http://scotcats.online.fr/abc/identification/pumadogtracks.html

A report in the Isle of Wight County Press on 6 th May 1994 stated:

Casts of large paw prints taken in a garden at St. John's Wood Road, Ryde, were sent by naturalist Martin Trippett to Dr. Karl Shucker for identification. The prints measured 4 by 4.5 inches and showed no claws. Karl identified the prints as canine rather then feline, and Ryde police were able to confirm that a Great Dane had been reported missing in the area on the previous day. Which proves yet again that the presence or absence of claws cannot be used as a definite indicator of their origin.

The following is an excellent paper which discussed just that problem.

Differentiating Mountain Lion And Dog Tracks

by K. Shawn Smallwood And E. Lee Fitzhugh

Department of Wildlife and Fisheries Biology
University of California, Davis

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Introduction

Mountain lions (*Felis concolor*) are cryptic and occur sparsely, so sportsmen, managers, and researchers use their tracks to determine presence and relative abundance (Fitzhugh and Gorenzel 1985, Kutilek et al. 1983, Shaw 1988). Yet, many people, including trained wildlife biologists, have difficulty differentiating between lion and dog tracks (Belden, 1978). This is perfectly understandable as dog tracks vary greatly in shape and size and many are similar to lion tracks. In California, at least 9.5% of volunteers conducting a statewide track survey could not tell them apart (Smallwood and Fitzhugh, unpublished data), even though most volunteer teams included a wildlife biologist. Thus, people often question the use of tracks in mountain lion research and management. Tracking can be an important and inexpensive tool for lion study, but it must be used accurately. This paper examines currently used dog and lion track discriminators, compares them to our observations from the field, and presents the first effort to apply multivariate techniques to distinguish dog from lion tracks. This paper is relevant only for tracks from dust or firm mud because we have little experience with tracking in snow and we have observed serious track distortion in soft mud. The result is a reliable field key and office procedure.

Possible Causes for Misidentification

Illustrative and descriptive errors depicting mountain lion tracks in publications may contribute to misidentifications. A few traits of tracks we observed in the field are consistently misrepresented in publications (except Belden 1978, Downing 1979, and Downing and Fifield 1986). Our field experience was in California, but lions from other states may differ genetically and

morphologically, thus they may leave tracks that look different. However, the same method we used for differentiation can be applied elsewhere to overcome possible geographical variations.

Current Techniques Used for Lion and Dog Track Discrimination

Current literature includes the following differentiators between lion and dog tracks:

1. The presence of claw marks in the tracks of dogs and their absence in the tracks of lions (Murie 1974, Belden 1978, C. B. Koford, unpubl. manuscript).

2. The presence of 3 heel lobes on the tracks of lions and their absence on dogs (Belden 1978, Shaw 1983, C. B. Koford, unpubl. manuscript).

3. The overall elongate shape of dog tracks vs. the round shape of lion tracks (Belden 1978, Shaw 1983, C. B. Koford, unpubl. manuscript).

4. The asymmetry of the lion's toes around the heel pad, including a leading toe, vs. the symmetry of the dog's toes (Belden 1978, Downing and Fifield 1986, C. B. Koford, unpubl. manuscript).

5. The squared front of the lion's heel pad vs. the more rounded and pointed front of the dog's heel pad (Downing and Fifield 1986, C. B. Koford, unpubl. manuscript).

6. The pointedness of the lion's toes vs. the blunt shapes of the dog's toes (Downing and Fifield 1986, C. B. Koford, unpubl. manuscript).

7. The occurrence of single, evenly-spaced tracks of dogs vs. The occurrence of pairs of tracks, usually one on top of the other for lions (Murie 1974, Shaw 1983). The placement of the tracks with respect to each other is referred to as the track pattern.

8. The larger size of the lion=s heel pad relative to the whole track compared to the dog=s (Murie 1974; Shaw 1978; and C.B. Koford, unpubl. manuscript).

9. The smaller ratio of the widths of the widest toe to the heel pad for lions. Belden (1978) suggested that when the ratio exceeds 0.44 the track was made by a dog, and below 0.44 the track was made by a lion.

10. The smaller distance between the dog=s toes than between the lion=s toes (Downing and Fifield 1986).

Almost all of the traits presented above can be used some or most of the time, but enough exceptions exist to warrant further analysis. Our paper is divided into three parts: Part 1, a list and discussion of the reliability of the traits presented in the literature, based on our observations from considerable field work plus some additional traits we found to help discrimination; Part 2, a multivariate analysis of traits we believe discriminate well; and Part 3, presentation of a dog/lion track classification key that uses the most accurate and easiest-to-apply discriminators from Parts 1 and 2. This paper will be relevant only for tracks from dust or firm mud because we have little experience with tracking in snow, and we have observed serious track distortion in soft mud.

PART 1: The Reliability of Track Traits Used to Discriminate Lions from Dogs

Methods.

We applied the traits presented in the literature as discriminators between lion and dog tracks to tracks we collected during our previous 5 years of field work. We evaluated the reliability of each of these traits in the order they were presented in the introduction, as well as for three other traits that we felt might be useful.

Results.

11. We never saw a lion track that included claw marks but we were told by professional trackers that they occur, and some authors have recorded their occurrence (Downing 1979, Shaw, 1983). We did encounter dog tracks that had no claw marks, including tracks from 2 of the 19 dogs in our quantitative analysis. Those who have observed claw marks in lion tracks reported that they are much thinner than claw marks in dog tracks. Therefore, the presence or absence of claw marks and their relative widths in a track is an excellent discriminator, but not a perfect one.

12. 2. Most dog tracks only showed to heel lobes. However, we encountered a fair number of dog tracks that included 3 heel lobes, and most dogs we examined had 3 lobes on their feet. This suggests that dogs walk more on their toes than lions so that relatively less weight is applied to the rear of the foot. However, when dog tracks included three heel lobes, they still differed from the 3 heel lobes of lions most of the time: the 2 outer heel lobes in dog tracks were smaller relative to the middle lobe (Figure 1), whereas mountain lion heel lobes were more equal in size and shape. Therefore, the number of heel lobes and their shapes can greatly increase our ability to discriminate dog and lion tracks, but again, not all of the time.

13. 3. Not all dog tracks were relatively elongate, and not all lion tracks were relatively round. However, both lion and dog tracks tended to follow a similar pattern of shape -- the rear tracks usually were more elongate than the front ones. Thus, the overall elongate shape of a dog or lion track was a poor trait for discrimination.

14. 4. Lion tracks usually included a leading toe. The second toe from the medial aspect of the track leads the third, and the first toe also usually leads the fourth. However, some lion tracks we found were nearly symmetrical, and a few dog tracks had leading toe prints similar to the lion's. Therefore, this trait should not be considered alone when differentiating dog and lion tracks.

15. 5. We found no dog tracks that were squared off at the front of the heel pad as in lion tracks. However, some rear tracks of lions failed to show the squared front of the heel pad, and appeared pointed very much like dog tracks. This probably results when the front of the lion's heel pad fails to press firmly down into the soil. This trait, therefore, should discriminate well except when only rear tracks are visible in a track set.

16. We found that lion toes usually were more pointed than dog toes. However, the shapes of dog toes varied enough to question any judgement based solely on this trait.

17. The common lion track pattern differed from that of dogs in several ways. Lion tracks more often occurred in pairs consisting of tracks made from the same side of the body (left with left, right with right) (Frames A and B of Fig. 2) than did dog tracks. Dog tracks tended to occur more singly, usually with fairly equal distances between each track (Frame C of Fig. 2). When dog tracks occurred as pairs they usually were offset, one beside the other. Pairs of lion tracks usually included the coincidence of the rear track directly on top of the fore, or directly in front of the fore. However, lion tracks sometimes occurred singly and were spaced similar to do's tracks. Therefore, the track pattern alone is not a good track discriminator.

18. Figure 3 presents some of the heel pads we encountered. Although the heel pad size relative to the overall track often was similar between dogs and lions, dogs exhibited a greater variety of heel pad shapes, many of which looked quite different than lions. Therefore, many dog tracks can easily be identified based on the relative size and the shape of their heel pads, but there will always be some that look similar to the heel pads of lions.

19. We applied Belden's ratio of the widths of the widest toe to the heel pad to many dog and lion tracks, and found that this ratio to not work often enough to rely on it alone. A modified version of this ratio was tried in a quantitative analysis presented later in this paper.

20. A partial measure of the distance between the toes also was tried in the quantitative analysis of Part 2.

In addition, we noted several other traits that served as good discriminatory indicators, but were not found in the literature. A fairly good discriminator between lion and dog tracks was the presence or absence of a mound of soil between the toes and the heel pad. Dog tracks almost always exhibited a pronounced mound of soil, but we never saw one in a lion track. Therefore, this trait should contribute greatly to discrimination, but because this mound of soil was absent in some dog tracks, it should be used with other traits as well.

We noted that travel behavior served as a fairly good discriminator of lion and dog tracks. Dogs often wandered around the road in an almost erratic fashion with a variety of speeds, plus the stopped and started. Lions exhibited 2 main travel behaviors when on the road: they usually either traveled the route of least distance by traveling straight lines from corner to corner, and then cutting the corners, or they stayed to one side of the road and did not cut corners. About half of the lion track sets we encountered stayed on one side of the road. When there was heavy cover on both sides of the road a lion exhibiting this type of behavior stayed on the uphill side of the road. But, without cover on the downhill side of the road the lion would move to this side and travel along it until cover reappeared. Therefore, travel behavior can add to the discriminatory powers of the other traits mentioned above.

The angle of the long axis of the outer toes with respect to each other also seemed to be a good discriminator. This trait was tried in the analysis of Part 2.

PART 2: A Quantitative Analysis of Some Track Traits

Methods.

We traced the tracks of 19 different dogs and 48 different mountain lions onto acetate sheets after Panwar (1979). These tracks were used in a multiple group discriminant analyses to determine which of the traits presented in Figure 4 may discriminate best. Modified from Belden (1978), we used the ratio of the second toe to the heel pad (A/B). The distance between the middle toes is represented by C. The angle of the long axis of the outer toes with respect to each other was measured by first drawing a line through each of the outer toes in the direction the toes point, and then subtracting the angle E from angle D. Angles D and E were formed by the intersection of lines D and E through the base line G. The base line G was drawn tangent to the most posterior aspects of the outer 2 heel lobes. F represents the average distances of the middle toes from the front of the heel pad (a partial measure for the degree of track elongation). We further divided this

average by the width of the heel pad B to normalize the values. H represents the presence or absence of claw marks, but was not tried in the analysis because the results were predictable. The concavity/convexity of the heel pad's posterior aspect was indexed by the degree and direction of discrepancy of the middle lobe's posterior aspect with the base line G. It could be concave (see track on the right), straight, or convex (see track on the left). An analysis was conducted with all tracks included, one was conducted on front tracks only, and another was conducted on rear tracks only to determine if any differences exist between front and rear track discrimination. Multiple Group discriminant analysis is a statistical technique that uses known cases to develop linear combinations of variables to predict group membership of unknown cases (Norusis, 1985). Figures 5, 6, 7, and 8 may help illustrate in an intuitive manner how the most discriminating combinations of variables are arrived at. The most discriminating variables best separate the two group distributions, and, as variables are combined, their discriminating ability is cumulated. The effectiveness of any chosen linear combination of variables is determined by the proportion of known cases correctly predicted to belong to their respective groups (dog or lion). A more rigorous description of this technique is presented in a paper showing how to identify individual mountain lions by their tracks (Smallwood and Fitzhugh in preparation).

Results and Discussion.

Of the traits we tried in the analysis, the angle of the long axis of the outer toes with respect to each other best discriminated dog and lion tracks, and was indifferent to the front and rear track distinction (Table 1). The ratio of the widths of the second toe to the heel pad was also a good discriminator, but more so for front tracks than rear ones. The distance between the middle toes was a fair discriminator, but again, more so for the front tracks than rear. The distance between the middle toes and the heel pad discriminated lion and dog tracks fairly well for the rear tracks but not so well for the front tracks.

The effectiveness of multiple variables in our discriminant analyses never improved enough beyond that of the angle of the long axis of the outer toes to justify the use of more variables in the field. In fact, the second toe to heel pad ratio suppressed the effectiveness of the angle of the outer toes when they were combined in an analysis.

From this exploratory analysis, we were able to consider one new discriminating variable between lion and dog tracks, as well as another derived from Belden (1978). The effectiveness of these measurements may decrease as our sample size of dog tracks increases, but the high effectiveness in this preliminary analysis is encouraging. These variables proved very useful when combining their effectiveness with some of the variables mentioned in Part 1 to develop the following track classification key.

PART 3: A Dog and Lion Track Classification Key

The following key is for distinguishing between dog and mountain lion tracks that are similar. Before using the key, screen out other species and obvious dog tracks. (Our smallest Adult lion track had a heel width of 37 mm., and lions always possess 3 lobes on the rear of the heel pad.)

1 Heel pad concave at rear, two lobes	Dog
1 Heel pad with 3 lobes, shape variable	Go to 2
2 Front of heel pad squared or concave	Mt. lion
2 Front of heel pad rounded	Goto 3
3 Claw marks present	Go to 4
3 Claw marks absent	Go to 5
4 Claws blunt	Dog

4	Claws knife-like, very narrow	Mt. lion
5	Angle D minus angle E = # 20°. 100% of Mt. lion, + 6% of dogs	Go to 6
5	Angle D minus angle E = $ 21°	94% of dogs
6	Check all interdependent factors to bring accuracy to 99%	

In this key, we used the best discriminating traits identified from the discriminant analyses as well as some easy-to-recognize traits we did not need to test (or could not) in the analyses. We did not observe the knife-like claw marks that identify mountain lions in step 4 of the key, but it seems reasonable that if claw marks do appear in a lion track, they should be very thin because their claws are narrow and sharp. Field biologists can considerably increase the reliability of their track identifications if, in addition to using the key, they consider the ratio of the widths of the second toe to the heel pad, whether or not there is a leading toe, the shape of the toes, the presence or absence of a mound of soil between the heel pad and the toes, the track pattern, and the travel behavior. With discriminant analysis it may be possible to identify additional traits that discriminate dog and lion tracks well.

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Figure 1: The typical shapes of "heels" of dog and lion tracks. The heel lobes in lion tracks are more equal in size and shape with more distinct grooves between them.

Figure 2: Typical dog and lion track patterns that we have found in the field. The arrow in center of frames is direction of travel.

Figure 3: An example of the varieties of heel pad shapes and sizes we have seen in dog tracks. The full track is presented for reference.

Figure 4: Traits used in the discriminant analyses to identify dog and lion tracks.

Figure 5: Distribution of measurements for the angle of the long axis of the outer toes for mountain lions and dogs.

Figure 6: Distribution of measurements for distance between middle toes of mountain lions and dogs.

Figure 7: Distribution of measurements for ratio of widths of second toe to the heel of mountain lion and dogs.

Figure 8: Distribution of index values for shape of heel pad base of mountain lions and dogs.

Table 1: Proportions of tracks correctly classified (and number misclassified) by different track traits from 19 dogs and 48 mountain lions in multiple group discriminant analysis. Variable labels are abbreviated: The angle of the long axis of the outer toes to each other = 'toe angles'; the ratio of the widths of the second toe to the heel pad = 'toe:heel ratio'; the average distance of toes 2 and 3 and the anterior aspect of the heel pad = "reach of toes"; the distance between toes 2 and 3 = 'spread of toes'; and, the shape of the posterior border of the heel pad = 'heel pad shape'.

All Feet Combined

Trait	Dog(n = 63)	Lion(n = 161)	Total(n = 224)
Toe angles	94.0 (4)	100.0 (0)	98.3 (4)
Toe:heel ratio	74.6 (16)	92.5 (12)	87.2 (29)
Reach of toes	58.2 (26)	79.5 (33)	73.3 (60)
Spread of toes	88.1 (7)	75.8 (39)	79.4 (46)
Heel pad shape	-	-	-
Toe angles + toe:heel ratio	92.5 (5)	100.0 (0)	97.8 (5)
All 5 traits combined	97.0 (2)	100.0 (0)	99.1 (2)

Front Feet Only

Trait	Dog(n = 30)	Lion(n = 69)	Total(n = 99)
Toe angles	93.3 (2)	100.0 (0)	98.0 (2)
Toe:heel ratio	90.0 (3)	98.5 (1)	95.9 (4)
Reach of toes	66.7 (10)	75.4 (17)	72.7 (27)
Spread of toes	90.0 (3)	78.3 (15)	81.8 (28)
Heel pad shape	-	-	-
All 5 traits combined	100.0 (0)	100.0 (0)	100.0 (0)

Rear Feet Only

Trait	Dog(n = 33)	Lion(n = 92)	Total(n = 125)
Toe angles	94.0 (2)	100.0 (0)	98.4 (2)
Toe:heel ratio	78.8 (7)	93.5 (6)	89.6 (13)
Reach of toes	57.6 (14)	85.0 (14)	77.6 (28)
Spread of toes	88.0 (4)	63.0 (34)	69.6 (38)
Heel pad shape	-	-	-
All 5 traits combined	94.0 (2)	100.0 (0)	98.4 (2)