A RETROSPECTIVE STUDY EVALUATING VITAMIN E SUPPLEMENTATION IN PELICANS AND PLASMA α-TOCOPHEROL CONCENTRATIONS IN PELICANS, STORKS, AND FLAMINGOS

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Abstract

A retrospective study was conducted to evaluate the effectiveness of two vitamin E supplement forms in pink-backed pelicans (*Pelecanus rufescens*). The forms were a paste supplying 100 IU vitamin E daily or a capsule supplying 10.5 IU vitamin E daily. Baseline blood α-tocopherol concentrations were 7.15 μg/ml in 1998. After 10 months receiving vitamin E in the capsule form, the α-tocopherol concentrations increased by 28% ($P = 0.046$), but were similar to the pink-backed pelicans receiving the supplement paste ($P = 0.17$). There were significant year to year variation in the α-tocopherol concentrations of eastern white pelicans (*Pelecanus onocrotalus*), marabou storks (*Leptoptilos crumeniferus*), and greater flamingos (*Phoenicopterus roseus*), although some of the variation may be due to a change in analytical laboratories. The pelicans, storks, and flamingos, regardless of supplementation strategy, had average α-tocopherol concentrations with ranges for other piscivorous birds.

Introduction

Due to lack of supplementation, rancid feed, and over supplementation, both vitamin E deficiencies and toxicity has been documented in captive pelicans.[2,8,10] Proper vitamin supplementation and food handling can prevent deficiencies and Baer and Allen (1989) suggested using a water soluble supplement to prevent the over-supplementation of vitamins in piscivorous species.[1] Two flocks of pink-backed pelicans (*Pelecanus rufescens*) at Disney's Animal Kingdom (DAK) and Disney's Animal Kingdom Lodge (DAKL) were recently combined. These flocks were receiving vitamin E and thiamin supplementation in the form of a paste or a capsule added to fish. Determining which supplement strategy to continue in the combined flock was the justification of a retrospective study to evaluate the method of vitamin E supplementation to pelicans and to look at the blood α-tocopherol concentrations of other piscivorous birds.

Methods

A flock of (8.8) wild born pink-backed pelicans were received in May 1998 at Disney's Animal Kingdom. A flock (8.6) was placed on exhibit in October 1998. Six birds (3.2) were removed from the main flock in February 2001 to create a new breeding group at DAKL. The flocks were recombined at DAK in October 2004. Three birds (0.3) were deaccessioned between 1998 and 2000. The pink-backed pelicans were fed a diet consisting of a variety of fish including rainbow trout (*Oncorhynchus mykiss*), lake smelt (*Osmerus mordax*), short spotted croaker (*Ophioscion*

punctatissimus), and mullet (*Mulgi* spp.). The current diet consists of 50% trout and 50% lake smelt by weight (Table 1). Initially, all birds received 1 g of a vitamin E/thiamin paste (1 g contained 100 IU of α-tocopherol acetate and 50 mg of thiamin mononitrate; Thiamin-E, Stuart Products, Inc., Bedford, TX 76021) in one fish daily. In November 2002, the DAKL flock started to receive a gelatin capsule (No. 2, Eli Lilly and Co., Indianapolis, IN 46285) containing 10.5 IU vitamin E (Rovimix E 20, DSM Nutritional Products, Inc. Parsippany, NJ 07054) and a ¼ of a of thiamin mononitrate tablet (Thiamin B-1; 50 mg tablet; Rugby Laboratories, Inc. Duluth, GA 30097) for each bird to be inserted into 1 fish daily prior to feeding.

Blood samples were collected during routine exams from the pink-backed pelican flock in May 1998, the DAK flock in March 2002, the DAKL flock in August 2003, and from six birds in the recombined flock in March 2005. Eastern white pelicans (*Pelecanus onocrotalus*), storks and flamingos had blood collected during routine exams between 1999 and 2005. Plasma or serum was harvested, stored at -80 °C (< 6 months) and analyzed for vitamin E (α-tocopherol) at commercial laboratories (Animal Health Diagnostic Laboratory, Michigan State University, Lansing, MI 48909; Wildlife Conservation Society, Department of Nutrition, Bronx, New York 10460).

Within each pink-backed pelican vitamin supplement group, blood α-tocopherol concentration was analyzed as a repeated measure using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). Additionally for bird species when serial blood samples were collected, trends were analyzed as a repeated measure using the GLM procedure of SAS. For the greater flamingo (*Phoenicopterus roseus*) flocks, where only a subsample of the birds had blood collected, the GLM procedure of SAS was used with least square means separated using the PDIFF ADJUST=TUKEY option. In species when serial blood samples were not collected, the mean, standard deviation, minimum and maximum were determined.

Results and Discussion

Changing the form of vitamin E supplementation from a paste to a capsule resulted in a decrease in the total daily amount offered (Table 1). Vitamin E dietary recommendations for exotic birds range from 100 to 500 IU/kg DM which is considerably higher than 5 to 28 IU/kg DM for domestic poultry.[1,4,7] Therefore, the two forms of supplementation were at the extremes of the suggested dietary requirements. Additionally, although a vitamin E supplemented fish was prepared for each bird daily, there were some days that the birds did not consume this fish or may have consumed two.

The pink-backed pelicans' initial blood α-tocopherol concentrations in 1998 (Table 2) averaged 7.15 µg/ml. The pink-backed pelicans which received the vitamin E supplement paste had similar α-tocopherol concentrations in 1998 and 2002. When the pink-backed pelicans were switched from the supplement paste to the vitamin E capsules for 10 months, the blood α-tocopherol concentrations increased 28% ($P = 0.046$). The α-tocopherol concentrations were similar between pink-packed pelicans in 2002 and 2003 ($P = 0.17$). The subsample of pink-backed pelicans sampled in March 2005, had blood α-tocopherol concentrations within the range of the previous years.

Ullrey et al. (1995) suggests that there is a large amount of variation in blood α-tocopherol concentration within an animal group and can vary 1.5 – 2 fold, with each individual having its own characteristic concentration range. This variation is evident in the eastern white pelicans at DAK (Table 3). Their blood α-tocopherol concentrations have fluctuated from year to year without changing the use of the vitamin E paste. Additionally, there may have been an impact on α-tocopherol concentrations due to a change in commercial laboratory. Given the variation in α-tocopherol concentration observed in both free-ranging and captive piscivorous birds (Table 4), both species of pelicans fell within these reference ranges.

The blood α-tocopherol concentrations for the storks, ibis, and spoonbills at DAK and DAKL (Table 3) are within the reference ranges for piscivorous birds listed in Table 4. These birds are not as piscivorous as the pelicans. In addition to fish supplemented with the vitamin paste, these birds receive small rodents and carnivore meat containing supplemental vitamin E (170 IU vitamin E/kg DM, TorontoZoo Carnivore Diet, Milliken Meat Products LTD, Scarborough, Ontario Canada M1V 3F1). There was one Scarlet ibis (*Eudocimus ruber*) that had a blood α-tocopherol concentration of 0.83 μg/ml, which was below the others in its group and may be considered deficient.

The American and greater flamingo (*Phoenicopterus ruber* and *P. roseus*, respectively) flocks (Table 3) had α-tocopherol concentrations within the reference ranges (Table 4). There was a significant increase ($P < 0.05$) in α-tocopherol concentrations of the greater flamingo flock in 2004 and 2005 compared with early years. Although this increase coincides with a change in laboratories, this magnitude of change is not represented in other recent α-tocopherol analyses and can not be explained by a change in the greater flamingo diet.

Although the use of the vitamin paste or capsule provided different daily vitamin E supply, vitamin E status as measured by blood α-tocopherol concentrations seem unaffected. Additionally, there was a reduction in cost when capsules were used to supplement vitamin E. There were year to year fluctuations in blood α-tocopherol concentrations that were not due to supplementation strategy. Alpha-tocopherol concentrations of piscivorous birds were greater than reference values for domestic poultry and can vary greatly within and between piscivorous species. Additional information is needed on the dietary requirements and blood α-tocopherol concentrations of piscivorous birds.

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Table 1. Current ingredients and estimated vitamin E content of the diet supplemented with a vitamin paste or capsule and fed to pink-backed pelicans (*Pelecanus rufescens*).

		Daily diet Offered		Vitamin E	
Item	DM, %	As-fed, kg	DM, kg	mg/kg DM	mg/day
Lake smelt[a]	22.4	0.511	0.114	38.8	4.42
Rainbow trout[b]	24.3	0.511	0.124	75.8	9.40
Unsupplemented diet, total	23.4	1.022	0.238	51.58	13.82
Vitamin E content of the diet supplemented with paste or capsules					
Paste, 1 g/day[c]	-	-	-	478.23	113.82
Capsule, 1/day[d]	-	-	-	102.18	24.32

[a]*Osmerus mordax*.
[b]*Oncorhynchus mykiss*.
[c]Vitamin paste supplement (1 g = 100 IU of α-tocopherol acetate and 50 mg of thiamin mononitrate).
[d]Vitamin capsule supplement (10.5 IU of α-tocopherol and 12.5 mg thiamin mononitrate).

Table 2. Influence of vitamin E supplement form on blood α-tocopherol concentration in pink-backed pelicans (*Pelecanus rufescens*).

Flock	Supplement Form	Analysis Date	*n*	α-tocopherol, µg/ml serum or plasma			
				Mean ± SE	SD	Minimum	Maximum
DAK[a]	Paste[c]	1998	8	7.04 ± 0.60[x]	1.71	3.95	9.84
(5.3 birds)	Paste[c]	2002	8	7.48 ± 0.93[x]	2.63	3.57	11.84
DAKL[b]	Paste[c]	1998	5	7.32 ± 0.87[y]	1.94	5.12	9.59
(3.2 birds)	Capsule[d]	2003	5	9.36 ± 0.53[x]	1.18	8.41	11.34
Combined (4.2 birds)	Paste[c]	2005	6	7.21	1.21	5.79	8.82

[a]Disney's Animal Kingdom.
[b]Disney's Animal Kingdom Lodge.
[c]Vitamin paste supplement (1 g = 100 IU of α-tocopherol acetate and 50 mg of thiamin mononitrate).
[d]Vitamin capsule supplement (10.5 IU of α-tocopherol and 12.5 mg thiamin mononitrate).
[xy]Means within location with unlike superscripts differ $P < 0.05$.

Table 3. Vitamin E (α-tocopherol) concentrations of piscivorous bird species housed at Disney's Animal Kingdom and Disney's Animal Kingdom Lodge.

Species	Analysis Date	*n*	α-tocopherol, µg/ml serum or plasma			
			Mean ± SE	SD	Low	High
Eastern white pelicans	1998	7	11.87 ± 1.03	2.74	8.89	15.8
(*Pelecanus onocrotalus*)[a]	2002	7	8.00 ± 1.09	2.89	3.85	10.64
	2004	7	14.48 ± 1.61	4.25	11.37	23.78
Marabou stork	2003	7	9.47 ± 0.94	2.50	4.69	11.87
(*Leptoptilos crumeniferus*)[b]	2004	7	12.71 ± 1.79	4.75	6.17	19.40
Abdim's stork	2003	3	8.77 ± 1.90	3.29	5.12	11.51
(*Ciconia abdimii*)[c]	2004	3	8.58 ± 1.00	1.72	6.83	10.28
	2005	2	9.05	-	7.46	10.64
Saddle-billed stork (*Ephippiorhynchus senegalensis*)	2004	7	28.01	12.56	7.53	40.3
Bald ibis (*Geronticus calvus*)	2003	4	15.93	3.00	13.75	20.28
Scarlet ibis (*Eudocimus ruber*)	2003/2004	8	44.89	33.04	0.83	109.72
African spoonbill (*Platelea alba*)	2003/2004	3	36.12	7.79	21.56	43.30
Roseate spoonbill (*Ajaia ajaja*)	1999/2003	3	41.39	4.34	36.45	44.56
American flamingo (*Phoenicopterus ruber*)	2001	9	13.12	2.17	9.89	16.40
Greater flamingo	1999	12	9.15 ± 0.76^{y}	2.65	5.25	13.18
(*Phoenicopterus roseus*)	2000	12	16.69 ± 1.21^{y}	4.19	11.03	27.31
	2001	3	7.34 ± 0.13^{y}	0.22	7.17	7.59
	2003	4	11.11 ± 1.71^{y}	3.42	7.54	14.48
	2004	13	51.45 ± 7.86^{x}	28.34	13.22	110.84
	2005	13	41.13 ± 1.75^{x}	6.31	33.01	58.65

[a]Linear effect $P = 0.17$, quadratic effect $P = 0.003$.
[b]Linear effect $P = 0.95$.
[c]Linear effect (2003 to 2004) $P = 0.087$.
[xy]Means within species with unlike superscripts differ $P < 0.05$.

Table 4. Reference values for blood Vitamin E (α-tocopherol) concentrations of domestic and piscivorous birds.

Species	α-tocopherol, μg/ml serum or plasma	Reference
Chickens	0.100 – 0.350	Puls, 1994
Quail and turkeys	0.300 – 1.400	Puls, 1994
Free-ranging birds		
Gentoo penguins	30.8 – 50.7	Monroe, 1993
(*Pygoscelis papua*)	8.3 – 32.6	Ghebremeskel et al., 1992
	16.3 – 22.3	Williams et al., 1989
Humboldt penguins	5.15 – 29.64	Wallace et al., 1996
(*Spheniscus humboldti*)		
Macaroni penguins	8.0 – 71.0	Ghebremeskel et al., 1992
(*Eudyptes chrysolophus*)		
Magellanic penguins	6.1 – 23.3	Williams et al., 1989
(*Spheniscus magellanicus*)		
Rockhopper penguins	22.3 – 40.8	Monroe, 1993
(*Eudyptes crestatus*)	21.7 – 50.8	Williams et al., 1989
Captive birds		
Humboldt penguins	5.35 – 66.4	Crissey et al., 1998
Boat-billed herons	7.9 – 14.2	Dierenfeld, 1989
(*Cochlearius cochlearius*)		
Saddle-billed storks	2.2 – 17.7	Dierenfeld, 1989
Flamingo	10.7 – 34.0	Dierenfeld, 1989
(Two *Phoenicopterus* spp.)		