Safety of fenbendazole in common peafowl (*Pavo cristatus*)

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Abstract: The present study was undertaken to find out the safety levels of fenbendazole in common peafowl. This bird, raised on aviaries and zoos, can be severely parasitized with *Ascaridia galli* (enteric worms) and *Syngamus trachea* (gapeworm) along with other parasitic worms. Fenbendazole is a highly effective benzimidazole-class anthelmintic in animals. The objective of this work was to provide target animal safety data in young peafowl and to demonstrate reproductive safety in adult birds. During the experimental study, diets containing fenbendazole at 0, 100, 200 and 300 ppm were fed for 21 days (three times the normal treatment duration). Data for feed consumption, feed conversion rate, and body weights were recorded for each bird in each group. Drug concentrations in different tissues of birds were determined to correlate concentrations with clinical observations, clinical pathology, and histologic findings. There were no morbidities or mortalities after study day 21. Additionally, there were no statistically significant treatment-related differences among above mentioned parameters. Analysis of fenbendazole concentrations in kidney, liver, leg/thigh, and breast muscle and skin with associated fat revealed that, even at the highest dose level used and with no feed withdrawal, fenbendazole concentrations were relatively low in these tissues. These findings indicate that fenbendazole has a relatively wide margin of safety in young peafowl and that the proposed dose of 100 ppm in the feed for 7 consecutive days is well within the margin of safety. In the reproductive safety study, five breeder peafowl farms fed fendbendazole at 100ppm for 7 days and collected data on hatching percentage of peahen eggs before and after treatment. Reproductive performance in peahen was not adversely affected.

Keywords: Fenbendazole, peafowl, *Ascaridia galli, Syngamus trachea.*

INTRODUCTION

Peafowl are susceptible to enteric parasites notably the round worms namely *Ascaridia galli* that cause the disease known as ascaridiasis and respiratory parasites namely *Syngamus trachea* that causes the disease known as gape. Among the parasites next to the coccidium, *Ascaridia galli and Syngamus trachea* infection in peafowl is considered to be of great importance as it can cause extensive economic losses in different ways such as loss of weight, egg production and mortality of birds. Control of these worms is mainly based on regular anthelmintic treatment. Fenbendazole (methyl 5-[phenylthio]-2-benzimidazole carbamate) is a highly effective anthelmintic that is approved for use in dogs, cats, and horses as well as several food-animal species. Because of their mechanism of action, benzimidazoles are usually more effective if administered over a course of several days compared to a single-dose or a short-duration treatment, thus making administration through the feed desirable (Lanusse *et al.,* 2009). Fenbendazole and related agents are used commonly for the control of nematodes, tapeworms, and trematodes (Lanusse *et al.,* 2009). Several oral formulations of fenbendazole are marketed for food-producing animals in the world; however, fenbendazole is not approved for peafowl even though it is effective against parasites that commonly infest these animals (Kirsch, 1984; Yazwinski *et al.,* 1986). Peafowl raised on propagation farms and zoo are frequently infested with gapeworm (*Syngamus trachea*) and round worms (*Ascaridea galli*). Depending on the severity of the infestation, morbidity and mortality can be high (Yazwinski, 2008). Kirsch demonstrated that fenbendazole was effective against *S. trachea, Capillaria* sp., and *Heterakis* sp. in pheasants and partridges when given at a dose of 100 parts per million (ppm) in feed for 4 consecutive days (Kirsch, 1984). Fenbendazole has been used in a variety of avian species (Yazwinski, 2008). However, feathering abnormalities, reproductive problems, and death have been observed as a result of benzimidazole treatment in some avian species (Bakst *et al.,* 1993; Bonar *et al.,* 2003; Devriese, 1983; Howard *et al.,* 2002; Papendick *et al.,* 1998; Stalis *et al.,* 1995). Similar problems have not been described in peafowl. Demonstration of target animal safety including reproductive safety is required for an anthelmintic to be approved for use in a food-producing animal. The main objective of this study was to provide target animal safety

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Table 1: Schedule of groups and related treatments

Group	Bird in each group	Treatment given	Drug	Dose	Route of administration
1	10	T0	-	-	Feed
2	10	T1	Fenbendazole (100 mg/ml)	100 ppm	Feed
3	10	T2	Fenbendazole (100 mg/ml)	200 ppm	Feed
4	10	T3	Fenbendazole (100 mg/ml)	300ppm	Feed

data to support the approval of fenbendazole-medicated feed for peafowl. A second objective was to quantify fenbendazole concentrations in tissues from peafowl being fed higher than recommended levels of the anthelmintic and correlate that with the clinical condition, clinical pathology, and histologic data. Data might also serve to indicate the safety and effective dose rates of fenbendazole for the off-label, veterinarian-prescribed treatment of peafowl for the more common helminth parasitisms.

MATERIALS AND METHODS

Peafowl

For the young bird safety study, day-old common peafowl (*Pavo cristatus*) chicks were obtained from local hatchery. No treatments were allowed at the hatchery or at the research facility prior to study day 0. The peafowl were placed in floor pens approximately 1.2 x 1.2 x1.2m, ten birds per pen at aviary of University of veterinary and Animal Sciences Lahore. Pens were bedded with wood shavings. Individual heat lamps were placed in each pen, and room temperature was maintained appropriately for the age of the birds. Room light was provided 16 hr daily. Water was provided by nipple waterers, and the peafowl were fed a basal diet containing no antibiotics or growth promotants (Hi-Tech layer Starter^{TM}) until day 0. The health status of the peacocks were examined including weighing, and the peafowl were individually identified with leg bands on day 42. Only normal and healthy-appearing birds were placed in the study after approximately 42 days of age. For the reproductive safety portion of the study, five peafowl breeder farms were allowed to use fenbendazole for control of gapeworm and intestine worm. Data on hatchability of eggs before and after a 7-day course of treatment were collected.

Experimental design

Experimental study protocol was approved by the Animal care and research committee of the University of Veterinary and Animals Sciences, Lahore and experimentation were carried out according to the guidelines of committee. The proposed dose for fenbendazole in peacocks was 100ppm in feed for 7 consecutive days. In the young bird study, concentrations of 0, 100, 200, and 300ppm in the feed (T0, T1, T2, and T3) fed for three times the normal treatment length were required for this target animal safety study (table 1). Peafowl were fed their experimental diets from approximately 42 days of age to 63 days of age. For the tissue concentration study, three peafowl were humanely euthanatized, weighed, and evaluated for feathering abnormalities. The feathers were removed from these birds, and sections of the breast, leg and thigh muscles, sections of the skin and associated fat, the entire liver, and as much kidney as possible were removed and placed in individual plastic bags. The tissues were frozen at -80^{o}C immediately after collection. For the reproductive safety study, breeder peafowl were fed rations containing 100 ppm fenbendazole for 7 consecutive days. Eggs were collected, processed, and incubated, and the hatchability determined.

Test diets

For the young bird target animal safety and tissue concentration studies, diets were formulated from a single lot of basal diet (Layer feed) and mixed according to standard procedure with the appropriate amount of Fenbendazole in mixer. Three samples were obtained from each diet and submitted for analysis to Quality operation laboratory (UVAS). A sample of each diet was also submitted for analysis at the end of the study to verify stability of the fenbendazole in the feeds. All samples were within tolerance for the specified level of fenbendazole. The birds were fed *ad libitum* and provided fresh feed each morning. For the reproductive safety study, diets were formulated by local feed suppliers for each farm.

Clinical observations, feed consumption, and feathering scores

In the young bird study, daily feed consumption was recorded and the feed conversion rate was determined. General clinical condition (- no clinical sign or healthy, + reduced spontaneous activity, ++ socially isolated but moves when approached, +++ pronounced lethargy, only moves when stimulated) and fecal scores (-normal droppings, + mild lose droppings, ++ moderate lose droppings, +++ severe loose droppings) of the peafowl were observed and recorded twice daily. Feathering was evaluated at study termination.

Pathology/clinical pathology

In the young bird study, two birds from each pen were randomly selected for necropsy on study day 21. Blood samples (2ml) were obtained for haematology and clinical biochemistry via wing vein. The blood was divided

Table 2: Hematology and clinical chemistry reference ranges for 9- weeks-old common peafowl

Parameters [A]	Low[B]	High
Manual white blood cell count ($x10^3$/µl)	4.77	18.3
Manual red blood cell count ($x10^6$/µl)	1.88	2.8
Packed cell volume (%)	33.23	44.7
Heterophils ($x10^3$/µl)	1.32	9.0
Eosinophil ($x10^3$/µl)	0.00	0.52
Basophils ($x10^3$/µl)	0.00	0.37
Lymphocyte ($x10^3$/µl)	1.57	9.3
Monocyte ($x10^3$/µl)	0.00	0.05
Blood urea nitrogen (mg/dl)	2	9.4
Alanine aminotransferase (IU/L)	2.5	14
Albumin (g/dl)	1.47	2.4
Alkaline phosphatase (IU/L)	140	457
Amylase (IU/L)	1364	2555
Aspartate aminotransferase (IU/L)	49	198
Calcium (mg/dl)	11.7	15.7
Chloride (mEq/L)	108	118
Cholesterol (mg/dl)	105	202
Creatine kinase (IU/L)	906	278
Creatinine (mg/dl)	0.6	1.3
Gamma-glutamyl transferase (IU/L)	0.0	7.3
Globulin (mg/dl)	0.00	1.3
Glucose (mg/dl)	324	492
Lactate dehydrogenase (IU/L)	98	437
Magnesium (mg/dl)	1.82	3
Phosphorus (mg/dl)	3.9	12.7
Potassium (mEq/L)	2.3	10.2
Sodium (mEq/L)	142	161
Total bilirubin (mg/dl)	0.0	0.3
Total protein (g/dl)	2.88	5.23
Uric acid (mg/dl)	0.8	5.8

[A]Data are from four groups of untreated pheasants submitted to Clinical Pathology Laboratory between 2014 and 2015.
[B] Low and high values represent 95% reference intervals.

between EDTA and heparinized tubes and submitted to clinical Pathology Laboratory, University of Veterinary and Animal Sciences Lahore for haematology and serum biochemistry analyses. The birds were weighed, euthanized by using pentobarbital sodium, placed in individual plastic bags on ice, and delivered to the necropsy laboratory for necropsy examination of all tissues. Samples from some organs (liver, kidney, lungs, heart, intestine and bursa of fabricius) were fixed in 10% neutral buffered formalin for histologic exam. Tissues from test group 1 (untreated) and test group 4 (high dose) were sectioned and examined for histopathological lesions. Haematological data from control peacocks (table 2) used to establish reference ranges for haematology and clinical chemistry variables (Samour *et al*., 2010). Reference intervals were generated in Microsoft Excel® using Reference Value Advisor freeware. Peafowl 95% reference intervals were calculated by nonparametric methods following laboratory Standards guidelines. Analysis of fenbendazole sulfate (FBZ-SO_4), fenbendazole sulfone (FBZ-SO_2), and fenbendazole (FBZ) in tissue samples was conducted using the method described previously (Sorensen and Hansen, 1998; Griffith *et al.*, 2014).

Reproductive safety evaluation

Eggs were collected from pens and processed according to each farm's protocol. Hatching data were compared for eggs laid the week preceding treatment and the week to 10 days following treatment. Egg fertility and hatching percentage normally decrease as the laying season progresses, making it difficult to compare data longer term. Hatching data were collected from March 2014 to July2014.

STATISTICAL ANALYSIS

Statistical analysis was performed using GraphPad Prism 6 software (GraphPad Software Inc. La Jolla, CA, USA) and values were expressed as the mean ± standard deviation of the mean (SDM). Two-way analysis of variance (ANOVA) was performed on the variables live

Table 3: Beginning and ending pheasant body weights (g).

Variable	Test group	Treatment [A]	Mean (g)	SD	P value
Beginning body weight	1	T0	207.3	0.77	-
	2	T1	202.6	0.65	0.9787
	3	T2	202.9	0.78	0.4592
	4	T3	203.5	0.55	0.0815
Ending body weight	1	T0	240.5	0.75	-
	2	T1	235.2	0.45	0.1581
	3	T2	234.8	0.65	0.2149
	4	T3	237.5	0.85	0.0927

[A] T0, T1, T2, T3= 0, 100, 200, and 300 ppm fenbendazole, respectively, in feed for 21 days (three times the recommended length of treatment).

Table 4: Feed conversion rate.

Test group	Treatment [A]	Mean [B]	SD	P value
1	T0	2.75	0.92	-
2	T1	2.68	0.77	-
3	T2	2.73	0.47	-
4	T3	2.72	0.35	0.7725

[A] T0, T1, T2, T3= 0, 100, 200, and 300 ppm fenbendazole, respectively, in feed for 21 days (three times the recommended length of treatment).
[B] Grams of feed per gram of weight gain.

weights, feed consumption, serum biochemistry and haematology data. The observations made for gross pathology and histopathology were summarized and compared to untreated controls, but no formal statistical analyses were performed. Means and standard deviations (SDs) were determined for the drug concentrations of each of the tissues at each treatment level. There were no statistical comparisons of tissue concentrations. Statistical significance was set at $P<0.05$ unless otherwise stated.

RESULTS

There were no morbidities or mortalities in the young bird study after day 21. Beginning and ending bird weights are presented in table 3. There was no difference in beginning (p=0.0815) and ending (p=0.0927) bird weights with test group 4. There were no statistically significant treatment-related differences in feed conversion (table 4), clinical observations, and feathering scores (P>0.05). Haematology and serum biochemistry reference ranges are presented in table 2. These can be compared to other published values (Ritchie *et al.,* 1994; Schmidt *et al.,* 2007), but differences in testing among laboratories should be taken into account as well as the ages of the birds. The reference ranges given here are from a comparatively large pool of birds but are limited to a single age group. The haematology and serum biochemistry determinations from this study are presented in tables 5 & 6. The haematology and serum biochemistry results were consistent with reference range values for peafowl of this age. Gross necropsies revealed a few birds with small lesions consistent with minor inflammation, but there were no discernible differences between untreated and treated peafowls. On histology, many of the peafowl had small areas of lymphocytic infiltrates in a variety of tissues and other mild lesions, but these were found in both test group 1 (untreated) and test group 4 (high dose) birds. These were characterized as insignificant lesions and were not drug-related since they occurred with equal frequency in untreated and high-dose group birds. Since tissues from birds in test group 4 showed no drug related histologic lesions as compared to those in test group 1, tissues from lower medicated groups (test groups 2 and 3) were not examined histologically. Tissue concentrations of FBZ-SO, FBZ-SO_2, and FBZ are presented in table 7. The limit of quantification for FBZ-SO, FBZ-SO_2, and FBZ, respectively, were kidney, 0.081, 0.035 and 0.162µg/g; liver, 0.029, 0.124, and 0.262µg/g; leg/thigh muscle, 0.012, 0.016, and 0.011mg/g; pectoral muscle, 0.009, 0.012 and 0.007µg/g and skin with adhering fat, 0.033, 0.029 and 0.020µg/g. Limits of detection ranged from 0.002 to 0.090µg/g. Quantification was limited by the lowest calibration standard, which was equivalent, at typical sample weight and dilution, to 0.030 µg/g. FBZ-SO2 is considered the marker residue. Allowable limits with a maximum 6-hr feed withdrawal time for liver and muscle tissues in turkeys are 6 and 2 ppm, respectively. The tissue samples in this study were taken without feed withdrawal. The mean liver and pectoral muscle concentrations of FBZ-SO_2 were 6.4 and 2.4 ppm, respectively, indicating that they were slightly above tolerance for those tissues at the highest dose. The results of the reproductive safety study are presented in table 8.

Table 5: Summary statistics for the haematology variables [A]

Variable	Test group	Treatment [B]	Mean	SD	P value
White blood cell count ($x10^3$/µl)	1	T0	10.77	3.71	-
	2	T1	10.48	3.26	-
	3	T2	10.71	3.89	-
	4	T3	10.86	4.54	0.7427
Manual red blood cell count ($x10^6$/µl)	1	T0	2.58	0.32	-
	2	T1	2.84	0.42	-
	3	T2	2.49	0.36	-
	4	T3	2.54	0.28	0.0846
Packed cell volume (PCV) (%)	1	T0	36.92	2.85	-
	2	T1	39.45	2.58	-
	3	T2	37.24	2.48	-
	4	T3	37.12	2.47	0.5692
Heterophils ($x10^3$/µl)	1	T0	3.92	2.81	-
	2	T1	3..58	3.42	-
	3	T2	4.12	3.21	-
	4	T3	3.72	2.58	0.0781
Eosinophils ($x10^3$/µl)	1	T0	0.16	0.12	-
	2	T1	0.18	0.14	-
	3	T2	0.15	0.16	-
	4	T3	0.15	0.11	0.4174
Basophils ($x10^3$/µl)	1	T0	0.09	0.04	-
	2	T1	0.08	0.05	-
	3	T2	0.06	0.07	-
	4	T3	0.07	0.08	0.0646
Lymphocytes ($x10^3$/µl)	1	T0	3.88	2.47	-
	2	T1	3.74	1.36	-
	3	T2	4.12	1.25	-
	4	T3	3.68	1.45	0.0855
Monocytes ($x10^3$/µl)	1	T0	0.075	0.17	-
	2	T1	0.075	0.15	-
	3	T2	0.094	0.12	-
	4	T3	0.078	0.11	0.0924

[A] Differences in test groups 1, 2, 3, and 4 were evaluated with ANOVA (P values).
[B] T0, T1, T2, T3= 0, 100, 200, and 300 ppm fenbendazole, respectively, in feed for 21 days (three times the recommended length of treatment).

DISCUSSION

The results from this study indicate that fenbendazole fed at 100 ppm for 7 days is safe for peafowl. On large domestic bird farms where birds are usually housed outside in multiple pens, administration of therapeutic drugs in the feed is often the only practical route. Because of their mechanism of action, benzimidazoles are usually more effective if administered over a course of several days compared to a single dose or a short duration treatment, thus making administration through the feed the only practical method for large groups of animals (Lanusse *et al*., 2009). However, there is no study related to safety of fenbendazole in peafowl. The studies necessary to provide acceptable data to support a label claim to allow feed use are often so costly that manufacturers are unwilling to undertake those studies for minor species, leaving many of the minor species without adequate means of disease control. The peafowl industry has a particular problem with *A. galli* and *S. trachea* infestation that can easily be prevented with the judicious use of fenbendazole (Supperer and Kutzer 1981; Sander and Schwartz, 1994; Ibarra-Velarde *et al.,* 2011). Benzimidazole anthelmintics are generally noted for their wide margin of safety. This is due to their greater affinity for tubulin of parasites compared to that of mammalian and avian species. However, this selective toxicity is not absolute, and teratogenicity, embryotoxicity and feathering abnormalities have been reported in a variety of species (Devriese, 1983; Papendick *et al.,* 1998; Stalis *et al.*, 1995). Some avian species in particular seem to be very sensitive to benzimidazoles (Bonar *et al.,* 2003; Howard *et al.*, 2002). Fenbendazole in high doses caused marked decreases in semen quality when fed to turkeys

Table 6: Summary statistics for the clinical chemistry variables [A]

Variable	Test group	Treatment [B]	Mean	SD	P value
Blood urea nitrogen (mg/dl)	1	T0	1.4	1.6	-
	2	T1	1.3	1.3	-
	3	T2	1.5	1.7	-
	4	T3	1.4	1.5	0.2604
Creatinine (mg/dl)	1	T0	0.7	0.5	-
	2	T1	0.5	0.2	-
	3	T2	0.8	0.4	-
	4	T3	0.6	0.3	0.5744
Glucose (mg/dl)	1	T0	417	48	-
	2	T1	445	67	-
	3	T2	411	43	-
	4	T3	422	49	0.6281
Total protein (g/dl)	1	T0	4.15	0.89	-
	2	T1	4.19	0.72	-
	3	T2	4.11	0.58	-
	4	T3	4.44	0.75	0.3665
Albumin (g/dl)	1	T0	2.14	0.27	-
	2	T1	2.41	0.27	-
	3	T2	2.55	0.27	-
	4	T3	2.22	0.27	0.4324
Creatine kinase (IU/L)	1	T0	1478	488	-
	2	T1	1485	433	-
	3	T2	1496	413	-
	4	T3	1445	459	0.3945
Aspartate transaminase (IU/L)	1	T0	147	48	-
	2	T1	132	31	-
	3	T2	145	58	-
	4	T3	158	45	0.7174
Alanine transaminase (IU/L)	1	T0	1.4	1.89	-
	2	T1	1.9	1.2	-
	3	T2	1.3	2.5	-
	4	T3	1.5	1.7	0.2895
Lactate dehydrogenase (IU/L)	1	T0	231	37	-
	2	T1	224	48	-
	3	T2	239	52	-
	4	T3	242	89	0.0926
Alkaline phosphatase (IU/L)	1	T0	294	96	-
	2	T1	288	91	-
	3	T2	246	37	-
	4	T3	278	77	0.2604
Gamma-glutamyl transferase (IU/L)	1	T0	1.8	3.7	-
	2	T1	1.4	3.5	-
	3	T2	1.9	2.9	-
	4	T3	1.5	2.8	0.3105
Calcium (mg/dl)	1	T0	13.8	3.25	-
	2	T1	13.4	1.7	-
	3	T2	13.7	2.22	-
	4	T3	14.2	2.8	0.2331
Phosphorus (mg/dl)	1	T0	6.2	2.1	-
	2	T1	6.4	2.1	-
	3	T2	6.8	2.1	-
	4	T3	6.2	2.1	0.4065

Sodium (mEq/L)	1	T0	149	4.5	-
	2	T1	155	2.4	-
	3	T2	135	2.8	-
	4	T3	159	3.1	0.5012
Potassium (mEq/L)	1	T0	3.47	1.1	-
	2	T1	3.42	1.7	-
	3	T2	3.27	1.9	-
	4	T3	3.41	1.7	0.3071
Chloride (mEq/L)	1	T0	124.5	68	-
	2	T1	130.9	45	-
	3	T2	120.9	36	-
	4	T3	130.5	26	0.5543
Magnesium (mg/dl)	1	T0	3.78	1.2	-
	2	T1	3.26	1.4	-
	3	T2	3.58	0.88	-
	4	T3	3.66	1.5	0.4964
Amylase (IU/L)	1	T0	1810	388	-
	2	T1	1814	378	-
	3	T2	1825	318	-
	4	T3	1817	357	0.4682
Uric acid (mg/dl)	1	T0	3.58	1.5	-
	2	T1	3.69	1.3	-
	3	T2	3.45	1.8	-
	4	T3	3.77	1.7	0.5706
Total bilirubin (mg/dl)	1	T0	0.45	0.3	-
	2	T1	0.56	0.2	-
	3	T2	0.68	0.2	-
	4	T3	0.5	0.8	0.3934
Cholesterol (mg/dl)	1	T0	157	34	-
	2	T1	147	21	-
	3	T2	153	75	-
	4	T3	152	27	0.4906

[A] Differences in test groups 1, 2, 3, and 4 were evaluated with ANOVA (P values).
[B] T0, T1, T2, T3= 0, 100, 200, and 300 ppm fenbendazole, respectively, in feed for 21 days (three times the recommended length of treatment).

Table 7: Fenbendazole and fenbendazole metabolite concentrations (µg/g) in peacock tissues [A]

Tissue /dose		FBZ-SO			FBZ-SO2			FBZ		
		T1	T2	T3	T1	T2	T3	T1	T2	T3
Kidney	Mean	0.382	0.984	1.464	1.822	3.701	5.705	0.205	0.447	0.585
	SD	0.313	0.457	0.731	0.469	1.281	0.723	0.340	0.221	0.315
Liver	Mean	0.3924	1.474	1.452	3.161	4.155	6.471	0.005	0.078	0.161
	SD	0.248	0.678	1.369	0.950	1.649	1.807	0.004	0.056	0.152
Leg/thigh	Mean	0.214	0.437	0.431	0.597	1.774	1.611	0.006	0.012	0.031
	SD	0.211	0.173	0.294	0.164	0.174	0.435	0.008	0.017	0.012
Pectoral	Mean	0.175	0.417	0.834	0.412	1.482	2.405	0.007	0.047	0.026
	SD	0.123	0.135	0.457	0.273	0.443	0.371	0.006	0.035	0.020
Skin/fat	Mean	0.174	1.734	0.701	0.714	1.623	2.402	0.034	0.067	0.161
	SD	0.180	0.725	0.397	0.334	0.514	0.454	0.018	0.024	0.154

[A] All values for untreated controls were below the limit of detection and are not listed.
FBZ-SO (fenbendazole sulfate), FBZ-SO2 (fenbendazole sulfone), and FBZ (fenbendazole)

Table 8: Hatching data from different zoo [A]

Group	% hatch week before treatment	% hatch after treatment
Farm 1	85.5	85.8
Farm 2	83.2	84.5
Farm 3	80.5	81.3
Farm 4	78.5	80.2
Farm 5	82.4	82.7

[A] Breeder pheasants were fed 100 ppm Fenbendazole fed for 7 consecutive days. Hatching percentage after treatment is for eggs that were laid within a week to 10 days after the end of treatment.

(Bakst *et al.*, 1993). However, administration of fenbendazole to quail was reported to not have any effects on egg laying, fertility and hatchability (Supperer and Kutzer 1981; Sambeth 1980). Administration of fenbendazole and albendazole to some bird species has been associated with an increased mortality rate (Stalis *et al.*, 1995). However, based on this work, there does not appear to be a problem with toxicity in peafowl. The drug concentration data from this study demonstrated that even when fed at high levels and with no withdrawal time, the tissue concentrations of fenbendazole and its metabolites were relatively low. Tissue concentrations of the drug are close to the allowable limits even when high doses are administered for an extended treatment period. Fenbendazole at 100ppm in the feed for 7 consecutive days did not affect fertility and hatchability of peafowl eggs. Hatching percentages remained stable at different breeder farms during 2014-2015. Data indicated an increase in hatching percentage that coincided with treatment. No statistical evaluation of the data was applied because there are multiple variables involved in the hatchability of peafowl eggs and there were no untreated control groups for comparison. Hatching percentages can vary from over 90% to less than 50%. Eggs laid very early in the season and those laid in wet, muddy conditions, or even those exposed to long periods of bright sunlight, can have lower hatching percentages. Refrigeration of eggs for extended periods prior to incubation can have a marked effect. There is a gradual decrease in hatching percentage as the season progresses. Given all those factors, comparison of hatching percentages from week to week can be misleading. A controlled study with individually identified birds under uniform conditions would provide additional information on reproductive safety including evaluation of the effects on semen quality.

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