Dietary Phosphorus Requirements of Deer

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Abstract: For more than 25 years, numerous authors of reports and texts have repeatedly published that 0.56% and 0.25% phosphorus are optimum and minimum dietary levels required by white-tailed deer (*Odocoileus virginianus*). Scrutiny of the literature reveals that data do not sufficiently support these statements. Original statements were based on the performance of 1 deer. Dietary levels of other nutrients were also low. Minimum dietary levels of phosphorus required by deer are not known. Obviously, authors have cited these results without carefully reading the literature.

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Much work has been done to determine nutritional contents of the major white-tailed deer foods in the Southeast (Lay 1957, Thorsland 1967, Blair and Epps 1969, Short, 1969, Blair et al. 1977). These researchers assumed that the values suggested by French et al. (1955:46, 1956:231), McEwen et al. (1957:124) and/or Magruder et al. (1957:2) of 0.56% (optimum) and 0.25% (minimum) were valid estimates of dietary phosphorus required by white-tailed deer; and they concluded that native forage is generally deficient in phosphorus. In fact, Blair et al. (1977) used these values and concluded that "phosphorus appears to be a major limiting factor for deer in the Southeast." These same levels continue to be recommended by other researchers throughout the United States (Swank 1956, Urness 1969, Torgerson and Pfander 1971, Boeker et al. 1972, Lawrence and Biswell 1972, Abell and Gilbert 1974, Schwartz et al. 1977, Kie et al. 1980). The purpose of this paper is to demonstrate that, regardless of numerous suppositions in the literature, neither these nor subsequent experiments provide an accurate estimate of dietary phosphorus required by deer for normal growth or reproduction.

Recommendations provided by French et al. (1955, 1956), Magruder et al. (1957), and McEwen et al. (1957) were obtained from the same research project at Pennsylvania State University. French et al. (1955, 1956) published data from the first 2 years while McEwen et al. (1957) and Magruder et al. (1957) published results from all 3 years. The experiment was designed to establish requirements for growth, maintenance, and antler development of several food nutrients (Magruder et al. 1957:2); however, this paper will only discuss data related to phosphorus. The phosphorus aspect of the experiment was originally designed to compare the performances of 2 deer fed a diet containing "low" phosphorus (0.25%) to 2 deer fed a diet containing 0.56% phosphorus (control) during a 3-year period. After the first year, deer on the higher phosphorus diet weighed only 4% more than deer fed the lower phosphorus diet (French et al. 1956:225). One deer on the higher phosphorus diet ate poorly the first year and was fed frequent supplements. If data from this deer were eliminated, the remaining deer on the higher phosphorus diet was 17.6% heavier and had antlers 2.5 times larger than the respective means for the 2 deer fed the lower phosphorus diet. However, these differences could have resulted from genetic variation rather than from a dietary deficiency. In fact, variation in body weight between deer fed a nutritionally complete diet was as high as 34% (French et al. 1955, 1956). In addition, Harmel (1979) found that antler sizes of 2 white-tailed yearlings fed the identical diet varied by 400%.

During the second year, only 1 deer remained as a control (high P) for comparison to the 2 deer on the low phosphorus diet. This deer injured an antler and exhibited "poor food consumption with frequent supplements" during the second year (French et al. 1956:230). One of the 2 deer on the low phosphorus diet was transferred to the control diet in spring. No additional deer were fed the high phosphorus diet; consequently, there were no valid control animals to compare antler development or body growth after the first year. The original conclusion of French et al. (1956) that phosphorus requirements are in excess of 0.25% was based on the poor performance of 1 deer. Magruder et al. (1957) presented the results of the third year by comparing 1 of the 2 deer originally fed the lower phosphorus diet to 7 deer fed a diet containing 55% more phosphorus, 18% more crude protein, and 4% more energy. The single deer fed the lower phosphorus diet for 3 years was smaller, its antlers did not develop as well as those deer fed the "complete" diet, and it died during this third year; but its performance may have resulted from genetic variation, lower protein, lower energy, disease, or a combination of all 4, rather than from a phosphorus deficiency.

In addition, during the third year, 5 deer that had been maintained on medium or high quality diets were transferred to low quality diets (McEwen et al. 1957). Two were fed rations low in calcium and phosphorus as was an additional deer that had been recently acquired. One deer died and the other 2

survived in poor condition. Three of the 5 deer were transferred to a low energy diet; these deer exhibited extreme stress during antler development. McEwen et al. (1957) concluded that single deficiencies of phosphorus (0.27%) or calcium (0.08%) were tolerated with no apparent stress, but rations restricted in both nutrients were too severe for survival. However, many other ration components were varied in diet formulation so that those having low mineral levels were also low in protein and energy and differed with respect to the balance of other ingredients McEwen et al. (1957:121). Therefore, no conclusion regarding mineral deficiencies for deer in these studies should have been made.

Data obtained from the studies by French et al. (1956), Magruder et al. (1957) and McEwen et al. (1957) only suggest that greater than 0.25% dietary phosphorus may be required for maximum body growth and antler development in male white-tailed deer. Due to inadequate sample size, this value should not be interpreted as the dietary level required by deer for maintenance. These values should, however, be used as guidelines for much needed future nutritional research.

Three other studies aimed at determining phosphorus requirements of white-tailed deer have been performed since 1957. Cowan and Long (1962) continued the nutritional work at Pennsylvania State University but increased the sample size by feeding 7 bucks a diet containing 0.20% phosphorus and 7 bucks *ad libitum* phosphorus. Their experiment was not designed to determine a minimum requirement but to compare the physiological responses of 2- to 3-year-old bucks fed 2 levels of phosphorus. They found no difference in antler development, and concluded that the phosphorus requirement of 2- to 3-year-old bucks is $\leq$0.20%. Ullrey et al. (1975) tested the effects of 3 levels of phosphorus (0.26%, 0.35%, 0.44%) on weaned male and female fawns and found no significant difference in growth between the 3 phosphorus levels. They concluded that "weaned white-tailed fawns require no more than 0.26% dietary phosphorus." Neither Cowan and Long (1962) nor Ullrey et al. (1975) determined minimum phosphorus required for normal body and antler growth of white-tailed deer. Reitz (1981) tested 2 levels of dietary phosphorus on yearling bucks and found that 8 deer fed a diet containing 0.16% to 0.22% phosphorus grew significantly smaller antlers than 7 deer receiving from 0.28% to 0.40% dietary phosphorus, but no significant difference was found in body weight. Reitz (1981) was the only scientist to detect a significant reduction in antler development due to low levels of dietary phosphorus. However, as Reitz (1981) suggested, antler development in older bucks fed the lower phosphorus diet may not have been reduced.

Dietz (1965:277) cited the 0.25% phosphorus level suggested by French et al. (1956) as the minimum recommended level needed to support white-tailed deer, and stated that "the National Academy of Sciences-National Research Council (1957) reported forage for pregnant ewes (*Ovis aries*) should contain at least 0.16% phosphorus." Other researchers have cited Dietz

(1965) as if he performed a nutritional study and found the minimum phosphorus level to be 0.16% for mule deer (*Odocoileus hemionus*) (Urness et al. 1971, Urness and McCulloch 1973).

No research has been performed to determine phosphorus levels required by deer for maintenance, growth, conception, pregnancy, or lactation. Research on domestic livestock has shown that inadequate dietary phosphorus will result in reductions in conception rates, milk production, and growth (Underwood 1966:37).

Most publications found dealing with phosphorus limitations of white-tailed deer cited 3 papers (French et al. 1956, McEwen et al. 1957, Magruder et al. 1957) that were based on studies of the performance of deer on a variety of diet formulations during a 3-year period. Even papers published after Cowan and Long (1962) and Ullrey et al. (1975) do not mention these authors; they continue to cite the early work of French et al. (1956), McEwen et al. (1957), and Magruder et al. (1957). Improper use of the literature continues. Recently, Leslie et al. (1984:722–773) improperly assumed that dietary phosphorus levels of 0.20% to 0.25% were critical for deer. They cited Short (1981) who appropriately cited Magruder et al. (1957) and wrote that dietary phosphorus of 0.20% to 0.25% is a useful recommendation. Short (1981:111) did not suggest that dietary phosphorus levels of 0.20% to 0.25% were critical.

It is quite clear that the minimum level of dietary phosphorus required for growth and reproduction of white-tailed or mule deer is unknown. Research is needed to define levels of dietary phosphorus which reduce pregnancy rates, birth rates, or weaning rates before valid conclusions can be made regarding whether the quality of native vegetation limits deer populations.

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