RADIOGRAPHIC APPEARANCE OF THE FEET OF MAMMOTH DONKEYS AND THE FINDING OF SUBCLINICAL LAMINITIS

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All feet of 10 clinically sound mammoth donkeys (Group I) were radiographed to determine the appearance of the distal phalanx. The distal phalanges had blunted to concave-shaped dorsal solar margins which varied in appearance from slight to pronounced. The distal phalanges of the forefeet were wider than those of the hindfeet, and also were positioned a greater distance from the dorsal aspect of the hoof wall. The greater distance between the dorsal aspect of the hoof wall and the distal phalanges seemed related to the presence of a periosteal-like bony proliferation on the dorsum of the distal phalanx. This bony proliferation occurred in those distal phalanges which also had radiographic findings consistent with pedal osteitis. Next, all feet of 5 additional mammoth donkeys (Group II) that were to be necropsied for various reasons, were examined similarly to Group I, necropsied and found to have laminitis. Only 2 of these 5 donkeys had been lame; only one had rotation of the distal phalanges (in the forefeet). Radiographic data from the 4 donkeys without rotation seemed most similar to that found in those Group I donkeys which had periosteal reactions on their distal phalanges. Conclusions from this study were that: 1) feet of mammoth donkeys have some anatomic differences from those of domestic horses, 2) subclinical laminitis and pedal osteitis can occur in mammoth donkeys, 3) rotation of the distal phalanx occurs in some, but not all laminitic donkeys, 4) laminitic changes may be more pronounced in their fore than in their hindfeet, and 5) additional studies of donkeys need to be done, examining both proven normal and confirmed laminitic feet. *Veterinary Radiology & Ultrasound, Vol. 36, No. 1, 1995, pp 32–37.*

Key words: donkey, anatomy, laminitis, radiography.

Introduction

IN 1988, THE world's domestic equine population consisted of 53% horses, 34% donkeys and 13% mules.[1,2] Ninety-six percent of the donkeys were found in developing countries, and their population was static or increasing.[1,2] Countries with the greatest numbers of donkeys were China, Ethiopia, Mexico, Pakistan and Egypt.[1,2] The number of donkeys per 100 people agriculturally employed was high in Bolivia (67/100), Venezuela (58/100), and Mexico (34/100).[1,2] The exact number of donkeys in the United States is unknown, but in 1989, the U.S. had 5,464 feral donkeys; in 1992 there were 12,976 donkeys registered in the Miniature Donkey Registry and the American Donkey Registry combined.[3,4]

In developing countries, donkeys are mainly used for transporting people and commodities.[1,2] In the United States, donkeys are used for pleasure riding, as breeding stock for production of donkeys and mules, and to protect flocks of sheep and goats against dogs and coyotes.[5,6]

In spite of a significant percentage of the world's equine population consisting of donkeys and the dependency of much of the world upon them, there is a paucity of documented medical information about these animals. Many health concerns in these animals are associated with their feet.[7,8] However, little information relating to even the normal radiographic anatomy of the donkey foot is available.[9] The radiographic appearance of the distal phalanx in 10 clinically sound mammoth donkeys, and in 5 mammoth donkeys with necropsy-confirmed laminitis will be presented in this paper.

Materials and Methods

Initially 10 healthy female mammoth donkeys were evaluated (Group I). Seven of the donkeys were 2 years old, 2 were 3 years, and 1 was 4. All donkeys were living on the same farm and receiving the same diet. The donkeys had

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been halter broken, but had not been used for riding or work. Medical histories and current physical examination, including a general lameness evaluation, indicated none of the donkeys were or had been ill or lame. Their feet appeared normal on visual examination. All 4 feet of all 10 donkeys were radiographed.

Later, 5 mammoth donkeys (Group II) that were to be euthanized for various reasons were evaluated both radiographically, and at necropsy. There were 2 males and 3 females; their ages were 3, 4, 6, 8 and 15 years. Two of these donkeys had been lame; radiographically one had rotation of the distal phalanges of the forefeet. All 5 donkeys were diagnosed by necropsy as having laminitis in all feet. Histologic findings consisted of extensive necrosis of epidermal laminar lining cells.

Radiographs (lateromedial and dorsal 60° proximal-palmarodistal) were made of all 4 feet of Group I (Figs. 1–2) and of Group II donkeys. A wire of known length was placed on the midline of the dorsum of each hoof, to enable calculation of and correction for radiographic magnification. The radiographs were examined to determine the radiographic appearance of the distal phalanx. Roentgen signs evaluated in the distal phalanx of all 4 feet were: 1) shape, 2) general radiographic opacity, 3) width of the bones, 4) position (relative to the hoof wall) and 5) margination (Table 1).

Descriptive statistical analysis of the findings consisted of means and standard deviations for the measured parameters. Student's t-test was applied to data on the forefeet of the Group I donkeys, to assess the association between the presence of periosteal-like proliferations and the distance of the phalanx from the hoof wall. Their hindfeet were excluded from the statistical analysis due to the small number with periosteal-like proliferations present. Statistical evalu-

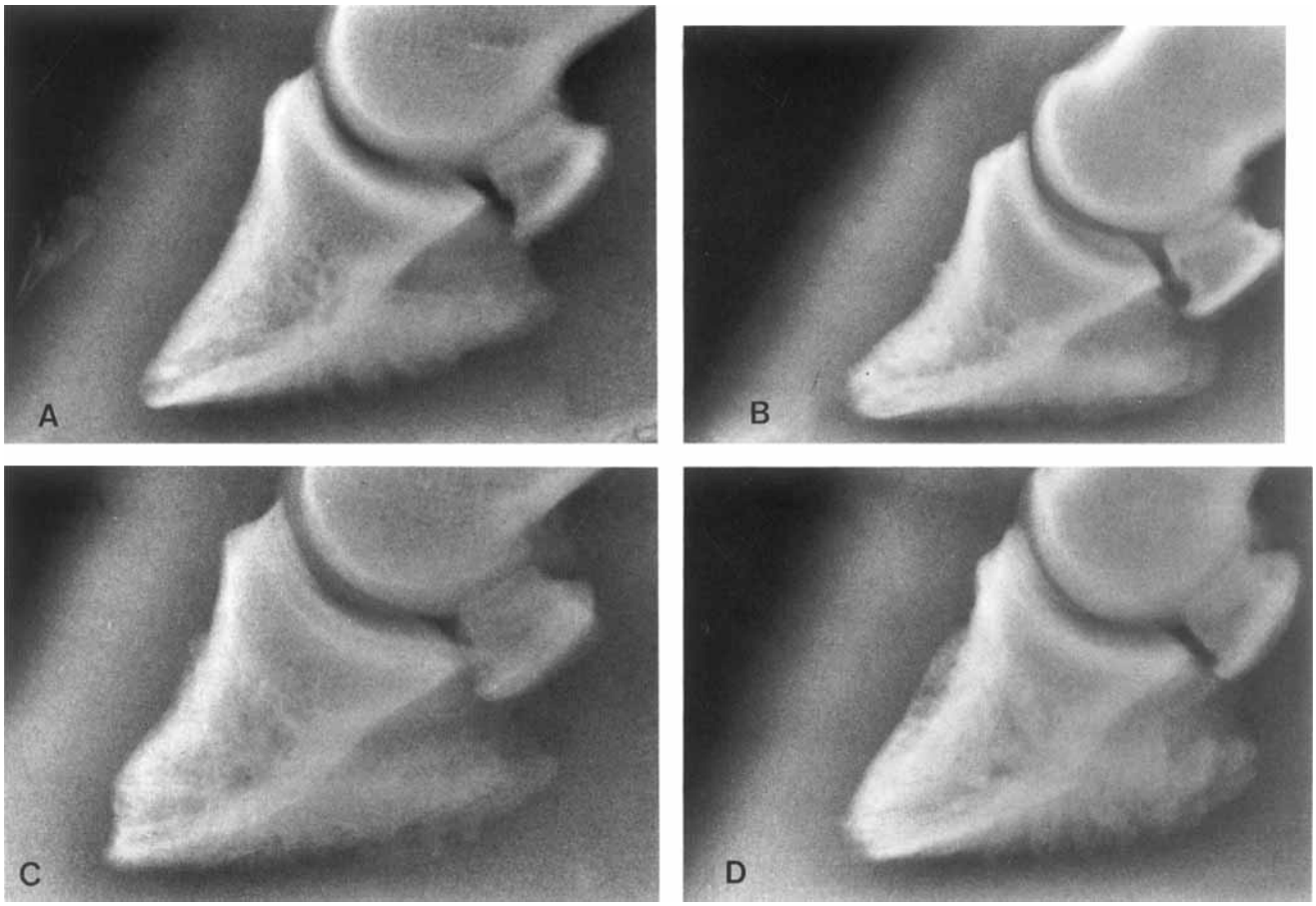
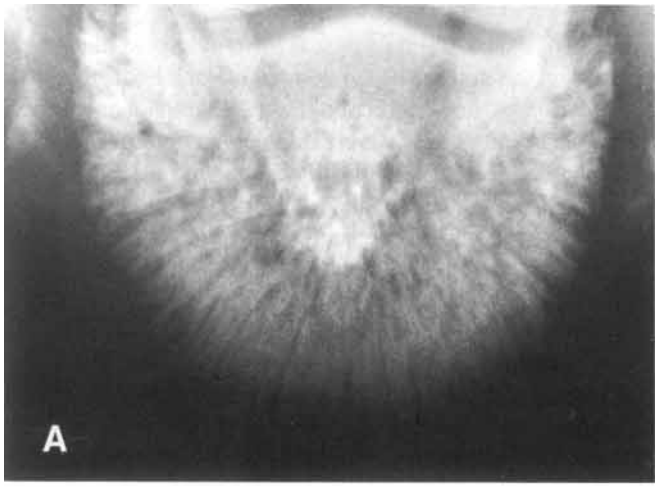
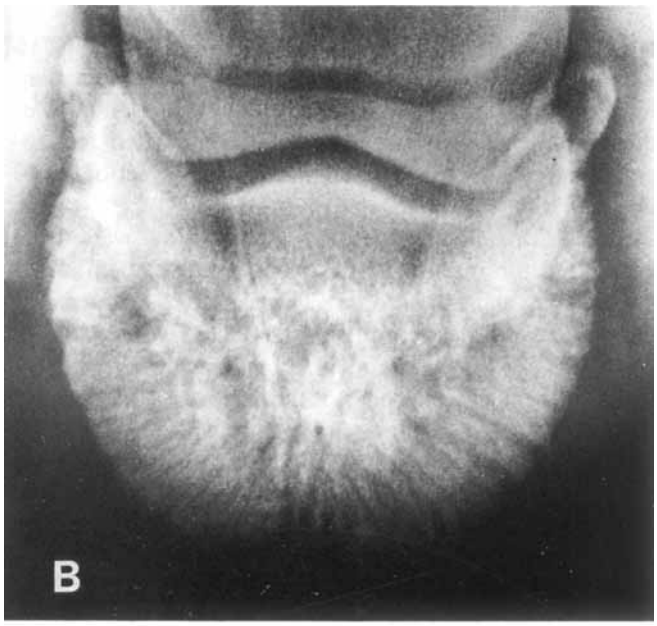
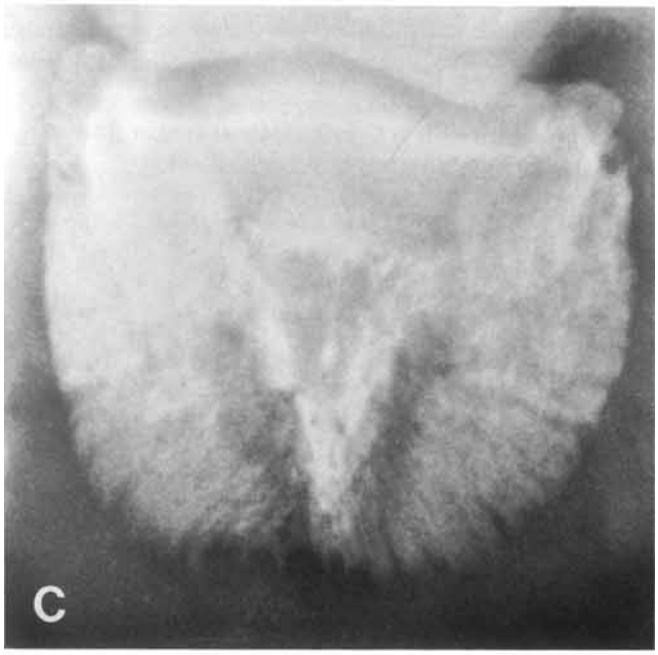
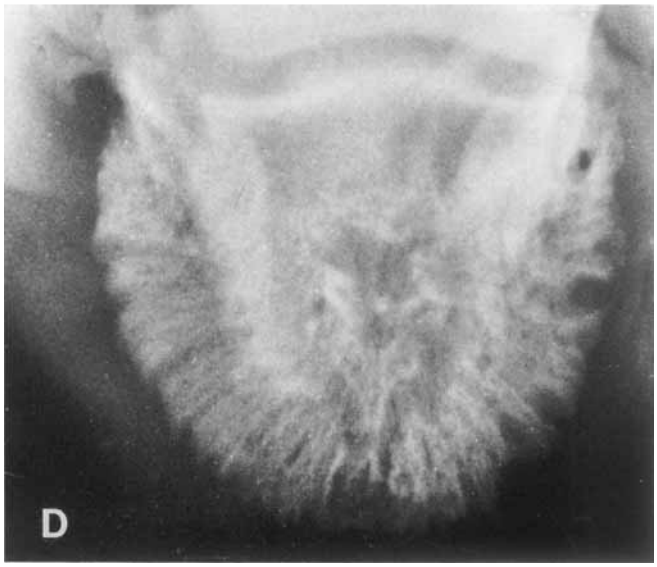


FIG. 1. (A–D). Lateromedial radiographs of distal phalanges, in which the spectrum of radiographic appearances in 10 clinically sound mammoth donkeys is apparent. Radiographic findings included thick appearing dorsal "cortices" in all bones, blunted dorsal solar margins to varying degrees in all bones, and dorsal periosteal-like bony proliferative changes to varying degrees in 15 of 40 bones (B–D). The distance from the mid-dorsal aspect of the hoof wall to the mid-dorsal aspect of the distal phalanx, discounting the periosteal-like proliferation was greater in 85% of the forefeet than in the hindfeet, and was especially so in those feet having the periosteal-like proliferation. External hoof conformation appeared normal, and the dorsum of the distal phalanx was parallel to the dorsum of the hoof wall in all 40 feet.









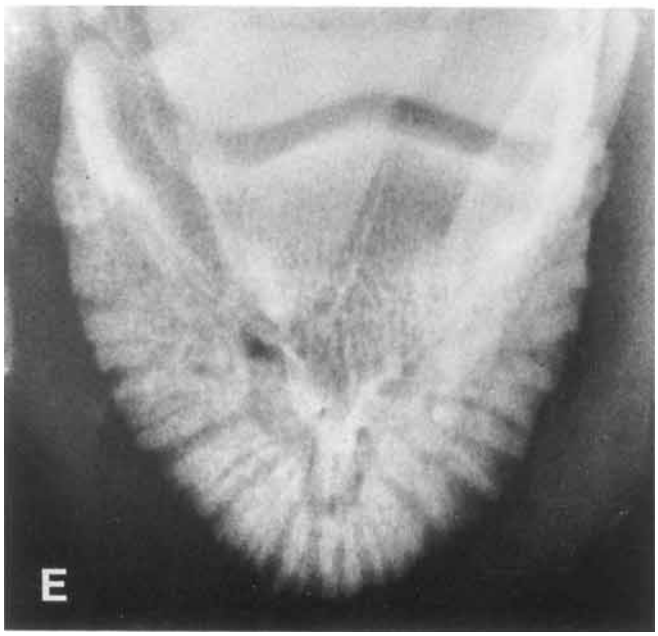


FIG. 2 (A–E). Dorsopalmar, -plantar views of 4 fore distal phalanges (A–D) and 1 hind distal phalanx (E), in which the spectrum of radiographic appearances in 10 clinically sound mammoth donkeys is apparent. The solar margins varied in smoothness. The shape of the dorsal solar margin of the distal phalanx in the forefoot was often flattened or concave. Vascular channels appeared widened in some. A crena was not always evident. Hind distal phalanges were always narrower in width than the fore, and 50% of the hind were pointed at the dorsal solar margin (E).

TABLE 1. Means, Standard Deviations, and Number of Donkeys Having Findings in the Distal Phalanges of 10 Clinically Sound Mammoth Donkeys, and in 5 Confirmed Laminitic Donkeys [ ].

	RF	LF	RH	LH
Number with Blunted Dorsal Solar Margin of Distal Phalanx	10, (1 slight) [5, 1 slight]	10, (2 slight) [5, 1 slight]	10, (3 slight) [5, 3 slight]	10, (3 slight) [5, 3 slight]
Number with Thick Appearing Dorsal Cortex	10 [5]	10 [5]	10 [5]	10 [5]
Width of Distal Phalanx $\bar{x} \pm$ SD (mm)	63 ± 5 [64 ± 2]	62 ± 5 [64 ± 2]	57 ± 4 [58 ± 2]	57 ± 4 [58 ± 2]
Dist. from Hoof Wall to Distal Phalanx $\bar{x} \pm$ SD (mm)	23 ± 2 [23 ± 2]	22 ± 2 [23 ± 1]	20 ± 3 [22 ± 1]	21 ± 2 [21 ± 1]
Number with "Perios. Rxn"	6 [5]	6 [4]	2 [1]	1 [1]
Number with "Osteitis-like" Appearance	6 [5]	7 [5]	1 [5]	1 [5]
Number with Rotation of Distal Phalanx	0 [1]	0 [1]	0 [0]	0 [0]

ation was not done on the small number of Group II donkeys.

Results

In radiographs from the Group I donkeys (Figs. 1–2) 10 of 20 of the hind distal phalanges were more pointed at their dorsal solar margin (Fig. 2E) than were the fore distal phalanges (Fig. 2A–D); none of the fore distal phalanges had this pointed appearance. The extensor process on all distal phalanges came to a point (Fig. 1A–D), similar to the shape seen in horses. The dorsodistal margin on the distal phalanges had a blunt, sometimes concave appearance on the lateromedial view (Fig. 1A–D). The blunted appearance varied from barely evident in 9 of the Group I donkey feet, to as much as 7mm of the dorsodistal margin being involved in 31 of the donkey feet. On the dorso-palmar, -plantar views of the affected bones, the dorsal solar margin of the distal phalanx appeared flattened rather than convex, and was often irregular in outline (Fig. 2B–D). Because of this appearance, it was often difficult to distinguish a typical crena, but a suggestion of one was found in 4 right forefeet, 3 left forefeet, 2 right hindfeet and 2 left hindfeet of the Group I animals. The palmar, -plantar processes of the distal phalanx were often difficult to visualize completely on the lateromedial views, but appeared similar to that seen in horses on the dorsopalmar, -plantar views. The radiographic opacity of the distal phalanx appeared similar to that of the horse, with the exception of a thicker cortical-like bone opacity on the dorsal margin of the bone (Fig. 1A–D). Lastly, the vascular channels appeared similar in arrangement to that seen in normal horses.

All of the hind distal phalanges were narrower than the fore in the Group I and the Group II donkeys. The widest dimension of the distal phalanx on the dorsopalmar views of the Group I forefeet ranged from 55 to 69mm, with a $\bar{x}$ and sd of 63 ± 5mm and 62 ± 5mm for right and left forefeet, respectively. In the hindfeet, the width of the distal phalanx ranged from 52 to 63mm, with a $\bar{x}$ and sd of 57 ± 4mm for the right, and 57 ± 4mm for the left. The widths of the Group II bones were similar to those of Group I (Table 1).

The distance between the hoof wall and the dorsal aspect of the distal phalanx was greater in the fore than in the hindfeet in 85% of the Group I feet and in 80% of the Group II feet. The magnification corrected distance from the mid-dorsal aspect of the hoof wall to the mid-dorsal aspect of the distal phalanx of the Group I donkeys ranged from 20 to 28mm, with a $\bar{x}$ and sd of 23 ± 2mm and 22 ± 2mm for right and left forefeet respectively. In the hindfeet, the range was 17 to 25mm, with a $\bar{x}$ and sd of 20 ± 3mm for the right, and 21 ± 2mm for the left. Among the Group II donkeys, the range was 21 to 25mm with a $\bar{x}$ and sd of 23 ± 2mm for the forefeet, and 20 to 23mm with a $\bar{x}$ and sd of 21 and 22 ± 1mm for right and left hindfeet respectively (Table 1).

Smooth to irregularly marginated periosteal-like bony proliferative changes occurred on the mid-dorsal aspects of the distal phalanges of both Group I and Group II donkeys. Among the Group I donkeys, this finding occurred in 6 right forefeet, 6 left forefeet, 2 right hindfeet and 1 left hindfoot. Among the Group II donkeys, this finding was present in 5 right forefeet, 4 left forefeet, 1 right hindfoot and 1 left hindfoot. These bony proliferations varied in length from 1 to 30mm, and in thickness from 1 to 6mm. The bony proliferation on the dorsum of the distal phalanges occurred in 14 of 20 Group I and in 9 of 13 Group II feet having at least 22mm distances (corrected for radiographic magnification) between the dorsal aspect of the hoof wall and the normal dorsal plane of the distal phalanx. This bony irregularity did not occur in any of the 16 feet from Group I and II in which the distance was between 17 and 20mm (magnification corrected). In the forefeet of the Group I donkeys, the periosteal-like reactions occurred in feet having mean hoof wall to phalanx distances of 24mm, as opposed to mean distances of 21mm in the forefeet without the bony proliferation. In

the forefeet of the 4 Group II donkeys with periosteal-like reactions, but without rotation, the mean distance was 23mm. Among the Group I donkeys the association of this proliferative change to the distance between the hoof wall and the distal phalanx was statistically significant for the right ($p < 0.01$) and left ($p < 0.03$) forefeet.

On the dorsopalmar, -plantar views, some of the bones had radiographic appearances similar to that observed with pedal osteitis in horses. This appearance included irregularity at the solar margin of the distal phalanx, with some of these feet also having widened vascular channels. Among the Group I donkeys, these findings were observed in 6 right forefeet, 7 left forefeet, 1 right hindfoot and 1 left hindfoot; 14 of these 15 findings were on distal phalanges also having the periosteal-like bony proliferation. Among the Group II donkeys, all distal phalanges had the osteitis-like appearance.

Discussion

The radiographic appearance of the distal phalanx in the Group I, the clinically sound mammoth donkeys, had some similarity to that of the normal horse. However, notable differences in some of these donkeys compared to horses included: 1) the shape of the dorsal solar margin of the distal phalanx, 2) the distance from the mid-dorsal aspect of the hoof wall to the mid-dorsal aspect of the distal phalanx, 3) the occasional proliferative bony change on the dorsal margin on the bone, and 4) the irregularity in the solar margin of the bone.

The blunted dorsal solar margin of the distal phalanx was dramatic in 32 of 40 Group I feet and in 15 of 20 Group II feet. The reason for this variation in shape from that seen normally in the horse is undetermined, but may represent 1) an exaggerated crena with or without pedal osteitis in the bone, or 2) normal anatomic variations in the mammoth donkey.

In the Group I donkeys, the distance from the dorsal hoof wall to the dorsal aspect of the distal phalanx was greater than the 14.6mm average described in the thoroughbred horse.[10] Mean distances in the Group I donkeys were 22–23 ± 2mm for the forefeet, and 20–21 ± 3mm for the hindfeet. In the thoroughbred, laminar elongation due to laminitis was reported to result in distances beyond 16.6mm. The reason for the wide distance between the hoof wall and the dorsum of the distal phalanx in these donkeys is uncertain, but appears to be associated with the presence of the periosteal-like bony proliferation. Potential hypotheses for the wide distances include: 1) the possibility of longer laminae in the mammoth donkey than in the horse, and 2) the possibility of subclinical laminitis in the donkey.

The irregular bony margin on the dorsal aspect of 15 distal phalanges is certainly different from that seen radiographically in the normal horse. In some cases of laminitis in the horse, there may be subtle irregularity of the dorsal margin, but rarely to the degree that was found in some of these donkeys. "Rotation" of the distal phalanx, which is a common finding in horses with laminitis, was not observed in any of the 40 feet from the Group I donkeys, and in only 2 of 20 feet in the donkeys with laminitis. Hypotheses for the periosteal-like bony proliferative changes observed in these donkeys include: 1) a normal anatomical variation found in mammoth donkeys but not in horses, and 2) changes secondary to subclinical laminitis without rotation of the distal phalanx. The reason that 12 of 15 of these changes in the Group I donkeys, and that 9 of 11 of them in Group II donkeys occurred in the forefeet is undetermined, but may be hypothetically related to 1) normal anatomy, 2) greater weight bearing stress on the laminae in the forefeet, or 3) laminitis changes being most manifest in the forefeet.

Care must be taken in interpreting the results of the statistical analysis since no hypotheses were established prior to performing this radiographic study. Data observation made apparent certain associations and these were statistically evaluated. Since these were data-suggested analyses, the p-values are only estimates of the role of chance in these associations and should be considered as hypothesis-generating tests only.

The reason for the irregular solar margins in 15 of 40 distal phalanges from Group I is unproven. These findings were observed in 14 of the 15 feet that had the periosteal-like bony proliferation on the dorsum of the distal phalanx, but was present in only one distal phalanx not having the dorsal change. Among Group II donkeys, 20 of 20 feet had the irregular solar margins. Causes of the irregular solar margins may have been 1) exaggerated "blunting" of the dorsal solar margin of the distal phalanx, or 2) subclinical pedal osteitis with or without laminitis.

Clearly this study increases our knowledge of the mammoth donkey's feet, but also raises important questions requiring further investigation. Gross anatomic and histologic evaluations of the feet need to be included in future studies. The periosteal-like reaction and the pedal osteitis-like appearance observed in this study needs further evaluation, as does the finding that a subclinical laminitis can occur in mammoth donkeys.

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