the present study to investigate distribution patterns of medium and large mammals in Douglas-fir forests in northwestern California (Raphael and Barrett 1984). Tracks on a hard surface provided by aluminum track plates differ markedly in size and shape from those in softer substrates such as snow or fine soil, appearing much smaller and providing much more detail. As a result, measurements and drawings in available field guides are unreliable and confusing. Increasing numbers of researchers are using this method and a standardization of the technique is required. Therefore we present a standard method of measurement (Figure 1, Table 1) and a key to distinguish the tracks of medium to large sized mammals from aluminum track plates in the Pacific Northwest. The list of mammals

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presented here is incomplete, as field work was restricted to forested areas of Northwestern California. We recommend that additional tracks and measurements be made available as they are identified.

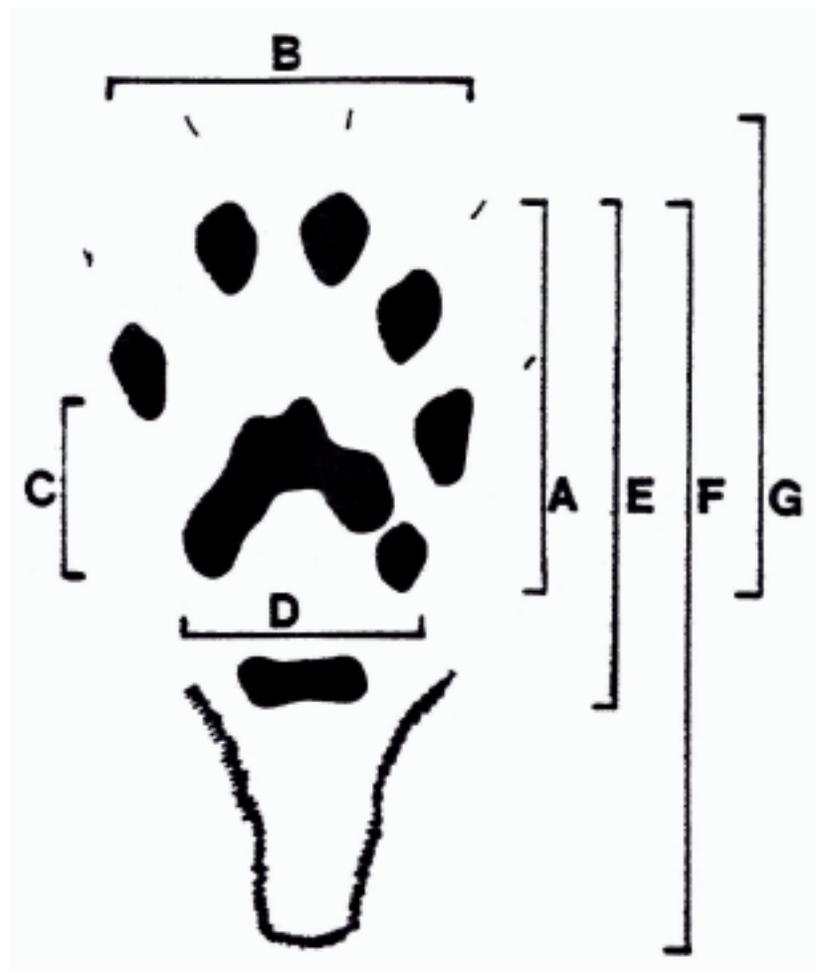


FIGURE 1. Standard measurements taken on all distinct tracks were as follows: A-Longest vertical line drawn from distal edge of foremost toe to back edge of palm pad; B-Horizontal line measuring widest spread of toes; C-Height of the palm pads; D-Width of palm pads; E-Vertical distance from foremost toe to back edge of heel pad; F-Distance from foremost toe to end of heel mark; G-Distance from foremost claw to back of palm pad.

TABLE 1. Means and 95% Confidence Intervals<sup>1</sup> for Track Measurements (mm)<sup>2</sup>.

Species		FORE FOOT				HIND FOOT			
		X	N	SD	95% C.I.	X	N	SD	95% C.I.
<i>Didelphis virginiana</i> .....	A	20.5	2	0.7	20-21	21.0	1		
	B	35.5	2	0.7	35-36	40.0	1		
	C	10.0	2	1.4	9-11	8.0	1		
	D	16.0	2	1.4	15-17	21.0	1		
<i>Tamias</i> spp.....	A	13.3	58	1.6	12.9-13.7	14.5	41	1.1	14.2-14.9
	B	14.7	58	2.0	14.1-15.2	16.6	40	2.2	15.8-17.3
	C	5.4	58	1.0	5.1-5.6	6.0	41	0.8	5.8-6.3
	D	6.5	58	0.8	6.3-6.7	8.3	41	1.0	8.0-8.7
	E	18.1	56	2.1	17.5-18.6				
	F					17.7	3	1.2	17-19

TABLE 1. Means and 95% Confidence Intervals<sup>1</sup> for Track Measurements (mm)<sup>2</sup>--Continued

Species		FORE FOOT				HIND FOOT			
		X	N	SD	95% C.I.	X	N	SD	95% C.I.
<i>Spermophilus beecheyi</i> .....	A	20.9	44	1.8	20.3-21.4	24.2	42	2.1	23.5-24.8
	B	19.0	44	2.6	18.2-19.8	23.8	42	4.1	22.5-25.1
	C	8.0	44	1.1	7.7-8.3	9.7	42	1.4	9.3-10.2
	D	10.4	44	1.5	10.0-10.9	14.1	42	1.9	13.5-14.6
	E	28.5	44	2.7	27.6-29.3				
	F					37.9	9	4.0	34.8-41.0
	G	27.9	7	3.8	24.4-31.3	30.9	12	4.2	28.2-33.6
<i>Spermophilus lateralis</i> .....	A	14.7	6	2.7	11.9-17.5	16.3	6	1.9	15.3-17.4
	B	13.3	6	2.4	10.8-15.9	14.5	6	1.9	12.5-16.5
	C	5.8	6	1.2	4.6-7.1	6.3	6	1.4	4.9-7.8
	D	6.5	6	1.4	5.1-8.0	8.7	6	1.5	7.1-10.3
	E	20.4	5	1.8	18.2-22.7				
<i>Sciurus griseus</i> .....	A	30.6	20	1.8	29.7-31.4	35.1	16	2.3	33.9-36.3
	B	26.6	20	2.8	25.3-27.9	35.4	16	6.4	32.0-38.8
	C	11.4	20	1.7	10.6-12.2	13.9	16	2.1	12.8-15.1
	D	13.6	20	1.7	12.7-14.4	19.3	16	2.1	17.8-20.8
	E	42.2	19	2.1	41.1-43.2				
	F					58.0	2	1.4	57-59
	G					41.0	2	1.4	40-42
<i>Tamiasciurus douglasii</i> .....	A	20.5	63	2.9	19.7-21.2	21.7	47	2.2	21.1-22.3
	B	20.2	63	2.8	19.5-20.9	23.9	47	4.1	22.7-25.1
	C	7.7	63	1.1	7.5-8.0	8.5	47	1.4	8.1-8.9
	D	9.2	63	1.1	8.9-9.5	11.8	47	1.7	11.3-12.3
	E	26.9	59	3.9	25.9-27.9				
	F					30.8	4	4.0	26-35
	G	26.2	5	5.0	22-33	27.3	10	3.7	24.6-30.0
<i>Glaucomys sabrinus</i>	A	14.2	49	1.4	13.8-14.6	14.3	69	1.1	14.1-14.6
	B	12.9	49	2.3	12.2-13.5	15.1	69	2.6	14.5-15.7
	C	5.0	49	0.7	4.8-5.2	6.0	69	1.1	5.8-6.3
	D	6.6	49	0.7	6.4-6.8	9.4	69	1.0	9.1-9.6
	E	19.5	48	1.3	19.1-19.9				
	F					31.3	12	3.3	29.3-33.4
	G	17.0	1			16.3	4	1.5	14-17
<i>Neotoma fuscipes</i> .....	A	12.6	29	1.3	12.1-13.1	14.9	24	1.6	14.2-15.6
	B	15.1	29	1.7	14.4-15.7	16.7	24	2.7	15.6-17.9
	C	5.9	29	0.6	5.7-6.1	7.3	24	1.3	6.7-7.8
	D	7.5	29	0.9	7.1-7.8	8.0	24	1.1	7.5-8.4
	E	16.9	29	2.6	15.9-17.9	21.0	19	3.1	19.4-22.5
<i>Erethizon dorsatum</i> .....	C	47.7	3	2.1	46-50				
	D	35.7	3	2.3	33-37				
<i>Canis latrans</i> ..	A	67.0	1						
	B	50.0	1						
	C	36.0	1						
	D	31.0	1						
	G	71.0	1						
<i>Urocyon cinereoargenteus</i> .....	A	34.7	52	2.7	34.0-35.5				
	B	33.8	52	3.2	32.0-34.7				
	C	12.3	52	2.3	11.7-13.0				
	D	18.7	52	2.2	18.1-19.3				
<i>Ursus americanus</i> .....	A	100.6	56	9.9	97.9-103.2	110.0	22	21.2	100.6-119.3
	B	105.3	56	8.8	102.9-107.6	99.4	22	12.4	93.9-104.9
	C	49.1	50	8.9	46.5-56.4	62.6	20	20.7	52.8-72.2
	D	88.9	50	11.1	85.8-92.1	83.9	20	15.3	76.8-91.0
<i>Bassariscus astutus</i> .....	A	24.0	23	1.7	23.3-24.8				
	B	21.6	23	2.8	20.4-22.8				
	C	12.4	23	1.6	11.7-13.1				

TABLE 1. Means and 95% Confidence Intervals<sup>1</sup> for Track Measurements (mm) <sup>2</sup>.-Continued

Species	FORE FOOT				HIND FOOT				
	X	N	SD	95% C.I.	X	N	SD	95% C.I.	
<i>Procyon lotor</i> .....	D	14.0	23	1.9	13.1-14.8				
	A	45.8	5	4.3	40-52	48.8	4	1.5	47-50
	B	36.6	5	3.5	33-42	37.3	4	5.5	32-45
	C	24.2	5	1.6	22-26	26.5	4	1.7	24-28
	D	25.4	5	1.1	24-27	25.3	4	2.8	22-28
<i>Martes americana</i> .....	E				67.0	3	7.9	61-76	
	A	32.5	8	4.5	29.5-35.5	32.8	4	2.2	30-35
	B	30.8	8	5.3	27.2-34.4	31.8	4	4.2	29-38
	C	12.4	8	2.6	10.7-14.1	13.0	4	1.4	12-15
	D	16.0	8	3.8	13.5-18.5	18.3	4	2.6	16-22
<i>Martes pennanti</i> .....	E	45.1	3	8.7	35-50				
	A	45.9	14	5.1	42.9-48.8	46.7	16	3.5	44.8-48.6
	B	44.4	14	4.9	41.6-47.2	42.9	16	4.9	40.3-45.6
	C	20.5	14	5.0	17.6-23.4	19.6	16	3.5	17.7-21.4
	D	25.4	14	4.3	22.9-27.8	26.6	16	4.1	24.4-28.8
<i>Mustela erminea</i> .....	E	72.5	2	5.0	70-75	58.0	5	7.0	49.4-66.7
	A	11.0	6	1.7	9.6-12.4	11.0	2	0	11-11
	B	13.5	6	2.0	11.2-15.8	16.0	2	1.0	15-17
	C	4.2	6	1.1	3.4-5.0	5.0	2	0	5-5
	D	5.2	6	1.6	4.0-6.5	5.0	2	0	5-5
<i>Mustela frenata</i> .....	E	19.5	3	1.5	18-21				
	A	15.4	5	0.5	15-16	14.5	2	0.7	14-15
	B	14.6	5	0.5	14-15	20.5	2	0.7	20-21
	C	6.4	5	0.5	6-7	4.5	2	0.7	4-5
	D	8.4	5	0.9	7-9	8.0	2	0	8-8
<i>Mustela vison</i> .....	E	19.3	3	0.6	19-20				
	A	26.9	8	2.7	25.1-28.7	28.5	4	2.1	26-31
	B	29.5	8	2.3	28.0-31.0	28.3	4	2.1	26-30
	C	12.0	8	2.1	10.5-13.5	10.3	4	1.7	8-12
	D	13.5	8	2.1	12.0-15.0	14.5	4	1.3	13-16
<i>Spilogale gracilis</i> .....	E	40.9	8	2.2	39.4-42.4				
	A	17.9	33	2.0	17.2-18.6	19.1	36	2.0	18.4-19.8
	B	16.9	32	2.4	16.1-17.8	17.8	36	2.1	17.1-18.5
	C	7.6	33	1.4	7.1-8.1	8.4	36	1.3	7.9-8.8
	D	10.6	33	2.0	9.9-11.3	12.1	36	2.2	11.3-12.8
<i>Mephitis-mephitis</i> .....	E	23.7	20	2.8	22.4-24.9	25.7	32	2.4	24.9-26.6
	A	24.3	7	1.6	22.8-25.8	29.3	4	4.4	25-33
	B	23.9	7	2.7	21.4-26.3	25.8	4	4.5	22-31
	C	11.6	7	1.3	10.4-12.8	15.5	4	3.5	12-19
	D	17.9	7	2.0	16.0-19.7	19.7	4	4.4	15-24
<i>Felis concolor</i> .....	E	36.0	2	1.4	35-37	40.3	4	6.1	34-46
	A	77.5	2	17.7	65-90				
	B	74.5	2	7.8	69-80				
	C	40.5	2	7.8	35-46				
	D	50.5	2	0.7	50-51				
<i>Felis rufus</i> .....	A	37.0	2	0	37-37				
	B	38.5	2	0.7	38-39				
	C	14.5	2	0.7	14-15				
	D	19.5	2	0.7	19-20				

<sup>1</sup> Actual ranges were used when sample size n ≤ 5.  
<sup>2</sup> Codes for track measurements follow those outlined in Fig. 1.

## METHODS AND MATERIALS

Track stations consisted of two adjacent 814 X 407 X 0.6 mm aluminum sheets covered by a thin layer of kerosene soot and baited with a can of tuna pet food (described by Barrett 1983) . We checked each of 135 stations for an 8-day period between 1 July and 15 September during 1981, and 166 stations during the same period in 1982 and 1983. Tracks were preserved in the field by firmly pressing transparent tape over them, then transferring the tape to a white data sheet. We recorded up to seven measurements for each track; distinguishing front and hind tracks. Tracks of 23 species were collected.

All track stations were located in the Klamath Mountains in Humboldt, Trinity, and Siskiyou counties in northwestern California. All forest stands were dominated by Douglas-fir, *Pseudotsuga menziesii*, in association with tanoak, *Lithocarpus densiflora*, and Pacific madrone, *Arbutus menziesii*.

### KEY TO MAMMAL TRACKS ON SOOTED ALUMINUM TRACKING STATIONS IN THE PACIFIC NORTHWEST

- I. FOUR TOES ON FORE FEET (FF) AND HIND FEET (HF) (Figure 2)
- A. CANIDAE: General shape is oval with the toes approximately  $\frac{1}{2}$  the size of the palm pad. Latter bi- or tri-lobed on posterior border, uni-lobed on anterior end. Fore foot slightly larger than similarly shaped hind foot, toes spread more widely on the forefoot.
    1. *Canis latrans* (Coyote): Large dog track, greater than 40 mm in length and width. Claw marks present.
    2. *Urocyon cinereoargenteus* (Gray fox): Small dog track in which the claws do not register. Palm pad small, anterior end rarely extends to a line drawn at halfway point on the posterior toes. Posterior end lacks protruding lobes found in bobcat track.
  - B. FELIDAE: Tracks generally round or slightly oval. Palm pad is larger than that of the Canidae in relation to toes, which are approximately  $\frac{1}{3}$  the size of the palm print. Tri-lobed on posterior end and bi-lobed on anterior end, the palm pad extends to or past halfway point on posterior toe prints. Claws do not register, prints of fore and hind feet are similar.
    1. *Felis concolor* (Cougar): Large cat track greater than 60 mm in length and width.
    2. *Felis rufus* (Bobcat): Small round track, about 38 mm in length and width. Posterior end of palm pad exhibits rounded, protruding lobes.
- II. FOUR TOES ON FORE FEET, FIVE TOES ON HIND FEET (Figure 3)
- A. SCIURIDAE: Squirrels of the Pacific Northwest exhibit following pattern: fore track has four toe pads, followed by three palm pads and two heel pads. Hind track has five toe pads followed by four palm pads in an arc.
    1. *Tamias* spp. (Chipmunk): Small squirrel track, similar in size to *Glaucomys sabrinus* and *Spermophilus lateralis* Species of chipmunk present must be determined through trapping.
 

FF: Central palm pad appears as one large pad while outer palm pads and heel pad are roughly kidney-shaped.

HF: Palm pads are kidney-shaped and are arranged in an exaggerated crescent shape. Toes irregularly spaced.

2. *Glaucomys sabrinus* (Northern flying squirrel): Size is similar to *Tamias* spp. and *Spermophilus lateralis*.  
 FF: Central palm pad is irregularly shaped or oval and outer pads are oval. Inner heel pad is twice the size of outer pad.  
 HF: Toe and palm pads are distinctly oval. Four palm pads occur in a smooth gradual arc and are evenly spaced. Three inner toes are evenly spaced in a tight linear array.
  3. *Spermophilus lateralis* (Golden-mantled ground squirrel): Similar to previous two species.  
 FF: Palm and heel pads are more obviously kidney-shaped than in previous two species and the central pad is T-shaped.  
 HF: Palm pads are triangular in shape, the third palm pad extending forward of the second in a lopsided arc.
  4. *Spermophilus beecheyi* (California ground squirrel): Similar in size to *Tamiasciurus douglasii*.  
 FF: Palm pads larger than toe pads; irregularly shaped.  
 HF: Palm pads larger than toe pads; irregularly shaped.
  5. *Tamiasciurus douglasii* (Douglas' squirrel): Medium-sized squirrel track, similar in size to *Spermophilus beecheyi*.  
 FF: Palm pads oval to round, similar in size to toe and heel pads.  
 HF: Palm pads and toe pads oval, similar in size to toe pads.
  6. *Sciurus griseus* (Western gray squirrel): Largest squirrel track.  
 FF: Palm pads irregularly shaped.  
 HF: Palm pads irregularly shaped. May register a long narrow heel pad on interior side of foot. This is the only squirrel to exhibit this auxiliary pad.
- B. CRICETIDAE: *Neotoma fuscipes* (Dusky-footed woodrat): Toes leave a distinct figure-eight pattern.  
 FF: Central pad of three palm pads is T-shaped while outer pads are exaggerated kidney-shaped. Three small, round heel pads occur in a row just posterior to palm pads.  
 HF: Three palm pads and three heel pads occur in groups of three, then two, then one. Central palm pad is T-shaped while all others are kidney-shaped.
- III. FIVE TOES ON FORE AND HIND FEET (Figure 4)  
 Members of the families Didelphidae, Erethizontidae, Ursidae, Procyonidae, and Mustelidae exhibit this pattern.
- A. *Didelphis virginiana* (Virginia Opossum): This odd track is easily distinguished.  
 FF: Five toes form a half circle around exaggerated crescent-shaped palm pad.  
 HF: First toe is widely separated from the other toes, points below palm pad on inner side of foot.
  - B. *Erethizon dorsatum* (Porcupine): This odd track is immediately recognizable. Toes rarely are evident; large, oval palm pads have a pebbled texture. Fore and hind prints are similar.

- C. *Ursus americanus* (Black bear): Largest track in the Pacific northwest. Toes form gentle arc over large palm pad.  
FF: One large crescent-shaped palm pad.  
HF: One large, elongate palm pad.
- D. *Bassanscus astutus* (Ringtail): Fore and hind feet leave similar impressions. Palm pad registers one large pad; very small second pad may appear posteriorly near the small first toe.
- E. *Procyon lotor* (Raccoon): Five elongated toe impressions.  
FF: The palm pad is thick and wide and usually appears as three to five large pads.  
HF: Large palm pad is crescent shaped, may appear as a multi-lobed pad or four distinct pads. Smaller pad appears posterior to the palm pad on the outer side of the foot.
- F. *Martes pennanti* (Fisher): Large weasel-like track greater than 40 mm in length and width. Toe prints are circular to oval, palm pad leaves a crescent-shaped impression.  
FF: Small secondary palm pad occurs below first toe. A wide, thin heel pad lies posterior to the crescent-shaped palm pad.  
HF: Similar to forefoot; no heel pad.
- G. *Martes americana* (Marten): Similar to the fisher track, a male marten's track may overlap in size with a female fisher track. Marten track generally more hairy than fisher track, small first toe may not leave an impression. The palm pads register as three distinct pads.
- H. *Mustela visor* (Mink), *Mustela frenata* (Long-tailed weasel), *Mustela erminea* (Ermine): These tracks exhibit the same pattern and may overlap in size. Five toes usually are evident though the first toe is smaller than the others. There are three palm pads, and heel pads rarely appear on forefoot track, resulting in similar fore and hind tracks.
- I. *Spilogale gracilis* (Western spotted skunk):  
FF: Three to four pads, central pad heart-shaped. Two small heel pads register posterior to the palm pads. Claw marks occur well past the toes.  
HF: Typically show: four palm pads and two heel pads. Larger palm pad is heart-shaped while other pads are oblong and more elongate than in the fore foot. Claw marks appear close to the toes.
- J. *Mephitis mephitis* (Striped skunk):  
FF: Five toes are oblong, large palm pad is wider than long. Elongated claws always leave scratch marks well past toes.  
HF: Large palm pad is adjoined by one or two round heel pads.

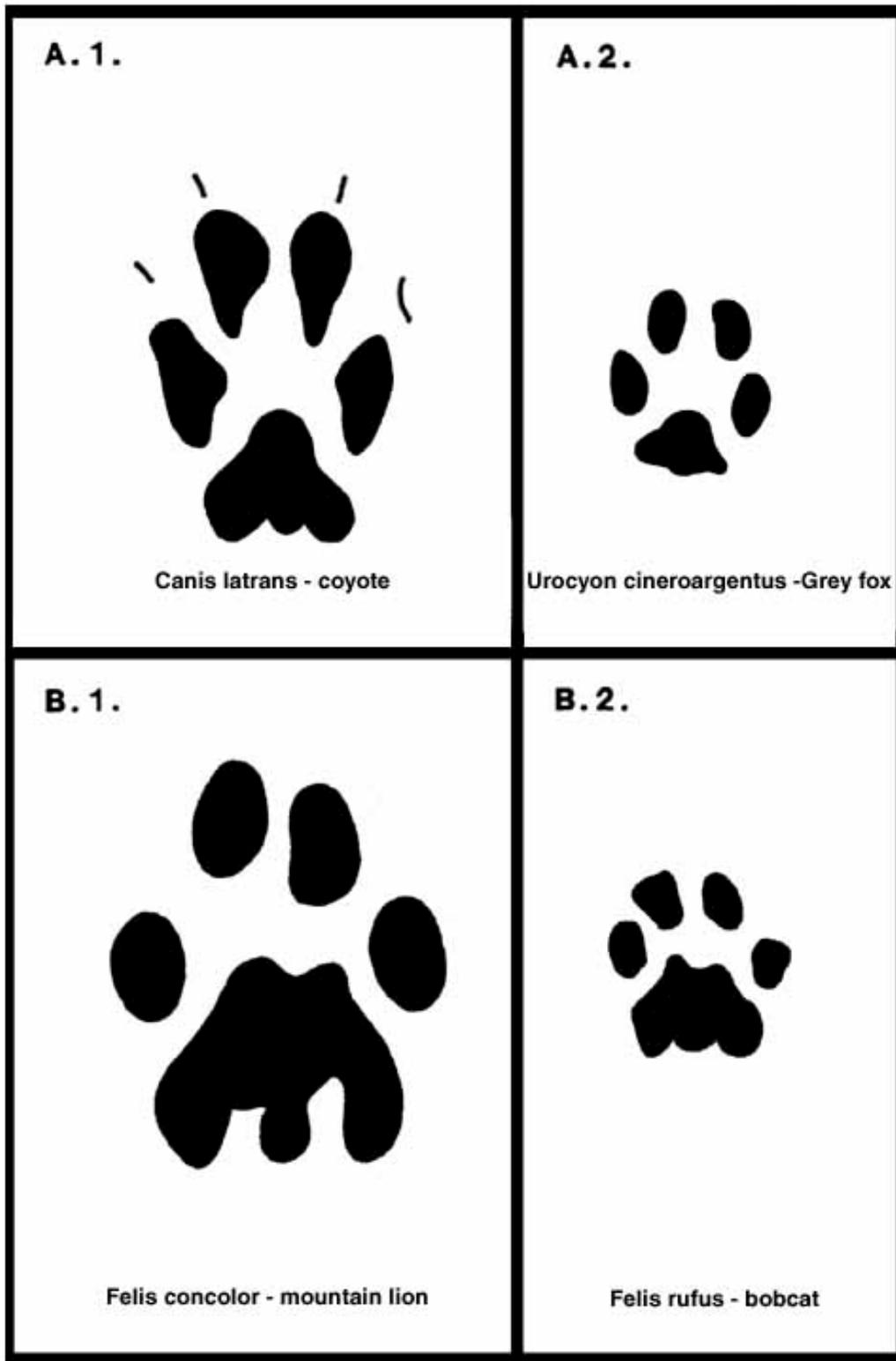


FIGURE 2. Mammals with four toes on fore feet and hind feet. A.1. *Canis latrans* A.2. *Urocyon cinereoargenteus* B.1. *Felis concolor* B.2. *Felis rufus*.

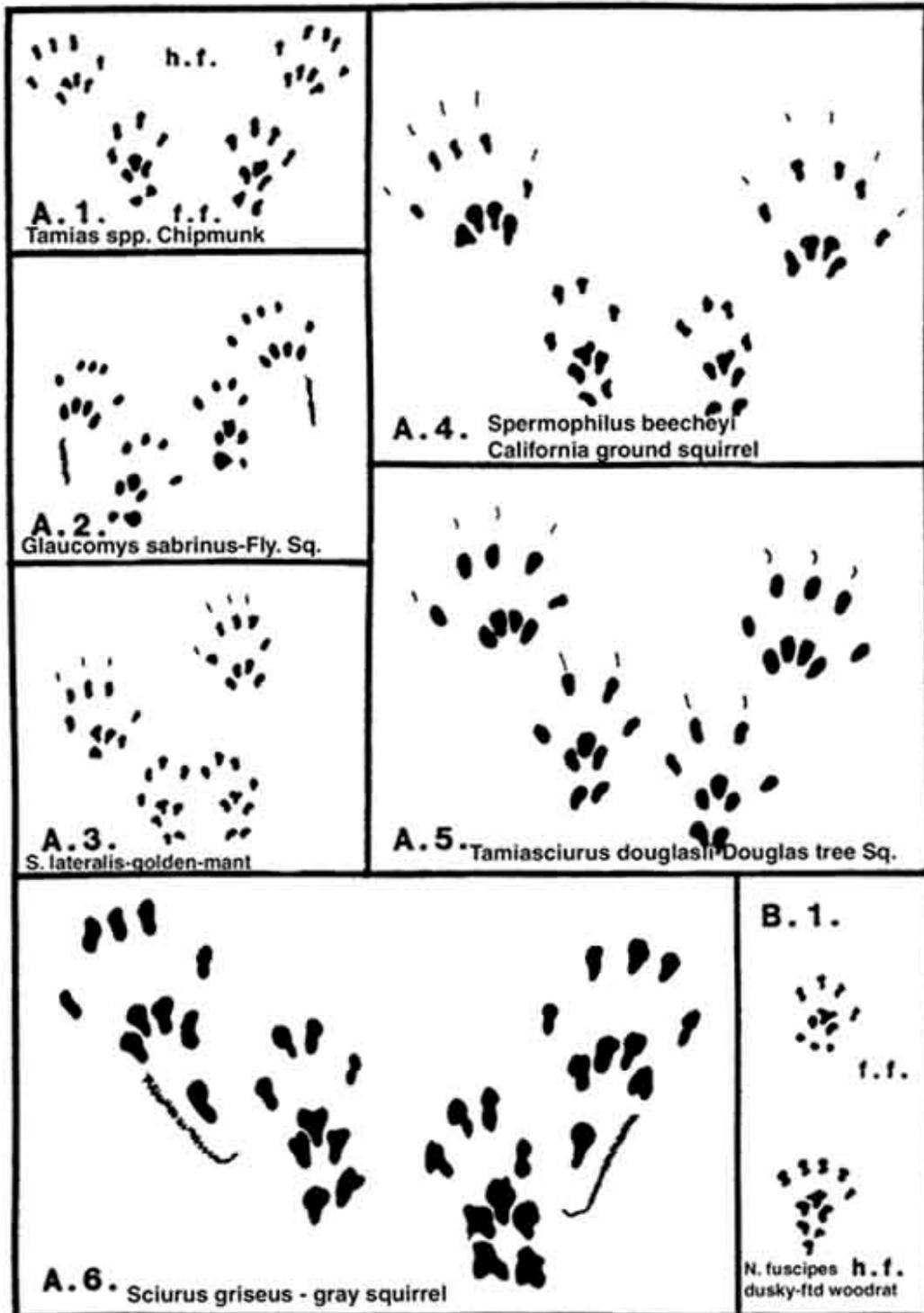


FIGURE 3. Mammals with four toes on fore feet and five toes on hind feet. A.1. *Tamias* spp. A.2. *Glaucomys sabrinus* A.3. *Spermophilus lateralis* A.4. *Spermophilus beecheyi* A.5. *Tamiasciurus douglasii* A.6. *Sciurus griseus* - gray squirrel B.1. *Neotoma fuscipes*. Tracks A.2. through A.6. exhibit the same pattern as that of A.1. (f. f. = fore feet; h.f. = hind feet).

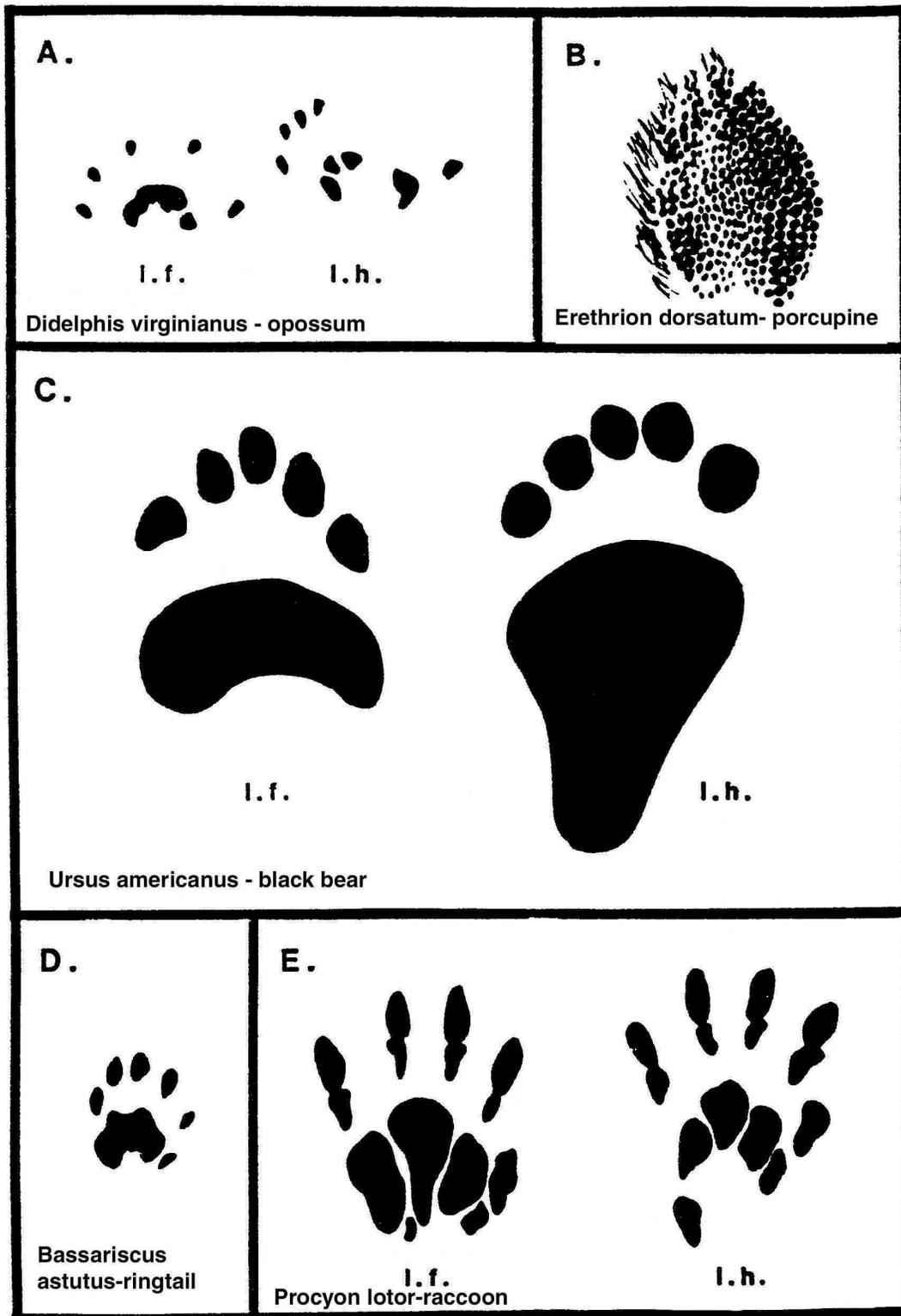


FIGURE 4. Mammals with five toes on fore and hind feet. A. *Didelphis virginiana* B. *Erethizon dorsatum*. C. *Ursus americanus* D. *Bassariscus astutus* E. *Procyon lotor*. (continued)

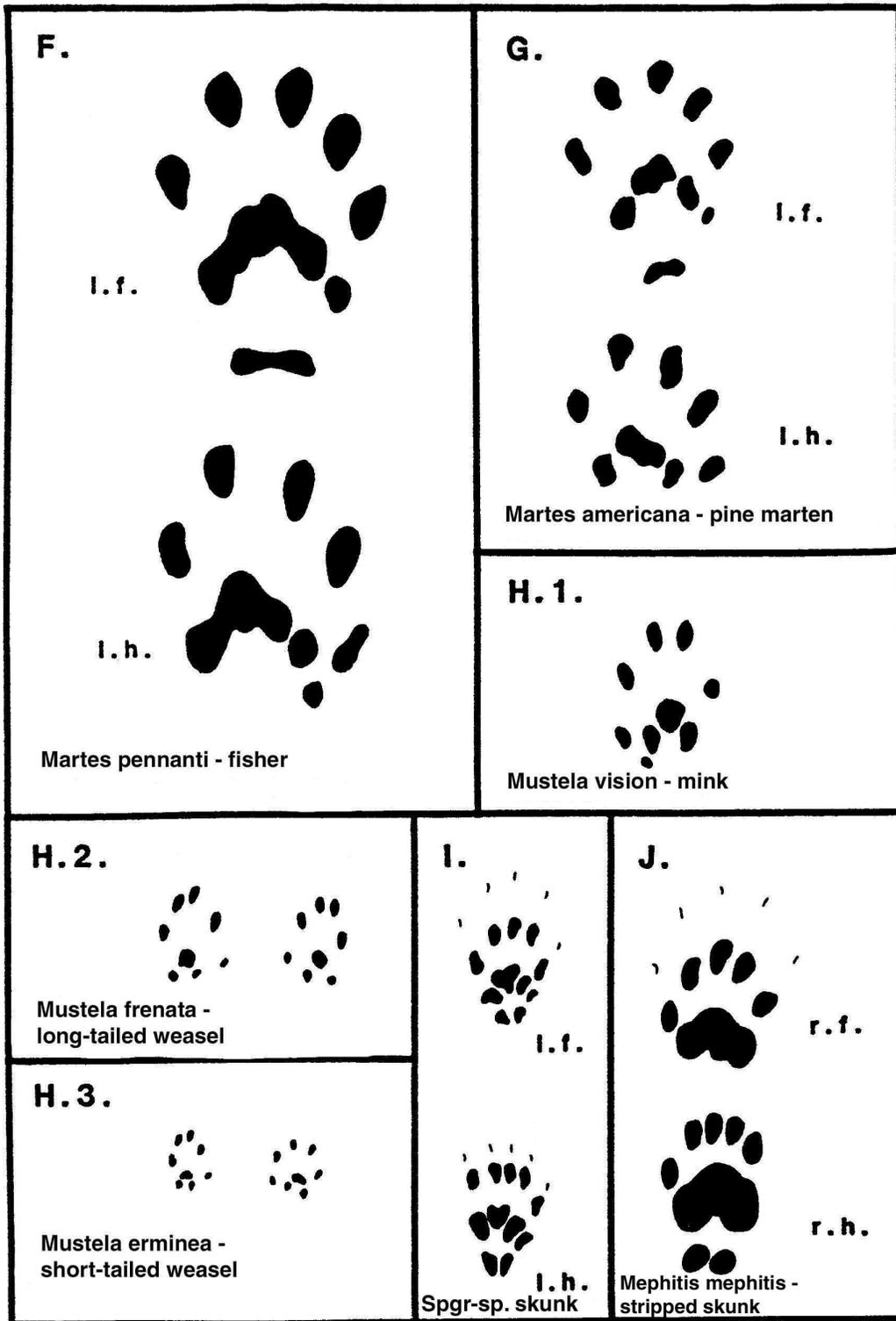


FIGURE 5. (continued) F. *Martes pennanti* G. *Martes americana* H.1. *Mustela vison* H.2. *Mustela frenata* H.3. *Mustela erminea* I. *Spilogale gracilis* J. *Mephitis mephitis*. (l.f. = left fore; l.h. = left hind; r.f. = right fore; r.h. = right hind).

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