

COAGULOPATHY IN PINK-BACKED PELICANS (*PELECANUS RUFESCENS*) ASSOCIATED WITH HYPERVITAMINOSIS E

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Abstract: Blood clotting abnormalities occurred in six pink-backed pelicans (*Pelecanus rufescens*) at the National Zoological Park. Three birds died and had extensive subcutaneous, intramuscular, and internal hemorrhages. Three surviving pelicans had prolonged blood clotting times that normalized after the birds were treated parenterally with vitamin K. The coagulopathy was attributed to excessive supplementation of the pelicans' diet with vitamin E (550-10,560 IU/kg dry matter), although excessive amounts of vitamins A and D also may have been involved. The dietary vitamin supplementation was greatly decreased, and signs of coagulopathy did not recur in the pelicans.

Key words: Coagulopathy, vitamin E, vitamin K, hypervitaminosis, pink-backed pelicans, *Pelecanus rufescens*.

INTRODUCTION

Dietary maintenance of captive piscivorous animals is often challenging due to seasonal variations in food availability and quality and difficulty in proper preservation of frozen fish.^{13,22,26} Fish frozen under improper conditions and/or for prolonged periods of time may become rancid, leading to loss of the fat-soluble vitamins A, D, E, and K. Consumption of previously frozen fish has resulted in deficiencies of fat-soluble vitamins in several species of zoo animals.^{5,6,13,21,22} Therefore, supplementation of fish-based diets with vitamins A, D, and E may be recommended.^{12,21}

Fat-soluble vitamins are stored in body tissues and may accumulate to high levels. Vitamin A and D toxicities are well documented. However, vitamin E toxicity is rarely reported.

This paper describes the occurrence of a vitamin K-responsive coagulopathy in pink-backed pelicans (*Pelecanus rufescens*) as-

sociated with the consumption of excessive amounts of vitamin E.

CASE REPORT

In August 1985, the National Zoological Park (NZP) received three male and four female pink-backed pelicans that had been recently captured at an estimated age of 1 yr each. During the winter, the pelicans were housed off-exhibit in an indoor, heated facility. The remainder of the year they were displayed together in an outdoor enclosure with several other species of birds. From August 1985 to December 1986, the pelicans consumed a diet consisting primarily of previously frozen whole seatrout (*Cynoscion* sp.) and herring (*Clupea harengus*), supplemented with vitamin E (several brands) and a multivitamin and mineral mixture (Sea Tabs, Pacific Research Laboratories, Inc., El Cajon, California 92022, USA). In December 1986, the pelicans' diet was changed to previously frozen butterfish (*Peprilus* sp.) with similar vitamin and mineral supplementation.

In March 1987, one of the female pelicans (F-1) was noted to have excessive bleeding of traumatized immature primary wing feathers. The bird was treated with 200 mg of oxytetracycline subcutaneously, and the injured feathers were removed. No further

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health problems occurred in the pelican flock until 1 June 1987, when two female pelicans (F-2 and F-3) were found dead in their exhibit. Gross necropsies of these birds revealed that each had extensive subcutaneous and intramuscular hemorrhage over the pectoral region without other signs of massive trauma. Large amounts of blood were also located in the abdominal air sacs of bird F-2. Significant histopathologic findings were limited to severe acute hemorrhage in the subcutis and pectoral muscle interstitium with scattered foci of mild to moderate hemorrhage in and adjacent to other body organs including the lungs, kidneys, and esophagus.

On 31 July, the fourth female pelican (F-4) was presented with hemorrhaging of a broken immature wing feather. Bleeding persisted despite feather extraction and repeated attempts over several hours to cauterize the feather follicle with topical silver nitrate. Hemostasis was eventually achieved by packing the wound with gauze and silver nitrate.

On 7 August, a male pelican (M-1) was found dead. Gross necropsy and histopathologic findings were similar to those seen in pelicans F-2 and F-3.

Physical examination of pelican F-4 on 7 August revealed that the bird was weak and had multiple foci of subcutaneous hemorrhage. Severe anemia (PCV = 12%; normal = 45–48%) and hypoproteinemia (total serum protein < 2.5 g/dl; normal = 4.1–4.7 g/dl) also were present. Blood samples obtained for serum chemical analysis did not clot. The bird was treated i.m. with 200 mg of chloramphenicol and 300 mg of thiamin on 7 August. The next day, the chloramphenicol therapy was repeated and 10 mg of vitamin K (Veta-K1, Professional Veterinary Laboratories, Minneapolis, Minnesota 55440, USA) was given i.m. The pelican clinically improved over the next 3 days with continued daily vitamin K therapy as above. On 11 August, the PCV was 33%, and the total serum proteins were 4.7 g/dl. Parenteral vitamin K therapy was discon-

tinued on 13 August, and the bird was returned to its exhibit.

The remaining three pelicans (F-1, M-2, M-3) were examined on 9–11 August. Blood clotting times of venipuncture sites in F-1 were considered (subjectively) to be markedly prolonged and initial blood samples from M-2 failed to clot. All three birds were given 10–12.5 mg of vitamin K s.c. b.i.d. for 4 days. Blood clotting times in the birds were then subjectively assessed to be normal, compared to clotting times in other avian species at the NZP, and the pelicans were returned to their exhibit.

Following the death of pelican M-1, it was revealed that the pelicans' diet had been supplemented as follows: on odd days of each month, one-fourth of a Sea Tabs tablet was placed in each butterfish, and on even days of the month, a capsule containing 100 IU of alpha-tocopherol (vitamin E) was added to each butterfish. A review of the daily feeding records for the period January–August 1987 revealed that the weight of the butterfish ranged from 28.4 to 42.5 g (average 31.2 g). Based on the labelled vitamin E content in each Sea Tabs tablet, the pelicans' dietary supplement on odd days was an average of 250 IU of vitamin E per kg of fish (range: 183–275 IU/kg). Assuming that the dry matter concentration in butterfish was approximately 33%,²² this was equivalent to an average of 750 IU of vitamin E per kg of fish dry matter. On even days of the month, the average dietary supplementation of vitamin E was 9,600 IU per kg of fish dry matter (range: 7,040–10,560 IU/kg).

Liver samples from the three dead pelicans contained alpha-tocopherol concentrations that varied from 244 $\mu\text{g/g}$ of liver (dry weight) for pelican F-3 to 500 $\mu\text{g/g}$ of liver in pelican F-2. These levels were 5–25 times the normal range of avian hepatic alpha-tocopherol concentrations (H. Stowe, pers. comm.).

In August 1987, dietary supplementation for the remaining pelicans was changed so that each bird received a single 100-IU vi-

tamin E capsule and $\frac{3}{4}$ of a Sea Tabs tablet per week. Since then, the surviving birds have been closely monitored for more than 1 yr and during this time have not shown signs of abnormal hemostasis.

DISCUSSION

Lesions present in the three dead pelicans and clinical signs and/or hematologic findings in three of the four surviving birds were indicative of abnormal blood coagulation. The coagulopathies present in the living pelicans were corrected by parenteral vitamin K therapy.

The most common causes of vitamin K-responsive coagulopathies are dietary deficiencies of vitamin K and ingestion of 4-hydroxycoumarin compounds that inhibit the interaction of vitamin K and vitamin K-dependent carboxylase. Fish normally contain abundant amounts of vitamin K,²⁶ and there is usually considerable vitamin K production by intestinal bacteria. Thus, a dietary deficiency of vitamin K is an unlikely cause of the pelicans' coagulopathies. Tissue samples from the dead pelicans were analyzed by the Animal Health Diagnostic Laboratory, Michigan State University, and did not contain any detectable levels of nine different coumarin compounds (including those used in rodenticides at the NZP).

Vitamin K-responsive coagulopathies due to chronic ingestion of large amounts of vitamin E have been reported in several animal species, including man.^{1,2,7-9,14,16,17} The exact mechanisms by which vitamin E interferes with coagulation are not known. However, *in vitro* studies indicate that the quinone metabolites of alpha-tocopherol may competitively inhibit the function of vitamin K.^{4,23,27} Administration of alpha-tocopherol quinone to rats and mice induces a hemorrhagic syndrome.^{24,28}

During the period from December 1986 to August 1987, the levels of vitamin E present in the pelicans' diet on even days of the month averaged 350–1,600 times the requirement for adult domestic poultry.^{3,11} On odd days, the diets contained an average of

27–125 times the levels of vitamin E recommended for poultry. Coagulation abnormalities that responded to vitamin K administration have been reported in young chickens that ingested feed hypersupplemented with vitamin E at a level that was less than $\frac{1}{4}$ that of the pelicans' diet.¹⁷

The nutritional requirements of pelicans and other piscivorous birds are not well established. Piscivorous animals appear to need greater levels of vitamin E supplementation than do many other animals,^{12,22} but the exact requirements for most species are unknown. Even if pelicans require 10 times the amount of dietary vitamin E that poultry does, supplementation of the pelicans in this report would range up to 190 times the necessary levels.

Based on the labelled content of vitamins A and D₃ present in Sea Tabs, the pelicans' diet also contained high levels of these two fat-soluble vitamins on odd days of the month. The average level of vitamin A present in the fish on days of Sea Tabs supplementation was at least 300,000 IU/kg (dry matter), and the amount of vitamin D₃ averaged 60,000 IU/kg (dry matter). Although these amounts of vitamins A and D₃ greatly exceed the recommended levels for poultry, they are below levels reported to induce acute toxicities.^{3,11} However, these levels exceed the feed concentrations that are considered safe for prolonged consumption by poultry.^{15,19} There is evidence that chronic ingestion of large amounts of vitamin A and/or D may induce coagulation abnormalities in some species.^{10,18,19,25}

It could be speculated that the excessive levels of vitamins A, D₃, and E present in the pelicans' diet interfered with intestinal absorption of vitamin K, thereby inducing a relative vitamin K deficiency. Studies in other species, however, indicate that this is not the primary mechanism by which vitamin E induces coagulopathies.⁹

When the pink-backed pelicans first arrived at the NZP in 1985, each bird was individually supplemented with a 100-IU vitamin E capsule and $\frac{1}{2}$ of a Sea Tabs tablet

daily. Once the pelicans were displayed on exhibit, they were fed as a group. Because vitamin E deficiency can be a significant problem in captive pelicans,^{5,20} each fish offered as food was supplemented with a vitamin E capsule or Sea Tabs tablet on alternate days to ensure that each bird received adequate amounts of fat-soluble vitamins and thiamin. The pelicans were maintained at this high level of vitamin supplementation for more than 1 yr without displaying any clinical signs of disease. In December 1986, the fish fed to the pelicans was changed to a much smaller species. Although the amount of Sea Tabs added to each fish was reduced, 100 IU of vitamin E continued to be placed in each fish on even days of the month because of the impracticality of dividing the vitamin E capsules. Due to the smaller size of the butterflyfish, this resulted in an increase of the already high vitamin E supplementation by 4–10 times. Excessive bleeding was seen in the first pelican 3 mo after this dietary change, and the first deaths occurred 3 mo later.

The surviving pelicans are now individually fed their vitamin supplements and have not shown signs of coagulation abnormalities since this feeding regimen was initiated.

This report documents the occurrence of coagulopathies in a captive flock of pink-backed pelicans associated with excessive dietary supplementation of vitamin E (and possibly vitamins A and D₃). It also illustrates how a series of dietary and husbandry changes can cause marked alterations in diet composition, producing severely adverse effects.

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