Research Article

Transport-Related Variations in Hematology and Biochemistry of Greater Flamingos at Dubai Safari Park

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Abstract

Dubai Safari Park, one of the leading wildlife conservation facilities in Dubai, maintains a diverse range of species in exhibits designed to support natural behaviors and contribute to ex situ conservation programs.

As in many modern zoological institutions, the park routinely engages in animal exchange programs to manage surplus populations, optimize enclosure space, and maintain appropriate social groupings. Although transportation is an essential component of these exchanges, it is well recognized that handling, confinement, and environmental changes of the animals can induce acute physiological stress in many avian species. The Greater Flamingo (Phoenicopterus roseus) is particularly sensitive to such disturbances, often exhibiting measurable alterations in blood parameters following transport.

This case study evaluated the hematological and biochemical profiles of newly arrived Greater Flamingos upon their admission to quarantine, with the aim of identifying physiological changes associated with transport and early acclimatization. Post-arrival blood analyses showed that 78% of the birds had elevated hemoglobin and hematocrit values, while 89% exhibited increased albumin concentrations, findings consistent with dehydration-related hemoconcentration following transport. All individuals demonstrated elevated bile acid levels, and 61% showed increased creatine kinase activity, suggesting muscular exertion and hepatic metabolic responses commonly associated with acute stress. In contrast, notable reductions were observed in globulin (94%), red blood cell count (61%), and uric acid (56%), indicating potential stress-related immune modulation and alterations in protein metabolism.

These physiological shifts are consistent with previously documented effects of transport on avian species and reinforce the importance of monitoring hematological and biochemical indicators during the acclimatization period. The results underscore the value of post-transport health assessments in evaluating welfare, guiding improvements in transport protocols, and supporting the overall success of ex-situ conservation programs.

Keywords: Greater Flamingo, hematology, biochemistry, transportation, stress physiology, avian welfare

Abbreviations: RBC, red blood cell count, WBC, white blood cell count, Hb, hemoglobin, HCT, hematocrit (packed cell volume), AST, aspartate aminotransferase, BA, bile acids, CK, creatine kinase, UA, uric acid, GLU, glucose, Ca, calcium, PHOS, phosphorus, TP, total protein, ALB, albumin, GLOB, globulin, K^+, potassium, Na^+, sodium, ICT, insufficient sample quantity for analysis.

Introduction

The Greater Flamingo (Phoenicopterus roseus) is the largest and most widely distributed flamingo species, occurring throughout Africa, the Mediterranean Basin, the Middle East, and South Asia.[1] It inhabits saline lagoons, coastal wetlands, salt pans, and alkaline lakes, where it plays an important ecological role within wetland ecosystems.[1,2] The species is currently classified as Least Concern by the International Union for Conservation of Nature (IUCN), with stable or increasing populations across much of its geographic range (BirdLife International, 2018). Nevertheless, captive population management remains an important component of ex situ conservation programs aimed at maintaining genetically and demographically sustainable populations within zoological institutions.[3,4]

Modern zoological institutions increasingly rely on cooperative population management and animal exchange programs, whereby individuals are transferred between facilities to maintain genetically and demographically sustainable populations, optimize enclosure space, support conservation goals, and promote high standards of animal welfare.[3,4] Dubai Safari Park (DSP), one of the leading wildlife conservation facilities in the United Arab Emirates, actively participates in such exchanges as part of its commitment to animal welfare, population management, and ex situ conservation. These exchanges allow institutions to alleviate overcrowding, provide adequate long-term housing opportunities, and ensure that animals are maintained in environments that support their physical and behavioral needs.

Although animal transportation is an essential component of zoo population management, the capture, handling, restraint, confinement, and environmental changes associated with relocation are recognized stressors that can induce physiological alterations in birds. Transport-related stress is known to induce measurable alterations in hematological and biochemical parameters in birds through dehydration, muscle activity, metabolic disturbances, and activation of the hypothalamic-pituitary-adrenal axis. These physiological responses may occur even during relatively short transportation periods and can influence welfare, health status, and subsequent acclimatization following relocation.[5,6] To reduce transport associated stress, DSP applies several welfare-focused measures during flamingo transfers. Birds are transported in climate-controlled enclosed vehicles equipped with air conditioning, and each individual is housed in a purpose-built transport crate designed to accommodate the species' morphology while minimizing excessive movement and reducing the risk of injury. Transportation time from the source institution to DSP is approximately one hour. These procedures are intended to maintain thermal comfort, minimize disturbance, and promote safe relocation.

Assessment of transport-associated physiological responses is essential for evaluating welfare during relocation. Hematological and serum biochemical analyses are widely recognized as valuable tools for monitoring health status, physiological stress, hydration, inflammatory responses, and metabolic function in avian species. Blood-based parameters are particularly useful because they provide objective and quantifiable indicators of an animal's physiological condition before clinical abnormalities become apparent. Changes in hematocrit, hemoglobin concentration, plasma proteins, leukocyte profiles, muscle enzymes, and metabolic markers have been extensively used to assess stress responses associated with capture, handling, transport, and adaptation in captive and free-ranging birds.[7,8,9]

As part of the standard quarantine protocol for newly arrived animals at Dubai Safari Park, comprehensive health screening procedures are conducted to evaluate health status and detect potential infectious or metabolic disorders prior to integration into the resident population. These examinations include physical assessment, behavioral observations, body condition evaluation, disease screening, and collection of blood samples for hematological and biochemical analysis. Blood testing serves as a critical component of quarantine health surveillance because it provides immediate information regarding physiological status, welfare, hydration, and potential transport-associated effects.

Objective

This study aimed to characterize hematological and biochemical parameters in Greater Flamingos (*Phoenicopterus roseus*) following transport to Dubai Safari Park and evaluate their usefulness as indicators of transport-associated physiological stress and welfare during the early acclimatization period.

Materials and Methods

Sample Collection

Blood samples were collected from 18 Greater Flamingos (*Phoenicopterus roseus*) immediately upon intake following transportation to Dubai Safari Park. Venipuncture was performed on the common dorsal metatarsal artery using a 1 mL syringe fitted with a 23-gauge needle, and approximately 1 mL of blood was obtained from each bird (Figure 1).

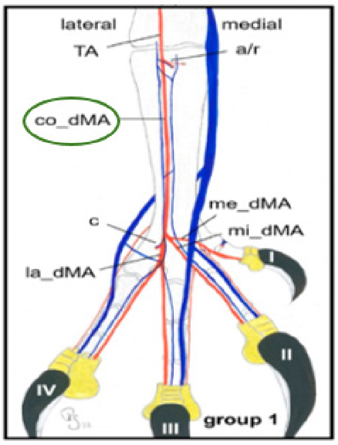

Figure 1 Blood vessel topography, sample collection in flamingo common dorsal metatarsal artery.

Sample Handling and Processing

Collected blood was immediately transferred into lithium heparin tubes for serum biochemistry and EDTA tubes for hematological analysis. Tubes were gently inverted to ensure proper anticoagulant mixing. All samples were processed within two hours of collection to preserve analytical integrity and minimize pre-analytical alterations.

Analytical Procedures

Hematological parameters were assessed manually following standard avian hematology protocols. Serum biochemical analyses were performed using an automated clinical chemistry analyzer calibrated for avian samples.

Results:

Table 1 Hematology and biochemistry blood parameter distribution in Greater Flamingos (Phoenicopterus roseus) upon arrival

Greater Flamingo	Hematology				Biochemistry											
	RBC	WBC	HB	HCT	AST	BA	CK	UA	GLU	CA	PHOS	TP	ALB	GLOB	K+	NA+
Unit	10^9/l	10^{12}/l	g/dL	%	U/L	umol/L	U/L	mMol/L	mMol/L	mMol/L	mMol/L	g/L	g/L	g/L	mMol/L	mMol/L
Reference Interval	1.77 - 3.19	3.47 - 19.65	11.5 - 15.8	39.1 - 51.9	115 - 325	4.33 - 76.35	0 - 2170	221 - 601	7.89 -13.87	2.45 - 3.21	0 - 7.27	37 - 53	17 -25	21 - 31	2.1 - 4.5	147 - 169
953 0100 0588 1425	1.7	3.74	17.8	65	190	<35	1664	85	11.2	2.65	1.02	44	30	14	2.9	150
953 0100 0588 1244	1.17	4.4	17.3	55	173	<35	1991	79	12.8	2.49	0.54	39	26	13	2.6	151
953 0100 0588 1424	1.4	7.26	16.6	56	214	<35	1020	86	8.8	2.62	0.86	41	30	11	2.8	146
953 0100 0588 1248	1.61	7.48	11.7	53	304	<35	7064	220	6.2	2.82	1.72	52	19	33	3	150
953 0100 0588 1252	2.34	1.54	18.1	57	228	<35	2889	128	8.9	2.67	0.6	42	30	12	2.6	154

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Table 1 Continued...

953 0100 0588 1387	0.89	3.96	17.3	60	146	<35	765	ICT	15.7	2.57	0.87	42	34	8	2.8	153
953 0100 0588 1250	1.46	6.16	15.5	60	194	<35	2781	124	10.4	2.61	0.92	40	31	10	2.5	153
953 0100 0588 1376	1.19	4.84	17.8	64	158	<35	538	ICT	8.7	2.57	0.65	47	34	13	2.3	149
953 0100 0588 1246	2.28	7.92	20.7	61	201	<35	2543	320	11.1	2.41	0.7	37	30	8	8.5	153
953 0100 0588 1395	1.76	3.52	14.7	48	264	<35	2820	206	13	2.44	1.37	33	25	9	2.8	150
953 0100 0588 1428	2.08	3.74	17.1	53	232	<35	4631	189	9.1	2.6	0.87	42	28	15	3.3	158
953 0100 0588 1411	1.12	3.52	18.4	60	266	<35	2858	ICT	9.7	2.77	0.74	45	33	13	3	149
953 0100 0588 1412	1.68	8.14	15.5	51	246	<35	3569	286	10.5	2.55	0.98	38	27	11	3.1	156
953 0100 0588 1433	2.39	3.3	16	48	157	<35	572	ICT	10.2	2.46	1.31	39	31	8	2.9	149
953 0100 0588 1434	1.81	5.28	17.5	46	265	<35	2795	90	7.7	2.35	1.01	47	31	16	2.6	149
953 0100 0588 1437	3.06	2.01	21.4	55	214	<35	2080	ICT	10.7	2.6	0.88	48	36	12	2.3	151
953 0100 0588 1243	1.92	1.7	18.1	62	248	<35	2800	ICT	9.2	2.61	1.02	42	31	11	2.6	148
953 0100 0588 1215	1.34	7.04	17.4	53	261	<35	2904	95	10.8	2.58	0.75	42	27	14	3.4	156

Discussion

In this study, hematological and biochemical parameters were evaluated in Greater Flamingos following transportation. Post transportation, elevations were observed in several analytes from both hematological and biochemical assessments. Serum biochemistry included creatine kinase (CK), albumin (ALB), globulin (GLOB), and uric acid (UA), while hematological evaluation included hematocrit (HCT) and other components of the complete blood count (CBC). Elevated concentrations of hemoglobin (Hb), albumin, and hematocrit were observed, alongside decreased globulin and uric acid values. These changes are consistent with physiological responses previously associated with transport-related stress, muscle exertion, and dehydration-related hemoconcentration (Figure 2).[5,10]

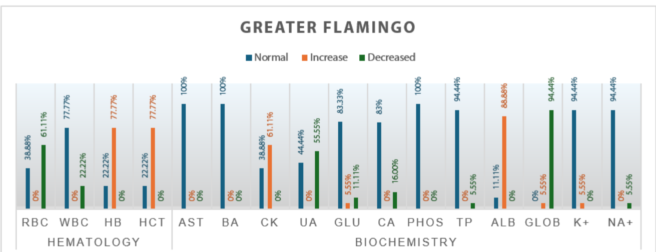

Figure 2 Percentage of Greater Flamingos (Phoenicopterus roseus) showing normal, increased, or decreased blood parameters upon arrival, reflecting physiological responses to transport.

Physiological stress induced by capture, handling, or transport is known to transiently affect hepatic metabolism and immune function in birds. Stress-mediated increases in glucocorticoids, particularly corticosterone, can alter hepatic circulation and enzyme activity, influencing bile acid synthesis and clearance. Experimental studies in poultry have demonstrated that chronic corticosterone elevation results in hepatic lipid accumulation, altered bile acid homeostasis, and shifts in protein metabolism.[11]These findings support the observed elevations in bile acids and CK in transported flamingos, suggesting increased muscular exertion and hepatocellular metabolic response to acute stress. Additionally, reductions in globulin levels may indicate short-term immune modulation, as glucocorticoids are known to suppress globulin synthesis and alter leukocyte distribution.[12] Overall, the hematological and biochemical changes reported here align with established physiological responses to transport stress in avian species and emphasize the importance of post-transport health assessments for optimizing welfare and husbandry in ex-situ conservation programs.

In a study conducted by Leineweber et al. (2022),[13] bile acid concentrations in clinically healthy greater flamingos (Phoenicopterus roseus) ranged from 4.33 to 76.35 µmol/L. In the present study, all bile acid values obtained from the 18 greater flamingos examined at Dubai Safari Park indicating normal hepatic function in the assessed individuals. These findings are consistent with previous work demonstrating that bile acids serve as reliable indicators of avian liver health. Hematological analyses of newly arrived flamingos were also performed to evaluate physiological responses to transport-related stress. Elevated hemoglobin (Hb) and hematocrit (HCT) levels were observed in 77.77% of the population, likely reflecting hemoconcentration secondary to dehydration, an effect commonly reported in birds following prolonged handling or transport. Increased creatine kinase (CK) activity was detected in 61% of the individuals, consistent with muscular exertion or trauma associated with capture, crating, and transport, and supporting the use of CK as a sensitive biomarker of muscle stress in avian species.[14] Albumin (ALB) concentrations were elevated in 88.88% of the birds, further supporting dehydration-related hemoconcentration as a primary physiological response.[15] Glucose (Glu) levels increased in 5.55% and decreased in 11.11% of the flamingos, indicating variable glycemic responses likely influenced by individual differences in acute stress, catecholamine activity, and metabolic rate during transportation. Globulin concentrations showed divergent patterns, with 5.55% of individuals exhibiting increases and 94.44% exhibiting decreases. The predominant reduction in globulins may reflect stress-induced immunosuppression, altered protein metabolism, or redistribution of immune proteins, phenomena commonly reported in birds under acute stress.[16]

Potassium (K) concentrations increased in 5.55% of the flamingos, whereas sodium (Na) levels don't show much deviation from normal range. suggesting overall electrolyte stability following transport. Red blood cell (RBC) counts decreased in 61.11% of the birds, a pattern that may be associated with oxidative stress, splenic sequestration, or fluid redistribution, all of which have been reported as physiological responses to acute stress in avian species.[7] White blood cell (WBC) counts decreased in 22.22% of the population, consistent with stress leukogram patterns characterized by lymphopenia and leukocyte redistribution under elevated corticosterone levels.[7] Uric acid (UA) concentrations decreased in 55.55% of the flamingos, potentially reflecting reduced protein catabolism or modulation of renal excretion influenced by hydration status and stress-induced metabolic changes.

Overall, these findings indicate that transportation induces measurable physiological alterations in greater flamingos with elevated creatine kinase, hemoglobin, and albumin serving as potential biomarkers of transport-related stress. The observed hematological and biochemical fluctuations underscore the importance of comprehensive post-transport health evaluations in ex situ conservation programs to ensure optimal welfare and to inform adaptive management strategies.

Hematocrit (Hct) refers to the percentage of blood volume occupied by red blood cells (RBCs). In dehydration, the volume of plasma decreases due to a loss of water and electrolytes, resulting in hemoconcentration. The decrease in plasma volume, with the RBC count remaining constant, leads to an increase in hematocrit, making the blood more viscous and more concentrated with cells. This increased blood viscosity may have significant effects on blood flow and oxygen delivery, as the reduced volume of plasma compromises the ability of the blood to flow efficiently, potentially impairing tissue oxygenation.[17] In cases of dehydration, reduced blood flow through the liver can impair its function, particularly in the processing and conjugation of bilirubin. As plasma volume decreases, the liver's ability to excrete conjugated bilirubin may also be compromised. The accumulation of unconjugated bilirubin in the bloodstream can exacerbate jaundice and result in icteric blood.

Conclusion

This study demonstrates that hematological and biochemical parameters measured upon arrival at a captive facility are sensitive indicators of short-term physiological stress in Greater Flamingos. The observed changes are largely driven by stress, dehydration and handling, minimizing these effects depends on careful planning and execution, including gentle capture techniques, reduced handling time, appropriate crate design that limits excessive movement without causing restraint injury, and maintaining optimal ventilation and temperature. Ensuring adequate hydration before and after transport.

These findings support the use of hematological and biochemical profiling as practical tools for monitoring welfare in Greater Flamingos and for informing management practices aimed at minimizing stress during relocation events.

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None

Competing interests

Authors have declared that no competing interests exist.

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