EFFECT OF LEVEL OF FEED INTAKE AND GELATIN SUPPLEMENTATION ON GROWTH AND QUALITY OF HOOFs OF PONIES

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SUMMARY

A pelleted ration was fed limited or ad libitum to two groups of seven Shetland 8-month-old ponies for 117 days. During the last 56 days, gelatin was added to the diets of four animals in each of the two intake groups. Gelatin was added at levels of 30 and 90 g per 100 kg body weight for the first and second 28-day periods, respectively.

Ponies fed the diet ad libitum consumed 180% more feed, had 50% greater rate of hoof growth (.384 ± .009 vs .254 ± .008 mm/d), 200% greater increase in height at the withers and 425% greater increase in body weight than ponies fed the limited level. The hoofs of ponies fed ad libitum had 82% greater surface area at the sole border than those fed limited amounts. The addition of gelatin did not affect (P<.05) hoof growth, base area, compression strength (yield point or elasticity), moisture, iron, zinc or nitrogen content. Rate of hoof growth declined with age. Hind hoofs grew faster than front hoofs. Sex of animals did not affect hoof growth or quality.

The average compression yield strength of hoof wall was 146 ± 5 meganewtons per meter (mN/m²). The tangent modulus of elasticity just prior to failure was 3.722 ± .111 mN/m². Neither yield strength nor elasticity were changed by level of diet intake or gelatin supplementation or by iron, zinc, or nitrogen content of the hoof wall.

The zinc content of the hoofs of limited fed ponies (136 ± 3 ppm) was higher (P<.01) than those that were fed ad libitum (114 ± 2 ppm). Hoof nitrogen, and moisture content were not different (P<.05) between groups. Hoof wall iron content was greater for limited fed ponies. Nitrogen content averaged 17.7 ± 1%. Moisture content of all postmortem hoof samples averaged 27.8 ± .2%. Specific gravity of limb bones was greater (P<.05) for the ponies fed ad libitum.

(Key Words: Ponies, Limited Growth, Gelatin.)

INTRODUCTION

Relatively little is known about the effect of nutrition on the growth and composition of the equine hoof. The rate of growth and quality of the hoof are of vital concern since they often affect the usefulness of a horse. Protein intake would appear to have an effect on hoof growth and quality since hoof is composed principally of the insoluble protein keratin. Although feeding of gelatin has been recommended for the treatment of defective hoofs, experimental data to substantiate this practice is limited. Preliminary studies indicated that when feed intake of young ponies was restricted, rate of hoof growth decreased. The objectives of the present study were to investigate the effect of the level of feed intake and gelatin supplementation on rate of growth and quality of the equine hoof.

MATERIALS AND METHODS

A commercial pelleted feed was fed ad libitum or limited to a near-maintenance intake of about 1 1/2% body weight per day to two groups of seven ponies with an initial average weight of 100 kilograms. The ponies averaged 8 months of age at the start of the trial which lasted for 117 days. Gelatin was added to the

1 The authors are indebted to G. W. Sanderson of Thomas J. Lipton Tea, Inc. for supplying the gelatin. The authors also wish to express their gratitude to P. Daniluk, S. Hallett, J. Lowe, C. Marquis, R. Saltsman, V. Soderholm and J. Williams for their excellent technical assistance throughout the experiment.

2 Choice, Agway, Inc., Syracuse, NY. (Containing crude protein, 16.2%; Zinc, 106 ppm; Iron, 2285 ppm on a 100% dry matter basis.)
diets of four animals in each of the two groups during the last 56 days of the trial. Gelatin was added at a level of 30 g per 100 kg body weight for the first 28 of the 56-day period and at a rate of 90 g per 100 kg body weight for the second 28 days. Changes in body weight, height, hoof base area and hoof growth rate were determined.

Hoof growth rate was determined by the monthly measurement of the distal movement of an inverted T hot brand mark from the proximal border of the hair. Hoof base area was determined by planimeter measurements of tracings of the sole border of the wall of trimmed hoofs at the beginning and end of the trial.

The animals were slaughtered and moisture, zinc, iron, nitrogen, compression strength and elasticity of hoof wall and specific gravity of bones were determined. Three parallel strips were taken from the hoof wall in the mid-toe region of a front and a hind hoof. After the samples were milled square on the sides, one was divided into four equal sections for moisture and mineral determination, one into two equal pieces for nitrogen determination and one into an average of nine equal pieces for compression yield strength and elasticity tests. Moisture was determined by oven drying samples for 7 days at 100°C. Zinc and iron were determined by atomic absorption spectrophotometry. Nitrogen was determined by the Kjeldahl method. Compression yield strength and elasticity of hoof wall were determined with an Instron Universal Testing Instrument. The square samples were oriented with the horn tubules perpendicular to the force plate. A crosshead speed of .127 cm per minute and a chart speed of 25.4 cm per minute were employed. Specific gravity of bones was determined in the manner reported by Schryver, et al. (1974).

RESULTS

Ponies fed the diet ad libitum had greater (P<.01) rate of hoof growth, increase in height at the withers, body weight gain and hoof base area than ponies fed the limited level (table 1). Gelatin supplementation did not affect (P<.05) these measurements. Hoof growth rate declined (P<.01) with age (figure 1). Hind hoofs grew faster (P<.01) than front hoofs. Sex of animals did not affect hoof growth or quality.

Hoof wall compression yield strength, tangent modulus of elasticity just prior to failure, iron, nitrogen and moisture were not affected (P<.05) by level of intake or gelatin supplementation (table 1). Hoof wall zinc content was greater (P<.01) in ponies whose intake was limited than those fed ad libitum. Specific gravity of limb bones was greater (P<.05) in ponies fed ad libitum. Figure 2 is a representative curve illustrating the behavior of moist hoof samples under compression. A representative curve for dry hoof samples is superimposed on it for comparison. The compression data in table 1 were taken from moist samples.

Discussion

The data demonstrate that when nutrition is inadequate for body weight gain and height increase of young ponies, hoof growth rate and increase in hoof base area is also retarded. Thus, hoof development can be correlated to body growth as Miyaki et al. (1969) have suggested. Though hoof growth rate and hoof base area were found to be significantly inhibited by limited intake feeding, further studies are needed to determine the effect of specific nutrients on hoof development and mature hoof size.

The addition of gelatin did not affect (P<.05) hoof growth or quality, although there appeared to be a trend toward the inhibition of hoof growth by gelatin. Protein content of the hoof apparently was not affected since nitrogen percentage was not different (P<.05) among groups or time periods.

Traditionally, gelatin has been utilized as an
### Table 1. Effect of Feed Intake and Supplementation on Growth and Postmortem Measurements

<table>
<thead>
<tr>
<th>Item</th>
<th>Intake</th>
<th>Supplementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Limited</td>
<td>Ad libitum</td>
</tr>
<tr>
<td>Feed intake (kg/d pelleted diet)</td>
<td>1.45 ± .02c</td>
<td>4.07 ± .26d</td>
</tr>
<tr>
<td>Average daily gain (kg)</td>
<td>.083 ± .015c</td>
<td>.435 ± .29d</td>
</tr>
<tr>
<td>Average height increase (cm/d)</td>
<td>.013 ± .004c</td>
<td>.039 ± .005d</td>
</tr>
<tr>
<td>Hoof growth (mm/d)</td>
<td>.254 ± .008c</td>
<td>.384 ± .009d</td>
</tr>
<tr>
<td>Hoof base area increase (cm²)</td>
<td>2.56 ± .48c</td>
<td>4.66 ± .42d</td>
</tr>
<tr>
<td>Hoof compression yield strength (mN/m²)</td>
<td>145 ± 6</td>
<td>147 ± 4</td>
</tr>
<tr>
<td>Hoof modulus of elasticity (mN/m³)</td>
<td>3.773 ± .129</td>
<td>3.670 ± .113</td>
</tr>
<tr>
<td>Hoof iron content (ppm)</td>
<td>15 ± 1c</td>
<td>13 ± 1f</td>
</tr>
<tr>
<td>Hoof zinc content (ppm)</td>
<td>136 ± 3c</td>
<td>114 ± 2d</td>
</tr>
<tr>
<td>Hoof nitrogen content (%)</td>
<td>17.6 ± .2</td>
<td>17.8 ± .2</td>
</tr>
<tr>
<td>Hoof moisture content (%)</td>
<td>27.7 ± .1</td>
<td>28.0 ± .2</td>
</tr>
<tr>
<td>Specific gravity of limb bones</td>
<td>1.451 ± .009e</td>
<td>1.482 ± .013f</td>
</tr>
</tbody>
</table>

*a* Values shown are the mean ± SEM.

*b* Choice, Agway, Inc., Syracuse, NY.

*c,d* Comparable means with unlike superscripts are significantly different (P<.01).

*ef* Comparable means with unlike superscripts are significantly different (P<.05).
Figure 2. Representative curves of compressed hoof samples. (Y = Yield Point, E = Slope or Modulus of Elasticity, L = Load, D = Deflection, P = Compression, AxB = Area of Hoof Sample, P = \( \frac{Y}{AxB} \) mN/m², and E = \( \frac{D/C}{\Delta D/\Delta L} \) Stress mN/m² and Strain m²/m²).

Adjuvant protein source and prescribed for treatment of brittle fingernails (Veis, 1964; Rosenberg et al., 1957; Tyson, 1950). Reis and Schinckel (1964) fed gelatin per abomasum to sheep and reported no significant effect on wool growth and composition. The high ratio of non-essential to essential amino acids in gelatin and especially the high glycine content, was shown to limit growth in rats by Hier et al. (1944) and Swendsie et al. (1962). Goodspeed et al. (1970) reported that gelatin feeding resulted in increased (P<.01) hoof specific gravity of horses after 4 months, even though hoof tensile strength and amino acid composition were not affected. However, only samples from the distal border of the hoof were analyzed and hoof growth was not reported.

The behavior of the hoof samples under compression may be explained in part by the biomechanical description of hoof structure by Rooney (1974). Since the cells of hoof wall tubules have been described as a series of concentric alternating coils by Trautmann and Fiebiger (1952), he likened their function to that of coil springs. Such a structure could account for the elasticity of the hoof wall measured by Lungwitz (1891) and Knezevic (1962, 1963).

However, observations in this study suggest that a biomechanical model of the hoof wall must account for the presence of moisture in the hoof wall. Variations in the moisture content and speed of compression greatly affected the variability of hoof strength measurements. The comparison of hoof tubules to some sort of hydraulic shock absorber may more nearly explain actual hoof physiology since tubular behavior is influenced by the presence of fluid. Furthermore, Wilkens (1964) reported the cells of the tubules were randomly arranged rather than in concentric coils. This also indirectly supports the need for including more information in a model of hoof structure.

Postmortem values for mid-toe hoof wall moisture averaged 27.8 ± .2% from coronary to sole border. The average of postmortem measurements at the sole border was lower (P<.05) than at the coronary border. (27.1 ± .2% vs 29.1 ± .2%). These values are similar to those reported by Miyaki et al. (1974).

Hoof strength was greater (P<.01) at the sole border than at the coronary border (163 ± 5m N/m² vs 125 ± 4m N/m²). Thus, the hoof wall is strengthened as it is pushed distally during growth. The 2% change in moisture content from proximal to distal borders would not appear to be sufficient to account for this increased strength. However, further studies are needed to determine the contribution of factors in addition to moisture content to hoof strength.

Iron content was greater (P<.05) in the hoofs of limited fed animals (15 ± 1 ppm vs 13 ± 1 ppm). Iron content was not affected by hoof pigmentation, sex, or addition of gelatin (P<.05).

The limited fed ponies had a hoof wall zinc content of 136 ± 3 ppm which is similar to the 142 ppm reported by Weiser et al. (1965) for horse hoof wall. However, the zinc content of the hoof wall of ponies fed ad libitum was only 114 ± 2 ppm. The difference (P<.01) in hoof wall zinc between levels of intake is not readily explainable. The diet contained 106 ppm zinc, whereas the requirement for growing horses was estimated to be not greater than 40 ppm (Schryver et al., 1974). The ponies fed the limited diet probably consumed more bedding.
than the ponies fed ad libitum, but the sawdust bedding contained only 7 ppm zinc. There were no differences in zinc content (P<.05) due to hoof pigmentation or sex. Neither hoof wall iron nor zinc content were related to hoof strength at these levels of mineral intake.

LITERATURE CITED
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