Understanding the Calcium-Phosphorus Ratio

Many different minerals and other nutrients have interactions between them that affect their availability or absorption in the body---for example, between copper and zinc, calcium and vitamin D, iron and manganese. One of the most important, and often overlooked, of these interactions is between calcium and phosphorus. A saying in animal science, (who are a not-very-poetic bunch and pathetically easy to amuse), is "as goes phosphorus, so goes calcium". What this means is that for every gram of phosphorus ingested in the diet, the body must match that with another gram of calcium before the phosphorus can be absorbed through the intestinal wall into the bloodstream. If the required calcium is not available from the diet, the body will obtain it from wherever it can---such as from the storage depots in the bones. It doesn't take a rocket scientist to figure out that in any horse performing stressful exercise (as well as remodeling bone in response to conditioning), you do NOT want calcium being removed from and decreasing bone integrity.

This is where the whole idea of calcium-phosphorus ratios comes in. The purpose of calculating such a ratio is to make sure that for every gram of phosphorus you're feeding, you're feeding AT LEAST an equal amount of calcium (a 1:1 ratio or better), so that calcium isn't being continually mobilized from bones. Most nutritionists recommend that the ideal levels are somewhere between 1.2-2 parts calcium to 1 part phosphorus. Although horses can tolerate ratios of up to 7 parts calcium to 1 part phosphorus, excessive levels of calcium are also ill-advised for the distance horse (see "Alfalfa for Distance Horses".)

The problem is that most grass hays contain only low to moderate levels of both calcium and phosphorus, while the majority of cereal grains are deficient in calcium and high in phosphorus---the highest of all being rice bran. So in a horse being fed grass hays and large amounts of grain, it would be very easy to have an inverted calcium-phosphorus ratio (less calcium being ingested than phosphorus).

For example, a horse eating 18 pounds of bermuda hay is getting 25 grams of calcium and 16 grams of phosphorus, or a ratio of 1.56---very good. Add to this diet 5 pounds of corn and the ratio drops to 1.18---still okay. Now add just two pounds of rice bran, and the ratio drops to .74---not good at all. Any value less than 1 means the ratio is inverted, and that more phosphorus is being ingested than calcium. Therefore, in this example, for every day that this ration is fed, 260 mgs of calcium are removed from storage depots in the bone, or about 95 grams a year. Over the lifetime and career of the horse, this may contribute to a decrease in bone density, as well as may decrease calcium availability for muscular contraction during exercise.

Earlier this year, I was contacted by an endurance rider whose horse was inadvertently being provided with a severely inverted calcium-phosphorus ratio. In this particular instance, the horse was stiff and reluctant to move forward during exercise, had a shortened stride, tired easily and was being pulled for cramps at endurance rides. After correcting the ration, the horse immediately returned to full work and has since completed several fifty mile rides in good shape.

Not to scare the hair off of anyone, but a few years ago when I was visiting the local equine hospital, a client brought in a lovely imported warmblood breeding stallion for x-rays because he

always seemed to be slightly lame, even though he was only ridden lightly in dressage in an arena with good footing. After taking radiographs and on his way back to the trailer, the stallion got frisky, broke away from his handler and went galloping merrily down the long barn row. At the end was a fence, the horse slipped trying to make the turn and fell---compleely shattering metacarpal and phalanx bones (the cannon and pastern). A bit extreme under the circumstances - it wasn't all THAT bad a crash. The damage was too great to repair and the very valuable breeding stallion was put down. I was told later that after they developed the original radiographs (now a moot point, since the horse was dead) the bones had so little calcium deposition, it looked like something was wrong with the radiograph equipment. It turns out the horse got colicky on alfalfa and was a hard keeper to boot, so he'd been living for all his long life on oat hay, grain and large amounts of bran. However, this was a really extreme example, so don't take this as the Voice of Doom predicting that every horse that has ever seen a cup of bran in his life will have crumbling legs by nightfall.

So much for the inverted calcium-phosphorus ratio. Most horse owners know that alfalfa is a good source of calcium, so all you have to do to balance an inverted calcium-phosphorus ratio is add more calcium in the form of alfalfa, right? Well, that's true. Adding five pounds of alfalfa to the above ration (18 pounds of bermuda, five pounds corn and two pounds rice bran) will balance the ratio back to 1.3, which is within the ideal range. However, many people (after hearing the above horror story) tend to want to REALLY make sure their horse is getting plenty of calcium and so feed alfalfa as much as 50% or more of the forage portion of the ration. This is also not an optimally balanced ration, being not only excessive in calcium, but also high in protein and possibly magnesium as well. A discussion of excessive calcium is covered under "Alfalfa for Distance Horses". .

Unfortunately, there are few outwardly visual signs of an inverted calcium-phosphorus ratio. One symptom which may or may not be visible is referred to as miller's disease in the United Kingdom and bighead disease in the U.S. What happens is that the calcium being removed from the bone is replaced by connective tissue--an attempt by the body to create stability and support when calcium-supported bone tissue isn't available. Although it's going on throughout the body, it will show up most visibly in the head, with enlargements along the jawbones, especially the upper mandible. The whole face looks swollen and hence "bighead disease". However, this symptom may not show up unless the inverted ratio is a severe one, and sometimes not even then.

So now that we're all properly impressed with the importance of a calcium-phosphorus ratio, how do you calculate one? Below are the calcium and phosphorus values for some commonly fed forages and grains:

Feed	Calcium (%)	Phosphorus (%)
Alfalfa hay, midbloom	1.24	0.22
Bermuda hay, 29-42 days	0.30	0.19
Oat hay	0.29	0.23
Orchardgrass hay, early bloom	0.24	0.30

Timothy hay, midbloom	0.43	0.20
Barley grain	0.05	0.34
Beet pulp, dehydrated	0.62	0.09
Corn grain	0.05	0.27
Oat grain	0.05	0.34
Rice bran	0.09	1.57
Wheat bran	0.13	1.13

Keep in mind these are average values and may vary somewhat from region to region.

To calculate a calcium-phosphorus ratio:

1) Convert the number of pounds of each feed to kilograms by dividing pounds by 2.2. For example, let's say you want to know the ratio for a diet comprised of 15.4 pounds of bermuda and 4.4 pounds of oats. 15.4 divided by 2.2 = 7; 4.4 divided by 2.2 = 2.

2) Multiply these numbers by both the calcium and phosphorus content of each feed. For example, bermuda hay contains 0.30% calcium and 0.19% phosphorus, so multiply 7 kgs by 0.30% = 0.021 kgs of calcium. Multiply this number by 1000 to convert to 21 grams, a more convenient number to work with. Do the same to calculate the phosphorus content of the bermuda hay; 7 kgs x 0.19% = .0133 kg; multiply by 1000 = 13.3 grams.

Now do the same for the oats to calculate both their calcium and phosphorus content. From the table above, oat grain contains approximately 0.05% calcium and 0.34% phosphorus. So, 2 kgs x 0.05% = .002 kgs, or 2 grams, of calcium. For phosphorus, 2 kgs x 0.34% = .0068 kgs, or 6.8 grams, of phosphorus.

3) Now add the two values for calcium together; 21 grams from the bermuda and 2 grams from the oats totals 23 grams.

4) Add the two values for phosphorus together; 13.3 grams from the bermuda and 6.8 grams from the oats = 20.1 grams total.

5) Divide the total calcium by the total phosphorus; 23 divided by 20.1 = 1.14. This is the calcium-phosphorus ratio if you fed this particular ration. Since the ratio is greater than 1, the value is not inverted. Although it falls slightly below the recommended ideal range of 1.2 - 2, this is still an acceptable value for a mature horse at light work.

What do you do if you find you have an inverted ratio? Calcium-phosphorus ratios can be adjusted and balanced by either decreasing the phosphorus content, or increasing the calcium content. By looking at the values in the above table, you'll be able to determine if one feed is providing an excessive amount of phosphorus. For example, rice bran is extremely high in phosphorus, with wheat bran a close second. By decreasing or eliminating a high-phosphorus

feed, and replacing it with another feed that provides either less phosphorus and/or more calcium, you'll be able to calculate a more balanced ration.

Are there any rations for horses that are already calcium-phosphorus balanced for horses? Yes. In looking at the above table again, you'll see that most grass hays (with the exception of orchardgrass) contain more calcium than they do phosphorus. The same is true of beet pulp, though is NOT true of any grain product. Therefore, regardless of the amount fed, feeding a horse any combination of grass hays and beet pulp will always provide a balanced calcium-phosphorus ratio, and is an excellent, low-protein ration ideal in many ways for endurance horses. In addition, corn or vegetable oil can easily be added to the beet pulp ration if more energy is needed, without upsetting mineral balances.