Avian hematology

Marie Gunnarsson
Institute for Clinical Chemistry
Swedish Agricultural University

Birds have nucleated erythrocytes. The cell is oval with an oval centrally positioned nucleus. Avian erythrocytes are much larger than most mammalian erythrocytes. The size varies among species.

This 1.5 year old African grey parrot had a problem with feather plucking but had normal appearing erythrocytes.

The chromatin in the nucleus is uniformly clumped and becomes more condensed with age. The cytoplasm has a uniform texture and stains orange-pink.

These are normal erythrocytes from a healthy 11 year old African grey parrot.

In avian blood smears variations from the typical erythrocyte are occasionally seen. The shape can vary (poikilo-cytosis) from irregular to round or elongated. Changes limited to certain areas are often artifactual.
The occasional abnormally formed erythrocyte was from the same normal African grey parrot seen previously.

Occasional immature polychromatophilic erythrocytes are normally seen. Their cytoplasm is more basophilic and chromatin more dispersed than in mature erythrocytes.

Immature erythrocytes are also more round than mature erythrocytes.

**Question:** Which one of these erythrocytes is the most immature?

**Answer:**
This is the most immature erythrocyte.

The blood is from a healthy 11 year old African grey parrot.
Anemia

An indication of erythrocyte regeneration (bone marrow response to an anemia) is the degree of polychromasia. 1-5 % erythrocyte polychromasia is normal in a healthy bird. In a blood smear from a bird with regenerative anemia the degree of polychromasia will increase.

Anemia

Anisocytosis (variability in cell size) occurs normally in blood smears from healthy birds. With an active bone marrow response to anemia, anisocytosis increases and it is characterized by younger larger and rounder erythrocytes.

Anemia

This is an example of regenerative anemia. Notice that about half of the erythrocytes are immature polychromatophilic cells.

This is blood from a 3 month old male red fronted kakariki with hemolytic anemia.

Anemia

Nonregenerative anemia has no or little increase immature erythrocytes and a low degree of polychromasia which indicates a lack of effective bone marrow response. One should identify the underlaying cause to allow a better prognosis.

Anemia

Increased erythrocyte destruction, decreased erythrocyte production or blood loss can result in anemia.

Blood loss anemia may result from trauma, bloodsucking ectoparasites, gastrointestinal parasitism, coagulopathies, ulcerated neoplasms or rupture of internal organs.
**Anemia**

Increased erythrocyte destruction may be associated with bacterial septicemias, acute aflatoxicosis, toxemias or blood parasites.

This is blood from the red fronted kakariki with hemolytic anemia.

**Anemia**

Decreased erythrocyte production may be associated with chronic infectious diseases such as tuberculosis, chlamydiosis, aspergillosis and chronic hepatic disease.

Other causes are nutritional deficiencies (iron, folic acid), chemicals and toxins (lead, aflatoxin). It may also be associated with neoplasias, such as lymphoid neoplasia.

This picture present anemia and hypochromic erythrocytes caused by lead poisoning.

**Thrombocytes**

Thrombocytes are nucleated and function like mammalian platelets in hemostasis. Thrombocytes are smaller and more rounded than mature erythrocytes.

Compared to the erythrocyte nuclei, thrombocyte nuclei are more rounded and have a higher nuclear/cytoplasmic ratio.
Avian thrombocytes are often mistaken for lymphocytes by beginning hematologists and even automated hematology analyzers.

The cytoplasm is clear but not homogenous. Thrombocytes contain specific granules in variable number, size and position in the cell. They take a pink to reddish color.

Thrombocytes tend to clump, so it is difficult to do a thrombocyte count. A subjective estimation can be made. Seeing 1-2 thrombocytes in an average monolayer oil immersion field is normal.

This is blood from a 3 month old female kakariki with signs of liver disease. The thrombocytes look normal.

Enlargement of the thrombocyte’s cytoplasm indicates a reactive change. Thrombocytes have a phagocytic defense function and the reactive changes are thought to be associated with this function.
Leukocytes

Differential white cell count:
Interspecies variations are great and these reference values are only a very rough guide.

<table>
<thead>
<tr>
<th>Cell Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heterophils</td>
<td>30-75%</td>
</tr>
<tr>
<td>Lymphocytes</td>
<td>20-65%</td>
</tr>
<tr>
<td>Monocytes</td>
<td>0-5%</td>
</tr>
<tr>
<td>Basophils</td>
<td>0-5%</td>
</tr>
<tr>
<td>Eosinophils</td>
<td>0-4%</td>
</tr>
</tbody>
</table>

Leukocytes

Disease or physiologic changes such as "stress" may cause leukocytosis (increased number of leukocytes in blood). Infection is the most common cause to disease related leukocytosis.

Leukocytes

Stress leukocytosis occur in species like macaws, cockatoos, African greys and ratites. Stress causes endogenous release of cortisone which has many effects on blood and other tissues. Treatment with corticosteroids can also result in stress hemograms. Elevated leukocyte counts are common although the bird may not be diseased.

Leukocytes

Mild leukocytosis: bacterial, fungal and chlamydial infections.

Moderate leukocytosis: yolk peritonitis, granulomatous disease, some phases of septicemia.

Severe leukocytosis: active chlamydiosis, aspergillosis, tuberculosis, leukemia.

Leukocytes

Leukopenia is reduced leukocyte numbers which are often an artifact related to sample handling such as:

- Blood clots before placement in anticoagulant
- Lysis due to excessive shipping and storage time
- Poor quality blood films

Leukocytes

True leukopenia is usually a result of overwhelming bacterial infection, severe viral disease or toxic substances.

Consider the variation of leukocyte count between species. Smaller birds tend to have lower leukocyte count than larger birds.
Heterophils, the cells analogous with mammalian neutrophils, are the most common leukocyte in avian blood. They are round with colorless cytoplasm and eosinophilic rod-shaped granules.

The nucleus is lobed in mature heterophils with clumped chromatin that stains purple. The cytoplasmic granules often hide the nucleus. Heterophils show a little variability in size.

Heterophils may exhibit toxic changes, including cytoplasmic basophilia, nuclear hypersegmentation, vacuolization and basophilic cytoplasmic granules.

Toxic heterophils

Heterophils, the cells analogous with mammalian neutrophils, are the most common leukocyte in avian blood. They are round with colorless cytoplasm and eosinophilic rod-shaped granules.

This is a heterophil from an 11 year old African grey parrot.

This is another heterophil from the same 11 year old African grey parrot as seen previously.

These are two toxic heterophils from a 17 year old Amazon parrot with respiratory disease.
Toxic heterophils are seen with septicemias, viremias and chlamydial infections. More severe toxic change indicates more severe and often infectious disease.

Left shift
Immature heterophils when seen indicates severe inflammation. Both toxic heterophils and immature heterophils have cytoplasmic basophilia and it is easy to confuse these two.

Artifacts
It is important to recognize a normal cell even if there is a technique artifact involved. Stain that is too old may cause this artifact where heterophil granules fail to stain. This is an artifact and not toxic change in these heterophils.

These heterophils were from a cockatoo with no clinical signs of disease.

Eosinophils
Eosinophils tend to be more irregular than heterophils. They are typically round and have round granules. Eosinophil cytoplasm is pale blue. Granules may be red, blue or clear. Cell size varies quite a lot.

This is a eosinophil from an 1.5 year old male African grey parrot.
**Eosinophils**

The nucleus of the eosinophil often stains more blue and is more noticeable than the heterophil nucleus. Eosinophil nuclei are lobed with clumped chromatin that stains purple.

This is an eosinophil from a healthy African grey parrot.

**Basophils**

Avian basophils are round with a round nucleus. The nucleus is centrally located and light blue. The cytoplasmic granules stain deeply basophilic and often hide the nucleus.

**Lymphocytes**

In some avian species lymphocytes are the most common leukocyte. They are round but can sometimes look irregular due to molding around other adjacent cells. The nucleus is round.

**Lymphocytes**

The amount of cytoplasm may vary from a narrow band to abundant cytoplasm in large lymphs. The nuclear to cytoplasmic ratio is high. The cytoplasm is light blue and hyaline.

**Reactive lymphocytes**

Antigenic stimulation transforms lymphocytes into reactive lymphocytes. Viral and chlamydial infections may be responsible but the nonspecifically indicate an immune response.
This is a reactive lymphocyte from a 15 year old parrot.

**Reactive lymphocytes**

The cytoplasm of reactive lymphocytes is darker blue reflecting protein synthesis. The nucleus often has an immature appearance.

This is another reactive lymphocyte from a 15 year old parrot.

**Monocytes**

Avian monocytes are large and round or irregular. The nucleus is eccentrically placed in many monocytes and may be round or bilobed. The chromatin is delicate and lacelike, but chromatin clumps can be present.

This is a monocyte from a 1.5 year old male African grey parrot.

**Monocytes**

The cytoplasm has a finely granular appearance and stains blue-gray. Sometimes it contains vacuoles.
This is a monocyte from an 11 year old male African grey parrot.

**Question**

One of these leukocytes is a heterophil. Which one is the heterophil and what type of leukocytes is the other one?

**Answer**

This is the heterophil (arrow) and the other leukocyte is a lymphocyte.

**Question**

One of these leukocytes is a monocyte. Which one is the monocyte and what type of leukocytes is the other one?

**Answer**

This is the monocyte (arrow) and the other leukocyte is a heterophil.

**Question**

How many lymphocytes do you see in this picture?
**Answer**
There are four lymphocytes in this picture. It’s easy to get confused by the immature erythrocyte (arrow).

**Question**
What characterize an immature erythrocyte?

**Answer**
Immature erythrocytes are polychromatophilic with basophilic cytoplasm. They are also rounder than mature erythrocytes.

**Question**
What kind of leukocytes can you see in this picture?

**Answer**
This is a monocyte (arrow). The other two leukocytes are lymphocytes.

**Question**
Identify these leukocytes.
The two leukocytes to the left are heterophils (arrows) and the two leukocytes to the right are lymphocytes.

Active chlamydiosis, aspergillosis, tuberculosis and leukemia are some examples of diseases that causes severe leukocytosis.

All the cells are erythrocytes. The one in the upper left corner is the most immature.

Name a disease that causes severe leukocytosis.

Identify these blood cells.

This blood is from a bird with anemia. How can you differentiate between non-regenerative anemia and regenerative anemia in a blood smear?
In regenerative anemia the degree of polychromasia and anisocytosis increases.

What kind of leukocyte is this?

This is an eosinophil (arrow).

Identify these leukocytes.

The two leukocytes are normal heterophils. Their abnormal appearance is due to an artifact.

What kind of leukocyte is this?
**Question**

What kind of cell is this?

**Answer**

This is a basophil (arrow).

---

**Question**

What is the cause of reactive lymphocytes?

**Answer**

Antigenic stimulation causes the transformation of resting lymphocytes to reactive lymphocytes.

---

**Question**

Identify these blood cells.

**Answer**

This is a reactive lymphocyte.
**Answer**

The two smaller cells in the middle are thrombocytes and the cells surrounding them are erythrocytes.

**Question**

Identify this leukocyte.

**Answer**

This is a toxic heterophil. Notice the dark and round and irregularly shaped granules.

**Good luck!**

This was a good start but continue reading the literature for more information about avian hematology.