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Paralysis is often a symptom of leucemia, altho affected birds may show only paleness and unthriftiness (see front cover).
Leucemia of Fowls

By C. A. Brandly, Robert Graham, and V. M. Michael

Leucemia is one of the most serious diseases affecting Illinois poultry flocks. It occurs in both acute and chronic forms and is usually fatal. Chickens and turkeys of all breeds and ages are susceptible. The leucemia syndrome also has been reported by other investigators in ducks, guinea fowls, and pigeons.

Leucemia appears to be transmitted naturally by direct and indirect contact, and circumstantial evidence indicates that it may to a limited extent be carried in the egg. The symptoms and lesions vary according to the organs and tissues affected and the type or types of the disease present. Recent investigations have shown that there is a close relationship or identity among various known types of leucemia.

When the nervous system is involved, the affected birds may show symptoms of weakness, lameness, paralysis, wryneck, loss of balance, discoloration of the iris of the eye, blindness, distortion of the pupil of the eye, and digestive and other disturbances. Involvement of the spleen, liver, bone marrow, and other organs and tissues may lead to paleness, weakness, emaciation, paralysis thru nerve pressure, difficult breathing, hemorrhage, deformed bones, the formation of tumorlike masses in various parts of the body, and marked changes in the structure and number of cells of the blood.

Prevalence in Illinois Farm Flocks

The sporadic occurrence of leucemia or a leucemic-like disease in Illinois has been recognized for many years. The distribution of the disease in Illinois flocks in 1934 and 1935, as judged by diagnosis of specimens submitted to the Laboratory of Animal Pathology and Hygiene, University of Illinois, is shown in Fig. 1. From July 1, 1931, to June 30, 1935, 10.2 percent of the 6,800 fowls received for autopsy at the Laboratory were diagnosed as having leucemia (see table). Heavy

1C. A. Brandly, Associate Chief in Animal Pathology and Hygiene, assigned by the State Department of Agriculture to assist in diagnostic work; Robert Graham, Chief in Animal Pathology and Hygiene; and V. M. Michael, formerly First Assistant in Animal Pathology and Hygiene.

2Altho certain of these relationships are not well understood, the term leucemia is here employed to include the several conditions variously known as leukemia, leucosis, lymphoctyoma, lymphomatosis, neurolymphomatosis, neurolymphomatosis gallinarum, myelo-leucosis, erythro-leucosis, lymphatic leucemia, myelocytomatosis, endothelioma, big liver disease, fowl paralysis, and range paralysis.
losses were reported in many of the diseased flocks. The largest percentage of infections occurred in young fowls between the ages of 1 and 10 months, altho older fowls were also afflicted.

![Map of Illinois showing counties from which leucemic fowls were received.](image)

**FIG. 1.—COUNTIES FROM WHICH LEUCEMIC FOWLS WERE RECEIVED FOR DIAGNOSIS, JULY 1, 1934, TO JUNE 30, 1935**

<table>
<thead>
<tr>
<th>Year</th>
<th>Total number of poultry specimens examined</th>
<th>Cases of leukemia</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>1931-32</td>
<td>1 949</td>
<td>128</td>
</tr>
<tr>
<td>1932-33</td>
<td>1 825</td>
<td>207</td>
</tr>
<tr>
<td>1933-34</td>
<td>1 433</td>
<td>148</td>
</tr>
<tr>
<td>1934-35</td>
<td>1 593</td>
<td>208</td>
</tr>
<tr>
<td>Total</td>
<td>6 800</td>
<td>691</td>
</tr>
</tbody>
</table>

Prevalence of Leucemia in Illinois Flocks as Indicated by Diagnosis of Specimens Received at the Laboratory of Animal Pathology and Hygiene, University of Illinois.
Cause of Leucemia Not Definitely Known

Various opinions are held concerning the cause of leucemia in fowls. Some investigators believe the cause to be tumorlike (neoplastic) in nature; some that it is due to a filtrable virus; some contend that it is associated with a nutritional disturbance; and others that it occurs as a result of bacterial infection. Little progress has been made toward definitely proving any of these theories. The general trend of opinion, however, appears to favor the filtrable virus theory.

Several Modes of Transmission

The pathology of leucemia strongly suggests that it is infectious. At the Illinois Experiment Station the disease has been induced experimentally in healthy chickens by intravenous and subcutaneous injection of leucemic material in the form of whole blood, some blood constituents, and tissue suspensions. Other investigators also have been successful in transmitting some forms of the disease from sick to healthy fowls by inoculating the healthy fowls with infected blood and tissues. There is circumstantial evidence indicating that leucemia may be transmitted from the adult to the chick by way of the egg. The disease may possibly be communicated by means of droppings from infected fowls and by contact with contaminated premises, altho the incidence of the disease at the Illinois Station following artificial exposure to these possible sources of contamination was so low as to be of no significance. Only 24 cases of leucemia developed in the 171 fowls inoculated or exposed by being fed feces, while 11 of the 150 controls developed natural cases from unknown sources. Apparently susceptibility of flocks, virulence of the causative agent, and other unknown factors influence transmission and spread of the disease.

There is no absolute proof that contact alone is sufficient to spread leucemia, but since the disease has appeared in several flocks following the introduction of newly purchased chickens, the danger of introducing it in this way should not be disregarded. It is also possible that some intermediate host or carrier, such as the blood-sucking parasites (mites, ticks, etc.), may help to transmit the disease.

'The early popular idea that the disease was caused by parasites such as coccidia or tapeworms has been virtually abandoned. Nevertheless such parasites may provide a means of entrance for the causative agent, in the same sense that a wound of the skin may provide an entry for infection. Many times, however, birds affected with leucemia are free from parasites and there is no evidence of previous infestation.
Symptoms Are Highly Variable

The incubation period—that is, the time between exposure and the development of leucemia symptoms—is comparatively long. Several weeks to two months or more may elapse before signs of abnormality appear.

The symptoms of leucemia are highly variable because of the differences in types of the disease and the differences in effects associated with involvement of various organs and tissues.

Among the symptoms which may appear in affected birds from the same flock are paleness, yellowing (jaundice) of the comb and wattles, dulness, un thriftiness, weakness, emaciation, impaired appetite, diarrhea, lameness, loss of balance, wryneck, paralysis, and discoloration of the iris of the eye with or without blindness and distortion of the pupil. Tumorlike masses of the skin or other superficial tissues, which in some cases bleed easily when feathers are picked or pulled, have been seen in outbreaks of leucemia (Fig. 2). Ordinarily not all the symptoms listed above occur in any one flock harboring leucemia, while some of these symptoms may develop as a result of other diseases.

In the acute form of leucemia death may occur suddenly without previous symptoms of illness. Definite or well-marked lesions likewise may not be found in the dead fowl. In the chronic form the symptoms develop slowly, and death losses in a flock may occur over a period of several months. Birds may lose in flesh without losing in total weight as the loss in flesh may for a brief time be offset by the development of extensive tumorlike masses within the body.
LEUCEMIA OF FOWLS

The type of leucemia involving the nervous system, and in which the eyes and the nerves of the legs and wings are affected, appears to be the most common form in Illinois at the present time. One or both limbs may be partially or completely paralyzed. The afflicted fowls may consequently assume varying positions. One leg may be extended full length backward or to the side, and the other full length in the opposite direction. Thus the fowl is forced to rest on its breast (see page 2). Paralysis of the legs may occur with or without drooping of the wings. The muscles of the affected limbs frequently shrink and become much withered as a result of disuse. When only the nerves of the limbs are involved, the birds show a good appetite, and they may maintain their normal body weight and live for some time.

Symptoms of lameness and paralysis accompanying leucemia are frequently observed in fowls on free range, hence the popular name “range paralysis.” Similar symptoms of paralysis, however, associated with coccidiosis are observed in birds on range.

When the brain is affected, the fowl may become either increasingly excitable or sluggish and sleepy, depending on the part of the brain involved.

Another leucemia syndrome is characterized by disturbed vision and often terminates in blindness. The affected eyes appear grayish in color and are commonly called “white eyes” (Fig. 3). Owners frequently detect the eye lesions and discard infected fowls in culling the flock. As the eye lesions develop, a bulging of the eyeball may occa-

FIG. 3.—EYE SHOWING LESIONS OF LEUCEMIA, “WHITE EYE,” AND EYE FROM NORMAL FOWL (Magnified X 4)
sionally be noted. Visual disturbances are often accompanied by lowered production and emaciation as the result of disturbed nutrition. Fowls afflicted in this manner may even starve to death.

In chronically affected leucemic flocks an increasing number of fowls become droopy and have pale combs and wattles, symptoms which resemble those of advanced tuberculosis. Bright green diarrhea is also a common occurrence in connection with the chronic malady, whereas in the acute form of the disease bowel disturbances may not develop.

Fowls may die a few days after the onset of symptoms or may live several weeks or months.

Pathological Changes

The principal pathological changes caused by leucemia are found in the blood and blood-forming organs, the nervous system, and the eyes.

A pronounced leucemic condition of the blood appears in only about half the fowls that show symptoms of the disease. The blood changes may develop rapidly, however, and the affected fowls die suddenly. The increase of white blood corpuscles is often pronounced (Fig. 4). Instead of the normal number (12,000 to 36,000) there may be as high as 95,000 per cubic millimeter. The proportion between the white and
red cells may range from 1:2 to 1:3, instead of 1:250 (normal). The diagnostician must keep in mind that there are other conditions, such as simple leucocytosis in chickens, which may at times be very difficult to differentiate from leucemia.

Anemia is also a characteristic of some forms of leucemia. The blood has a pale red, watery appearance, and clots less readily than that of normal fowls.

Masses of leucocytes may infiltrate the liver, spleen, kidneys, skin, or muscles; in fact, practically all the visceral organs may show varying degrees of small round-cell invasion. Sometimes the cellular infiltrations are so extensive as to form distinct tumorous masses (Figs. 5 and 6). The liver of a leucemic fowl is often greatly enlarged, congested, and sprinkled with minute whitish spots (Figs. 7 and 8), or it may show a diffuse whitish yellow discoloration. A cross-section of the enlarged liver may be mottled in appearance and firm. In fowls having the acute form of the disease the liver may be greyish, soft, pulpy, and four or five times its normal size.

![Fig. 5.—Tumor in Leg Muscle of Leucemic Fowl, and the Leg Muscle of a Normal Fowl](image-url)
The changes in the spleen of a diseased fowl generally conform to those in the liver. The diseased spleen frequently becomes greatly enlarged, light in color, and may have a mottled appearance. It may be soft and pulpy or a firm, compact mass. Not infrequently it is from two to five times normal size.

FIG. 6.—TUMOROUS MASSES IN VISCERAL ORGANS OF LEUCEMIC FOWL

The ovaries may be increased several times in size by tumorous leucemic masses. Ovarian leucocytic infiltration is common in leucemia, but other causes of cystic and tumorous masses of ovaries are recognized.

Leucemic kidneys may show white streaks (urates) or they may be greatly swollen and vary in color from a pale brown to almost white. One or more lobes of the organs may be involved, and the principal kidney tissue appear normal. In some cases noticeable infiltration of
lymphoid tissue in the liver, heart muscle, skeletal muscles, kidneys, ovaries, etc., may result in tumorlike growths or masses. Leucemia of the muscle is characterized by yellowish white enlargements or tumor factions which have an altered texture.

In fowls that show lameness or drooping wings, gross enlargements of the ischiatic and brachial nerves may be present, with resulting atrophy of the muscles. The involved nerve trunks may be enlarged, dull yellowish or glistening and watery, with an absence of normal cross striations (Fig. 9).

A striking anatomical change appearing in connection with leucemia
Fig. 8.—"Spotted" Liver and Spleen of Leucemic Fowl

Fig. 9.—Leg Nerves of Leucemic Fowl and of Normal Fowl
is the greyish-red discoloration of the bone marrow. The marrow in diseased fowls is often firmer than normal and fills the marrow cavity more completely. Sometimes this diseased marrow is almost white, very dry, and contains very little fat. Another manifestation of leucemia occurs in the bones of chicks six weeks old or older. This type of the disease is chronic, seldom fatal, and is characterized by large, irregular swellings of the leg or wing bones. At the distal portion of the bone the marrow cavity is almost obliterated, irregular, and is surrounded by dense, greatly thickened bone tissue; the proximal portion of the bone is much enlarged and porous. The periosteum is adherent to the bone and the marrow appears swollen.

**Diagnosis**

Positive diagnosis of leucemia must be based on symptoms, post-mortem findings, and the histological appearance of the blood and other tissues. The occurrence of the lesions described above are suggestive but not always conclusive.

Tuberculosis, rickets, perosis, parasitism, vitamin-A starvation, toxemia, and other diseases in fowls may be confused with leucemia, both in symptoms and post-mortem observations. Nevertheless there are distinct differences between leucemia and the various other conditions resembling it. The characteristic circumscribed lesions of tuberculosis of an enlarged spleen and liver may be differentiated from leucemia by their structure and texture. They are more yellowish, nodular, and circumscribed than those of leucemia. In tuberculosis the center of advanced, or well-developed, lesions is friable, while leucemic lesions of the liver and spleen are usually diffused uniformly throughout the organ. A differential leucocyte count may serve to identify certain forms of leucemia, but this procedure may be utilized only by an expert.

Because of the great variation in the appearance and distribution of leucemic lesions it is often necessary, before a diagnosis is possible, to examine not less than four live sick birds from a suspected flock. In certain flocks the evidence of leucemia has been so indefinite even in post-mortem findings as to delay positive diagnosis until blood smears could be made and histological sections examined.

To assist flock owners in the identification of this disease in sick poultry, live specimens of suspected birds should be taken to the local veterinarian or they may be sent parcel post or express prepaid to the Laboratory of Animal Pathology and Hygiene, University of Illinois, Urbana, where they will be examined without charge.
Prevention and Treatment

There is no known cure for leukemia. Prevention is the only known method of control, and since the mode of transmission from diseased to healthy animals is not well understood, prevention must be based on general sanitary practices. The following measures are recommended:

1. Kill and burn all diseased birds.
2. Obtain eggs for hatching purposes from disease-free flocks only.
3. Cull the flock frequently. Watch for early symptoms of leukemia and discard immediately all fowls about which there is any question.
4. Obtain new breeding stock and baby chicks only from flocks in which the disease has never been known to occur, or from flocks that have demonstrated a high resistance to the disease as indicated by only negligible losses following an outbreak.
5. Keep houses, feed, ground, and water clean in order to check the possible spread of the disease.
6. Do not bring fowls from shows or exhibitions into the flock.
7. Do not allow adjoining flocks to intermingle.
8. Either plow or spade the ground near the laying houses or keep all fowls confined in clean houses.
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LEUCEMIA has long occurred sporadically in Illinois poultry flocks, but has become a serious hazard to the industry only during the last few years. Chickens of all breeds and ages are susceptible to the disease, but the largest percentage of infections has been observed in birds between the ages of two and eighteen months.

Leucemia occurs in both acute and chronic forms and is usually fatal. The symptoms and lesions are highly variable, making diagnosis difficult in many cases.

Prevention is based upon general sanitary measures of disease control.