Interpreting the Avian Blood Panel Report

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Anemia

- General Considerations

  Clinical signs- pale mm, pale feet, heart murmur, thin blood

  Rule out artifacts- diluent errors, old sample hemolysis, errors in analysis

  Seasonal/Gender Differences- probably not clinically important in pet species

  Lower Hct/RBC in neonates, nestlings

Anemia (12.7% incidence)

- Decreased RBC; Decreased Hematocrit
- Decreased Hemoglobin

Anemia Classification

Anemia-hypochromic microcytic

- MCV Decreased; MCHC Decreased
- Iron deficiency anemia
  - experimentally induced in the fowl
- Blood loss
  - chronic hemorrhage; blood-sucking parasites
- Uncommon in pet birds

Anemia-hypochromic macrocytic

- MCV Increased; MCHC Decreased
- Experimental- fowls: rapeseed meal
- Initial response to hemorrhage
- Response to lead toxicosis (untreated)

Anemia-normocytic normochromic

- Non-regenerative anemia- most common clinically
- MCV Normal; MCHC Normal
- Polychromasia=0 to slight
- Anisocytosis=0 to slight
- Anemia of inflammatory disease or chronic disease
- Little or no RBC response- be worried!!

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Anemia-normocytic normochromic

- Production outflow decrease
- Avian RBC half-life much shorter than mammals
- Increased phagocytic removable in mammals with inflammatory disease
- bacterial/fungal infections, chlamydiosis, yolk peritonitis, tuberculosis, aspergillosis, viral (PBFD), and organ inflammation
- cyclophosphamide yes; chloramphenicol-no

Anemia-regenerative

- Patient response to successful treatment of inflammatory or chronic disease, OR
- Patient response to (untreated) continued RBC loss or RBC destruction
- Increased variability in cell size (anisocytosis increased)
- Increased Red Cell Distribution Width % (RDW%)

Anemia-Hemolytic (0.3% incidence author's lab)

- Rule out sampling/storage/processing artifact
- AIHA not documented in pet birds
- Toxins can cause hemolytic anemia
  - Fowl - Phenylhydrazine; aflatoxin
  Lead toxicosis Petroleum products
- *Plasmodium*
- Transfusion reaction

Anemia-Heinz Body

- Fowl-dimethyl disulphide, a breakdown product of the amino acid S-methylcysteine, associated with rapeseed meal feeding
- Pet Bird- unlikely, mistaken for:
  - Staining artifact
  - Intracytoplasmic organism

Anemia- Lead Toxicosis

- Marked RBC response to anemia
- Increase in polychromatophilic RBCs
- Macrocytic hypochromic anemia
- RDW% increases markedly
- Erythrocytic ballooning; No stippling
- (Hemolytic anemia of zinc toxicosis appears to show less profound morphological changes)

Anemia- "Conure Bleeding Syndrome"

- RBC changes resemble lead toxicosis
- Not a neoplastic syndrome; erythemic myelosis not appropriate term
- Clinical association with hypocalcemia/response to therapy
- Good prognosis for recovery with treatment

Anemia-Blood Parasites

- Decreasing incidence on lab reports as most psittacine reports originated in wild-caught patients
- Psittacine blood parasites rarely cause anemia or clinical disease
- Plasmodium in passerine birds, particularly canaries, can regionally cause anemia, morbidity, and mortality

Polycythemia- increase in PCV

- 3.2% incidence author's laboratory
- Relative- in birds mostly due to dehydration; correctable with fluid therapy
- Absolute
  - Primary - neoplastic proliferation of hematopoietic stem cells; poorly documented in pet birds
  - Secondary-physiologically appropriate response to decreased blood oxygen levels. Most common in pet birds

Polycythemia, Secondary Absolute

- Any condition, which results in reduced oxygen levels, will increase output of erythropoietin
  - Chronic respiratory disease due to pulmonary infection
  - Pulmonary hypersensitivity of macaws
- Increase in PCV and RBC, NOT MCV typically seen; variable RDW% change

RBC Morphology

- 7.4% incidence abnormal morphology
- Avian blood smears should NEVER be made from anti-coagulated blood
- Pet bird RBCs range in size from 130-180 fl
  - Artifactual MCV increase- old blood in EDTA
- Canary RBCs are smaller than Cockatiels than Macaws
- Erythroplastids - anucleated RBCs are most commonly artifacts

RBC Morphology-Reticulocytes

- Comprise 2-10% of the normal circulating RBCs
- Slightly larger than mature avian RBCs
- Younger RBCs are rounder show polychromatophilic cytoplasm, generally more basophilic in color

RBC Morphology- Anisocytosis

- Variability in cell size
- Younger cells have larger MCVs
- "Normal" Anisocytosis= slight or 1
- RDW% is approximately 11%
- Increased anisocytosis= increased RDW%

RBC Morphology- Polychromasia

- Polychromatic cells occur normally at a rate of 1-5% in the peripheral blood
- Increases when the patient is exhibiting a regenerative response to anemia
- Non-regenerative anemia will show a paucity of immature RBCs and polychromatic cells are typically absent

RBC Morphology- Poikilocytosis

- Poikilocytes are RBCs with variability in cell shapes
- Many of the mammalian types of poikilocytes are not recognized in birds
- Poikilocytes may represent simply a preparation artifact resulting in distortion and damage of a large percentage of cells
- Poikilocytosis occurs when severe systemic infections adversely affect the bone marrow

RBC-Erythrocytic Ballooning

- Describes cells with bulges in the normal elliptical cell shape and often accompanied by areas of hypochromasia
- Frequent finding in lead toxicosis, but a similar morphologic changes can be observed in the poorly characterized “Conure Bleeding Syndrome”

Leukocytosis

- Clinical comparisons of leukocyte counts in same patient should be based on same sampling and tabulation techniques
  - Hematocytometer (Natt and Herrick, Unopette), Estimate from smear, Laser flow cytometer

Leukocytosis/Heterophilia

- 22.1% Incidence in author’s laboratory
- Leukocytosis occurs primarily due to increases in numbers of circulating heterophils
- Heterophilia occurs generally due to inflammation or stress

Leukocytosis-Stress

- Physiological Stress
  - Anesthesia Cold Stress Conspecific conflict Crowding (Exogenous corticosteroids) Fear Heat Stress Hemorrhage, internal Hypoxia Nervousness Pain Restraint Road Transport Starvation Trauma Wetness

Leukocytosis- Inflammation

- Air sacculitis Arthritis, septic Aspergillosis
- Chlamydiosis, acute/active Dermatitis
- Gram negative/positive inflammatory lesion
- Hypersensitivity Neoplasia Necrosis of tissue
- Nephritis Pneumonia Septicemia Tuberculosis
- Yolk peritonitis Viral disease (occas)

Leukopenia

- Consider leukopenia in the clinically normal bird with suspicion
- Pseudoleukopenia
  - Smudge cell artifact (16.7% incidence) - ruptured leukocytes due to smearing techniques
- Probably impacts granulocytes more than mononuclear leukocytes
  - Technical counting errors
  - Aging whole blood- lowers cell counts

Leukopenia

- Smaller species tend to run lower normal ranges (canaries, budgies etc)- know your species!
- Bacterial degenerative left shift
- Viral disease
  - example: circovirus (PBFD) in young African Grey Parrot

Leukocyte morphology

Toxic heterophils

- Toxemic processes
- Bacterial/fungal infections, chlamydiosis, infections and some viral infections.
- Basophilic cytoplasmic granules, nuclear hypersegmentation, cytoplasmic vacuolation, and basophilic cytoplasmic color (first two most reliable)

Leukocyte Degranulation

- Degranulation of leukocytes occurs very rarely in peripheral blood
- In vivo, leukocyte migration to an inflamed tissue site occurs > degranulation in TISSUE under septic conditions
- Degranulation seen in peripheral blood smear is a cytological artifact. -> granule dissolution in methanol, > cell rupture (smudging), >other chemical/osmotic

Reactive Lymphocytes 55% incid

- Frequently in some sick and clinically normal avian patients.
  - Antigenic stimulation from viral infections and possibly chlamydial infections may be responsible for reactive changes.
  - Typical reactive avian lymphocytic changes include a darker blue cytoplasm, nuclear changes, prominent nucleoli. Scalloping of lymphocytic cytoplasm suggested to be another reactive change. This is supported by electron microscope studies (EM)

Reactive Lymphocytes

- The most marked reactive lymphocytic changes are clinically observed in certain cases of terminal viral diseases, including polyomavirus and herpesvirus infections. In addition the above changes, cytoplasmic vacuolation may be noted.

Reactive Lymphocytes

- Plasma cells occasionally appear in peripheral blood. These large, oval cells usually have an eccentric nucleus and deeply basophilic cytoplasm. Plasma cells occur with certain chronic inflammatory processes.

Basophils

- Increased with tissue damage, stress and some sorts of respiratory disease

Eosinophil

- Poorly understood- increases associated with tissue damage but not necessarily parasitism, allergy or hypersensitivity

Monocytes

- Chronic disease; aspergillosis, chlamydiosis, tuberculosis

Leukemia

- Studied extensively in the fowl
- pet birds: leukemia is uncommon
  - Canaries, budgerigars, and Amazon Parrots tend to develop lymphocytic leukemia, while granulocytic leukemia is more frequent in the macaw
- Suspected when the leukocyte count is greatly elevated and when a large number of blast-like cells in the peripheral blood
- Large #s of progranuloyctes and myelobasts may be present with granulocytic leukemia.
- Lymphocytic leukemia may be suggested with increased lymphoblasts in the peripheral blood
- Anemia common finding with leukemias.

Leukemia

- Diagnosis of leukemia is not straightforward
- High leukocyte counts due to severe inflammatory processes and accompanied by profound morphological changes can sometimes suggest leukemia.
- Hematopoietic neoplasms may reside primary in the bone marrow or sequestered in extravascular locations

Biochemical Parameters

Enzymes

- Small animal enzymology knowledge can be partially applied to interpreting avian plasma enzyme profiles.
- Normal enzyme ranges in avian patients tend to run higher in some cases than mammals and represent the normal turnover of tissue.

Enzymes

- Some differences occur with enzyme specificity and sensitivity compared to the dog and cat
- Clinical detection of current liver damage is only possible when the right pattern of plasma enzyme elevates. These elevations represent hepatocellular leakage and damage, but give no indication as to the cause of the damage or the degree of liver function impairment

Avian Enzyme Activity Studies

- like mammals, AST (SGOT) is present in all muscle types and liver tissue
- CK (CPK) is plentiful in skeletal muscle and also present in cardiac and smooth muscle; absent in liver tissue
- ALT (SGPT) is present in a number of tissues
- AP (alkaline phosphatase) is NOT present in liver in appreciable quantities

Avian Enzyme Activity Studies

- LD (LDH) is present in a number of tissues
- GGT activity is very low in the avian liver

Avian Enzyme Activity Studies

- activities in tissues don't necessarily correlate with plasma levels
- Example: in spite of high levels of ALT activity in avian liver tissue; plasma elevations are uncommon in well-documented hepatocellular disease
- Multiple enzymes are measurable in kidney tissue, but not in the plasma as the products of cellular damage/leakage pass in the urine

Enzyme Half-Lives (see chart at lecture)

Enzymes- sample/patient effects

- Hemolysis elevates LD and will have lesser effects on AST, ALT, and CK.
- Patient excitement, rough handling, trauma, irritating injections elevate particularly CK and to a lesser extent LD, AST, and ALT.
- Lumeij measured plasma enzyme response to an IM injection of doxycycline. CK elevated the most rapidly, followed by LD, AST, and ALT

Differentiate elevation> muscle or liver damage; artifact

- LD is not specific or sensitive for detection of avian liver damage.
- The main benefit of the LD assay is a very short plasma half life and shorter than CK.
- Persistent LDH elevation without concomitant CK elevation suggests that liver damage is more likely than muscle damage.
- Exception is sample hemolysis

Differentiate elevation > muscle or liver damage; artifact

- Marked CK elevations are specific for muscle damage and call into doubt the existence of liver damage when AST is also elevated

Differentiate elevation > muscle or liver damage; artifact

- GLDH (glutamate dehydrogenase) most specific enzyme for avian liver damage, but low sensitivity is relatively low
- Only some kinds of severe liver damage will result in GLDH elevation, because the enzyme is mitochondrially bound. Hepatocyte damage and leakage of cytoplasmic contents will not elevate GLDH

Elevations in AST(SGOT)

- but not LD or CK can indicate either muscle damage or liver damage which is declining in intensity
- Muscle sources of plasma AST may elevate in the clinically ill bird due to muscle wasting, tissue damage, or IM injections
- Liver disease should never be based on the AST value alone, nor does a normal AST indicate normal liver function

Muscle Tissue-Associated Enzyme Elevations

Normal enzyme values (see chart at lecture)

- Can only be interpreted as no current detectable source cell damage and leakage
- LD, AST, and CK : like mammals, these most commonly tested enzymes are not liver-specific, so should not be referred to as liver enzymes

Clinical Interpretation of Enzyme Profile Combinations (see charts at lecture)

Gamma-GT

- shows high specificity to avian liver tissues, however the sensitivity is low
- GGT has not proved useful for routine liver screening, however Phalen noted the value of this enzyme as an aid to detection of hepatic carcinomas associated with papillomatosis and possible herpesvirus infection

Test Specificity/Sensitivity (Lumeij 1997)

- see chart at lecture

ALT (SPGT)Changes

- Elevations-Infrequent with hepatocellular damage; Sample hemolysis
- Depressions- Uncommon

AST (SGOT) Changes

- Elevations Liver or Muscle damage within days; Severe sample hemolysis
- Depression- severe loss of hepatocellular mass

AP (ALP) Changes

- Elevations - Bone activity or damage; Sample hemolysis

CK (CPK) Changes

- Elevations - Recent muscle damage; Severe sample hemolysis
- Depression - 1) Degradation by bacterial sample contamination

Gamma GT Changes

- Elevations-Liver damage (inconsistent and generally insensitive but may be useful as an aid to detect hepatic carcinomas); Sample hemolysis

LD (LDH) Changes

- Elevations - Recent liver or muscle damage (generally decreases faster than CK); Sample hemolysis (common)
- Depression- severe loss of hepatocellular mass

GLDH Changes

- Elevations- Severe liver cell necrosis, but elevation is inconsistent among pet bird species

Amylase - poorly studied in avian clinical medicine.

Elevations greater than 1000U/L associated with histopathological changes

Bile Acids and Bile Pigments

- Green or yellow-stained urates MAY present in the clinically ill avian patient with liver disease
- Avian patients, with few exceptions, rarely show signs of “icterus” of mucus membranes or skin

Bile Acids and Bile Pigments

- Bile pigments are derived from erythrocyte breakdown products by the reticuloendothelial system
- Primary pigment produced is biliverdin

Bile Acids and Bile Pigments

- Bilirubin occurs in very scant quantities in avian plasma; assays provide no useful clinical information
- Biliverdin assays are not commercially available, however biliverdin is not detectable in the plasma of normal chickens
- Researchers feel that hepatic uptake is very rapid

Bile Acids

- Provides a useful measure of avian liver function
- Bile acids or salts are usually secreted as conjugates continuously into the bile
- A variety of conjugates are secreted, including cholic acid and allocholic acid

Bile Acids

- Normally over 90% of the bile salts are reabsorbed in the jejunem and ileum. The enterohepatic circulation system faciltates reuptake by the liver
- Bile acid assay has been demonstrated to be useful to measure liver function in man, domestic animals and birds, because all major hepatic functions (extraction, conjungation, secretion) are involved

Bile Acids-post prandial

- Controlled studies mostly show post-prandial increases in plasma bile acids when normal birds are tested
- Post-prandial elevations occur in falcons, ostriches, racing pigeons and selected psittacine species

Bile Acids-post prandial

- Flammer found that post-prandial levels decreased in the Oranged-winged Amazon Parrot, Blue-Fronted Amazon Parrot, Goffin's Cockatoo, Timneh African Grey, and pigeons
- Controlled post-prandial studies in the cockatiel are inconsistent regarding post-prandial testing

Bile Acids

- Single point bile acid assays provide useful information because there is not great overlap between bile acid levels in the normal vs. diseased bird, irrespective of eating history. Assay considerations do not appear to differ, based on the presence or absence of the gall bladder in the avian patient

Bile Acid Assays

- colorimetric bile acid assay> measures multiple types of bile acids; tends to run higher than RIA, due to the wider spectrum of bile acids measured; reference ranges used should be specific to that laboratory. The colorimetric method will be adversely affected (elevation) by lipemia or hemolysis
- radioimmunoassay (RIA) performed by some laboratories; normal ranges run lower

Bile Acid Assays

- Plasma bile acid elevations do not indicate the nature or cause of the liver dysfunction
- Moderate to severe elevations are associated with marked loss of hepatic mass and function and carry a poor prognosis
- Two examples of severe elevations include bile duct hyperplasia and severe hepatic fibrosis

Bile Acid Assays

- Causes of variable elevations:

  - fibrosis, lipidosis, hepatic vacuolation, cholangitis, bile duct proliferation, chlamydial infections, and mycobacteriosis

Bile Acid Assays

- Elevations not common in these conditions:
- Iron storage disease, described as hemosiderosis or hemochomatosis
- Neoplasms in the liver including cholecarcinoma and invading neoplasms, such as lymphoma
- Presumably, adequate normal hepatic cell architecture remains intact in many of these cases

Liver Pathology/Bile Acid Levels (see chart at lecture)

Bile Acid Assay-Value

- Clinically provides specific indications for liver biopsy to lead the clinician to a specific liver diagnosis and therapy

Calcium

- Calcium assays do not provide reliable information regarding total body calcium (consider history/radiography)
- Most assays are dye-binding method and can be affected by normal physiological changes and artifacts
- Artifacts: hemolysis (decrease or increase depending on assay)

Calcium - Hypercalcemia

- Normal Physiological changes-female reproductive activity
- Lipemia and increases in proteins
- "Malignant" hypercalcemia very rare in birds

Calcium- Hypocalcemia

- Rule out hemolysis artifact or sample in EDTA
- True hypocalcemia may be associated with neurological signs, polyuria, bone disease.

Calcium - Normocalcemia

- Does not rule out a negative nutritional balance

Phosphorus

- Not valuable in renal disease
- Broad range of values experienced due to changes in physiology and metabolism
- Decreases or increases in polyuria, metabolic bone disease, female reproductive activity
- Adversely affected by hemolysis or EDTA

Renal Analytes

- Urea - birds do not manufacture significant quantities - Lumeij states that urea useful to assess pre-renal dehydration
- Creatinine- not a reliable indicator of renal function; non-specific chromogens
- Renal clearance testing not clinically available

Renal-Uric Acid

- Main avian nitrogenous waste product
- Tubular secretion
- Insensitive indicator of renal function
- Elevation often late in renal disease

Kidney Disease diagnosis

- Other aides: urinalysis, imaging, biopsy

Visceral Gout

- serosal deposition often with normal plasma levels of UA

Articular gout

- elevations in uric acid common

Inflammatory Proteins

- Total Protein(analyzer) provides minimal information
- Total solids (refractometer) unreliable
- Avian albumin assays often fail to measure adequately

Inflammatory Proteins

- Fibrinogen assay
  - acute inflammatory proteins

Electrophoresis

- acute and chronic inflammatory proteins

Fibrinogen

- Heat precipitated assay of citrated or EDTA whole blood
- Elevations typically associated with acute inflammation/infection
- Like EPH can sometimes be more sensitive than hematology
- False elevations in reproductively active females

Avian Blood Volumes and Typical Sample Sizes

Species	Patient Wt, gm	Total Blood Volume, mls	Safe Maximum Blood Sample, milliliters	Sample Size, typical hematology/chemistry profile, milliliters
Canary	18	1.8	0.18	0.10-0.30
Budgerigar	32	3.2	0.32	0.10-0.30
Cockatiel	90	9.0	0.9	0.10-0.50
Conure	180	18	1.8	0.10-0.50
African Grey	425	42.5	4.25	0.25-0.60
Amazon, YN	450	45	4.5	0.25-0.60
Macaw, Blue/Gold	1050	105	10.5	0.25-0.60
Duck	1500	150	15	0.25-0.60

Avian Blood Collection, Processing and Submission Guidelines

Test	*Collection Tube*	*Processing*	*Comments*
Hematology-cell counts	Lavender (EDTA)	Keep cool	Cell swelling during shipment can affect counts; hemolysis occurs with ostrich blood. Do not use for chemistry
Hematology-cell counts	Green (heparin)	Keep cool	Always make blood smears before placing blood in sampling container to minimize artifacts
Hematology-cell counts	Blue (citrate)	Keep cool	Always make blood smears before placing blood in sampling container to minimize artifacts; may be best for laser flow cytometry. Do not use for chemistry
Hematology-Packed Cell Volume	Capillary tubes (red ringed-heparinized)	Centrifuge for packed cell volume (PCV)	Not recommended for cell counts due to micro-clots and sludging in capillary tubes
Fibrinogen	Lavender (EDTA)	Keep cool; whole blood	Sample cannot be contaminated with heparin
Fibrinogen	Blue (citrate)	Keep cool; whole blood	Sample cannot be contaminated with heparin
Chemistry-plasma	Green (heparin)	Centrifuge immediately; harvest **plasma**	Preferred method for avian chemistry samples. Centrifugation, separation and harvesting is enhanced by the use of containers with silicone separator plugs.
Chemistry-plasma	Capillary tubes (red ringed-heparinized)	Centrifuge immediately; harvest **plasma** by breaking tubes at cell/plasma interface; discard cells	Useful method for small birds and small samples. To avoid artifact, physically separate cells from the plasma
Chemistry-serum	Red (additive-free)	Centrifuge immediately, harvest **serum**	**Not** the preferred method for avian chemistry samples. Centrifugation, separation and harvesting is enhanced by the use of containers with silicone separator plugs. Properly processed samples may show fibrin jelling of serum.
Lead	Lavender, Blue or Green	Keep cool; whole blood	Depending on lab; most assays require whole unclotted blood
Zinc	Green	Centrifuge immediately; harvest **plasma**	To submit plasma, use polypropylene tube or tube without rubber stopper
PCR testing (DNA detection)	Green	Keep cool; whole blood	Whole blood usually requested for detection of etiologic agents and gender determination using PCR or gene-based diagnostics
Serology (antibody detection)	Green	Centrifuge immediately; harvest **plasma**	Varies with testing procedure, but plasma usually safe bet; serum harvested from red top tube may also be acceptable

Interpretation of Blood Sampling Artifacts

Artifact	*Cause of Artifact*	*Effects on Testing*
Aged Whole Blood	Excessive shipping times resulting in hemolysis and loss of cell morphology	Lowered cell counts, inaccurate differential counts
Smudge cells	Ruptured leukocytes due to making smear from aged whole blood or by slide to slide technique	Lowers total number of leukocytes recognizable on smear. Probably affects granulocytes more. Lowered estimated cell counts, inaccurate differential counts, loss of morphology information
Staining artifacts	Smears made from old blood, heparinized blood or from smears exposed to formalin fumes	Marked degradation in cell morphology features, decreasing the accuracy of differential counts and morphology assessment
Clotted Whole Blood	Excessive time taken to collect blood or multiple punctures; inadequate admixture with anticoagulant; coagulopathy (rare)	Lowered cell counts
Hemolysis- hematology sample	Damage to sample during collection; excessive shipping times	Lowered cell counts
Hemolysis- chemistry sample	Damage to sample during collection; failure to immediately and properly centrifuge and harvest plasma	False elevations in bile acids (photometric method), LDH, CK(CPK), Alk Phos, Potassium. Decrease or increase in calcium, depending on methodology.
Lipemia	Patient: female reproductive activity or hepatic disorder	False elevations in bile acids (photometric method), calcium, phosphorus, uric acid
Iatrogenic	Injections	Transient muscle damage can elevate the non-specific enzymes LDH, AST (SGOT), and CK (CPK)
Patient Stress	Adrenal release of increased corticosteroids	Elevation in leukocyte and heterophil counts; hyperglycemia
Bacterial Contamination	Contamination of skin flora during collection or sample processing; organism growth during shipment or storage	False depressions in glucose, CK (CPK)

Frequency % of Selected Abnormalities of Avian Blood from Complete Blood Counts

(Source: California Avian Laboratory)

	Percentage	Number in survey
Anemia (PCV)	12.7	31,419
Anemia (Hgb)	13.95	4443
Abnormal RBC morphology	7.44	27050
Polycythemia	3.2	4419
Hemolysis (non-artifactual)	0.3	27050
Hemolysis (artifactual)	4.25	27050
Lipemia	2.87	27050
Smudge cells (artifactual)	16.7	27050
Leukocytosis	22.15	27050
Left Shift	0.65	27050
Lymphocytosis	6.8	27050
Monocytosis	7.2	27050
Eosinophilia	6.9	27050
Heterophil toxicity	10.43	27050
Reactive lymphocytes	52.0	27050

Avian Anemia Classified by MCHC/MCV

Hypochromic Microcytic

Decreased MCHC

Decreased MCV

Increased Polychromasia

Normal to Increased Anisocytosis

1. Nutritional Iron Deficiency (experimental)
2. Chronic hemorrhage
3. Blood-sucking parasites

Hypochromic Macrocytic

Decreased MCHC

Increased MCV

Increased Polychromasia

Normal to Increased Anisocytosis

1. Response to acute blood loss
2. Response to lead toxicosis
3. Experimental toxins
4. Response to hemolytic anemia
5. Conure bleeding syndrome

Normochromic Normocytic

Normal MCHC

Normal MCV

Slight to No polychromasia

Slight to No anisocytosis

1. Aspergillosis
2. Tuberculosis
3. Chlamydiosis
4. Chronic bacterial infection
5. Organ inflammation
6. Yolk peritonitis
7. Hematopoietic neoplasm
8. Mesenchymal neoplasm
9. Viral disease (circovirus)
10. Starvation
11. Drugs: cyclophosphamide; corticosteroids

Causes of Avian Heterophilia

Physiological Stress

Anesthesia
Cold Stress
Conspecific conflict
Crowding
Exogenous corticosteroids
Fear
Heat Stress
Hemorrhage, internal
Hypoxia
Nervousness
Pain
Restraint
Road Transport
Starvation
Trauma
Wetness

Inflammation

Air sacculitis
Arthritis, septic
Aspergillosis
Chlamydiosis, acute/active
Dermatitis
Gram negative inflammatory lesion
Gram positive inflammatory lesion
Hypersensitivity (uncommon in pet birds)
Neoplasia
Necrosis of tissue
Nephritis (inconsistent)
Pneumonia
Septicemia
Tuberculosis
Yolk peritonitis
Viral disease (uncommon change)

Causes of Avian Monocytosis

Aspergillosis
Bacterial granuloma
Chlamydiosis, Active/Chronic
Chronic bacterial dermatitis
Fungal granuloma
Salmonellosis, granulomatous
Tuberculosis

Factors Influencing Circulating Avian Eosinophil Numbers

Experimental Studies (fowl; waterfowl)

Increased Numbers

- Coccidia infections (inconsistent, infrequent)
- Helminth infections (inconsistent, infrequent)
- Intraperitoneal horse serum (increases with age of bird)
- Intraperitoneal horse serum, heated (more pronounced)
- Subcutaneous alum
- Subcutaneous bovine serum albumin (BSA)

Decreased Numbers

- Corticosteroids
- Physiological stress

No Effect

- Acute inflammatory reactions
- Anaphylactic reactions
- Diurnal rhythm
- Many parasitic infections
- Subcutaneous bovine fibrinogen
- Subcutaneous dextran sulfate
- Subcutaneous histamine
- Subcutaneous *Mycobacterium avium*
- Subcutaneous *Staphylococcus aureus*
- Subcutaneous talcum
- Subcutaneous turpentine

Clinical Observations (pet birds

Increased Numbers

Air sac mites (inconsistent)
Blood parasites (rare; inconsistent)
Intestinal parasitism (inconsistent)
Post-surgery, abdominal (inconsistent)
Tissue damage (>48 hours post blunt trauma)

Decreased Numbers

Corticosteroids
Physiological stress

No Effect

Antihistamine-responsive pruritus
Basophilia
Filarid cysts
Knemidocoptes sp. infection
Suspected hypersensitivity reactions based on histopathological diagnosis (lung, subcutaneous, dermal).
Suspected allergies

Factors Influencing Circulating Avian Basophil Numbers

Experimental Studies (fowl; waterfowl)

Increased Numbers

Acute inflammation (slight increase associated with localized tissue migration)
Non-infectious - turpentine, *Staphylococcus aureus*, trypan blue, bovine serum albumin, saline
Infectious- injections of *E coli* endotoxin
Anaphylactic reactions
Cutaneous basophil hypersensitivity- fowl sensitized to phytohemagglutinin
Induced molting
Stress, severe and prolonged
Starvation stress
Environmental stress

Decreased Numbers

Mature vs. immature birds

No Effect

- Corticosteroids
- Delayed hypersensitivity
- Parasitism

Clinical Observations (pet birds)

Increased Numbers

- Air sac mites (inconsistent)
- Chlamydiosis (amazons, cockatiels, budgerigars)
- Respiratory infections (inconsistent)
- Trauma, tissue (>48 hours post)

No Effect

- Eosinophilia

Calcium and Phosphorus Interpretation

Results	Interpretation
Normal plasma calcium	Most common result in many samples; does not rule out negative calcium balance, particularly when otherwise supported by history, physical, radiographic studies.
Low plasma calcium	True hypocalcemia associated with nutritional imbalance- most commonly due to seed diets but also observed with formulated diets. Sample artifact Associated with calcitonin therapy (poorly documented)
High Plasma Calcium	Normal in ovulating females Sample artifact including lipemia Vitamin D-type rodenticide (poorly documented) Occasionally observed with metabolic bone disease. Sample collected immediately after parenteral calcium therapy
Normal Plasma Phosphorus	Most common result in clinically normal birds, even when patient consumes a high phosphorus seed diet.
High Plasma Phosphorus	Uncommon and non-specific; not typically observed during renal failure Lipemic sample
Low Plasma Phosphorus	Clinically associated with polyuria, including high phosphorus seed diets. Sample artifact

Plasma Glucose Interpretation

Result	Interpretation
Normal Glucose 180-350 mg/dl (most species)	Vast majority of samples from healthy and sick birds return normal values
Hyperglycemia 500-1000 mg/dl	Physiological stress (temperature, pain, mental) Corticosteroid therapy Female reproductive activity/disease Developing pancreatic disease/insufficiency
Hyperglycemia >1000mg/dl	Most likely diabetes mellitus, when accompanied by profound polydipsia/polyuria
Hypoglycemia <150mg/dl	Starvation, inanition, hepatopathies, endocrinopathies
Hypoglycemia< 100mg/dl	Sample artifacts: unseparated whole blood; bacterial contamination

Laboratory Profile of Hemochromatosis

Species Affected: passerines, particularly mynahs, toucans; Psittacines, particularly lorikeets
Hematology: Unremarkable CBC; chromatic changes to RBCs inconsistently observed
Enzymes: Infrequent elevations of LDH, CK, AST (SGOT)
Bile Acids: Infrequent elevations
Plasma Iron: Nondiagnostic
Plasma Ferritin: Unavailable
Definitive Diagnosis: histopathologic examination of the liver
Pathology can involve multiple organs besides the liver, particularly the heart, which may account for CK elevations.

Laboratory Profile of Hepatic Lipidosis

Species Affected: Amazon parrots, budgerigars, cockatiels, lovebirds and Quaker parrots; possible in any avian species
Hematology: Unremarkable leukogram; mild non-regenerative anemia sometimes present
Enzymes: elevations in LDH, AST (SGOT) are common but not consistent
Bile Acids: Moderate to Severe elevations in fatal cases
Lipemia: common but not definitive
Definitive diagnosis: histopathologic examination of the liver

Mean (±SD) Half-Life in Plasma of IV-Injected Homologous Enzymes in the Racing Pigeon (n = 6)

Source	Enzyme	Half-Life (hours)
Liver	AST	7.66 +/- 1.55
	ALT	15.99 +/- 1.70
	LDH	0.71 +/- 0.10
	GLDH	0.68 +/- 0.17
Muscle	AST	6.51 +/- 0.83
	ALT	11.99 +/- 1.32
	LD	0.48 +/- 0.07
	CK	3.07 +/- 0.59

From Lumeij, JT 1988 with permission

Table 4 Summary of Specificity and Sensitivity of Plasma Chemical Variables in Liver and Muscle Disease Based on Experimental Studies in Pigeons by Lumeij

	Liver Disease		Muscle Disease	
Variable	Specificity	Sensitivity	Specificity	Sensitivity
Bile Acid	+++	+++	-	-
Gamma-GT	+++	+	-	-
AST	-	+++	-	+++
ALT	-	++	-	+++
AP	-	-	-	-
CK	-	-	+++	+++
LD	-	+	-	+
GLDH	+++	(+)a	-	-

a. Elevated GLDH activity is a sign of extensive liver cell necrosis, since GLDH is a mitochondrial and not a cytoplasmic enzyme. Liver cell degeneration will not cause elevated GLDH activities. In the budgerigar (Melopsittacus undulatus) GLDH activity in liver tissue is relatively low when compared to that of man and most of the domestic animals, including cockerel, duck, turkey, and pigeon (Lumeij and Wolfswinkel, 1987). However, in Amazon parrots with extensive liver necrosis due to Pacheco's disease, elevated GLDH activities were observed in plasma, which indicates that this variable is also useful in at least some of the psittacine species (Lumeij, unpublished observations). From Lumeij, 1997, with permission

Muscle Tissue-Associated Plasma Enzyme Elevations

Condition	Enzymes Affected
Blunt trauma	CK, AST, LD
Capture myopathy	CK, AST, LD
Exertional/athletic activity	CK, AST, LD
Feather picking	CK
Furazolidone cardiotoxicosis	CK-MB isoenzyme
Irritating injections	CK, AST, LD
Nutritional myopathy	probably CK, AST, LD
Self-mutilation	CK, AST, LD
Starvation	CK, AST, LD
Surgery	CK, AST, LD

Avian Liver Pathology and Bile Acid Levels

Pathological change	Likely Effect on Plasma Bile Acid Levels
Bacterial hepatitis, necrotizing	mild to moderate elevation
Bile duct carcinoma	minimal to mild elevation
Chlamydiosis, chronic	mild to moderate elevation
Chlamydiosis, acute	minimal to mild elevation
Cholangitis/Cholangiohepatitis	mild to moderate elevation
Fibrosis	moderate to severe elevation
Hemosiderosis/Hemochromatosis	minimal to mild elevation
Hepatic lipidosis	moderate to severe elevation
Hepatic vacuolation	minimal to mild elevation
Hepatoma	minimal to mild elevation
Herpesvirus hepatitis	unknown
Lymphoma	minimal to mild elevation
Mycobacteriosis	mild to moderate elevation

Guidelines for interpretation, using the enzymatic/photometric assay method (RIA assays will result in lower values):

Minimal: 50-150 micromoles/liter
Mild 150- 250 micromoles/liter
Moderate 250-500 micromoles/liter
Severe 500-700 micromoles/liter