HISTOPATHOLOGICAL STUDIES ON BONE DYSPLASIA OF CHICKENS

I. HISTOPATHOLOGY OF THE BONE

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No report has been made on bone dysplasia (the abnormal development of tissue) of chickens. The present authors encountered a collective occurrence of bone dysplasia among chickens. Thereupon, histopathological investigation was conducted on this disease.

This paper describes the histopathological features of the affected bone in detail. In it, consideration was also given on the pathogenesis of the disease. Judging from the aspect of the occurrence, it is thought that the agent of the disease may be in the diet, including additives to feed.

The histopathology of the parathyroid of the chickens involved in the present occurrence will be reported in a paper to come.

MATERIALS AND METHODS

All the materials used for the investigation were collected from chickens on a poultry farm. The keeper of this farm was an expert in poultry raising and had been engaged in rearing broiler chickens for 20 years. He had chiefly used a diet of his own recipe in order to produce meat with a characteristic taste. On this farm, 1,500 day-old chicks used to be purchased at intervals of 2 weeks, raised up to about 150 days old, and then sold.

No particular disease or accident had been encountered on this farm. Such abnormal birds as mentioned below, however, began to be observed at the end of 1967. All of them had successfully been reared up to about 60 days of age. After that, they began to show anemia, swelling of the hock joint, and bending or twisting of the leg below the metatarsus. In flocks where such affected chickens were found, there was a decrease in feed intake, and the birds became lean, showing individual difference in growth. At autopsy of the affected birds, it was noticed that the bone decreased in hardness and often could be easily cut with a knife.

The frequency of occurrence of such changes as mentioned above was about 10 to 30 per cent of the birds of the same age group when judged from the external appearance. Such incidence had been experienced several times up to the time of writing (May, 1968). Moreover, the occurrence of the same disease was recognized on another poultry farm run by a member of the same family and raising birds under the same rearing conditions as on the original farm.

The main methods employed on this farm for rearing are as follows. Birds were

reared by the battery method during all the periods. Chicks began to be fed unpolished rice at 2 days of age. From 3 to 20 days of age, a certain formula feed for chicks was mainly used, and fish soup, greens, and rocambole were added. From 5 to 8 days of age, some additive medicines were given with feed. At 21 days of age and later, the formula feed for chicks was replaced by that for broiler chickens and rice-bran, to which were added greens and boiled fish refuse. From 21 to 25 days of age, some additive medicines were given with feed again.

Twenty-five chickens were examined histopathologically. Eight of them, however, were not used for this study, since they showed no significant lesions. Of the 17 chickens with distinct lesions, one was 56 days old, two were 56 days old, four 68 days old, two 81 days old, four 95 days old, and four 120 days old. All the 17 birds were White Cornish × White Rock hybrids and slaughtered to autopsy.

After postmortem examination, entire tissue specimens were collected from all the birds and fixed in 10% formalin. Bone tissue specimens for histological examination were collected from almost the entire skeleton: cranium, mandible, eighth or ninth cervical vertebra, fifth thoracic vertebra, fifth rib, sternum, scapula, humerus, ulna, metacarpus, coracoid bone, lumbo-sacral vertebral mass, femur, tibia, metatarsus, and third toe. After the electric decarciification of cross and longitudinal sections, bone tissue blocks were embedded in celloidin, sectioned at about 20 μ, and stained with hematoxylin and eosin.

RESULTS

A. Description of Cases

The findings of the cases examined are described in the increasing order of age.

Case 1 (autopsy No. 882) Female 36 days old (Figs. 6 and 9)

Macroscopical: No deformation was observed in the skeleton, nor swelling in the cartilaginous area. The bone decreased in hardness (this means that the cranium, vertebral column, and sternum could be cut easily with a knife; this statement is applicable to the following corresponding description).

Microscopical:—Cortex: In the posterior parts of the ulna and tibia the osteogenous tissue came to maturity. In the tubular bones, however, the osseous tissue of the cortex increased in thickness to varying degrees, showing a coarse network pattern, in which trabeculae were formed indistinctly. In the other bones, there were bone-producing pictures. In the inner part of the scapula, however, the osseous tissue closed to maturity. Medullary cavity: Osteogenous tissue with newly formed bone pieces was observed within and on the inner surface of medullary cavities of the coracoid, humerus, and tibia. In the ulna, metacarpus, femur, metatarsus, and third toe, a hyperplastic change was slight. Of the other bones, the rib and scapula exhibited hyperplasia of newly formed osteogenous tissue.

Case 2 (autopsy No. 889) Male 56 days old

Macroscopical: The left leg below the metatarsus bent slightly outward. The right one below the metatarsus twisted slightly inward. The bone decreased in hardness.

Microscopical:—Cortex: The posterior parts of the femur, tibia, and metatarsus increased in thickness. In them, the bone column ran aslant and often looked like the fish bone. In the other parts of those bone, the osseous tissue was very close to maturity. An external basic lamella was formed in the anterior part of the tibia. Furthermore, the posterior part of the rib increased slightly in thickness, and consisted of osseous tissue which tended to be highly close to maturity. Medullary cavity: Osteogenous tissue was
slightly hyperplastic in the epiphysis of the coracoid. In an area near the proximal epiphysis and the middle portion of the humerus, the newly formed epiphyseal osteogenus tissue was hyperplastic, occupying an area over 0.7 cm long within the medullary cavity. In no other bone such hyperplastic picture was recognized.

Case 3 (autopsy No. 891) Female 56 days old (Fig. 20)

Macroscopical: No deformation was recognized in the skeleton. The cartilaginous area was swollen [this means that swelling occurred to the junctions of the thoracic vertebrae and vertebral ribs and the rib junctions (cf. Fig. 1); this statement is applicable to the following description]. The bone decreased in hardness.

Microscopical:—Cortex: Both anterior and posterior parts of the coracoid, femur, and tibia, and the posterior part of the metatarsus increased in thickness. In them slender rod-shaped osseous tissue ran aslant or the osseous tissue was forming trabeculae and became scarce. So that the histological pictures were markedly deranged. The posterior parts of the humerus, ulna, and third toe increased slightly in thickness. In them the osseous tissue tended to be close to maturity (including trabecular formation and so on). The osseous tissue in the anterior parts of the humerus, ulna, metatarsus, and third toe were close to maturity. Medullary cavity: When the tubular bone were examined, newly formed bone pieces were found in all the areas of the medullary cavity of the coracoid, metacarpus, metatarsus, and third toe, those of the middle portions of the femur and tibia, and those near the distal epiphysis of the humerus. In the other bones, newly formed epiphyseal osteogenus tissue was slightly hyperplastic.

Case 4 (autopsy No. 873) Male 68 days old (Fig. 5)

Macroscopical: The keel of the sternum twisted slightly as though it had been subjected to pressure. The curvature of the rib bent deeper. The cartilaginous area was swollen. The bone decreased in hardness.

Microscopical:—Cortex: The posterior part of the femur increased in thickness. In it the bone columns showed an arabesque pattern. The posterior parts of the coracoid, humerus, ulna, tibia, and metatarsus also increased slightly in thickness. In them, the bone columns remained running aslant and, moreover, pictures exhibiting the process of formation of trabeculae were observed. In the posterior parts of the femur and third toe, the osseous tissue formed a network tending to be close to maturity. In the anterior parts of the coracoid, humerus, ulna, metacarpus, and third toe, it was close to maturity. In the other bones, the osseous tissue generally showed a normal development. Medullary cavity: In the tubular and other bones, the osteogenus tissue was hyperplastic, forming trabeculae.

Case 5 (autopsy No. 874) Female 68 days old (Figs. 2, 4, 7, and 8)

Macroscopical: The changes were the same as those in case 4.

Microscopical:—Cortex: Both anterior and posterior parts of the coracoid and tibia, and only the posterior parts of the humerus, femur, and metatarsus increased in thickness. In the outer layers, the hyperplastic osseous tissue was rod-shaped and ran aslant (in the posterior parts of the coracoid and metatarsus), or showed an irregular arabesque pattern (in the anterior part of the coracoid, the posterior parts of the humerus and metatarsus, and the proximal epiphysis of the scapula) or a network (in the posterior part of the femur). In the inner layers near the medullary cavity, trabeculae were distinctly formed (in the coracoid, humerus, ulna, femur, and third toe). No external basic lamellae were completed. In the other bones, the osseous tissue generally showed a normal development. Medullary cavity: In the tubular bones, the newly formed osteogenus tissue was hyperplastic in both proximal and distal diaphyses. Moreover, all the areas of the medullary cavity were occupied by hyperplastic bone pieces (in the
coracoid, metacarpus, femur, metatarsus, and third toes). The inner surface of the medullary cavity in the diaphysis was also covered by such bone pieces (in the humerus, ulna, and tibia). In all the other bones, except the cranium, the medullary cavities were occupied by newly formed bone pieces.

Case 6 (autopsy No. 875) Female 68 days old (Figs. 10 and 21)

Macroscopical: The changes were the same as those in case 4.

Microscopical:—Cortex: The posterior parts of the coracoid and the proximal halves of the tibia and metatarsus increased in thickness. In them the osseous tissue generally form a network. In the coracoid and femur, slender rod-shaped osseous tissue ran aslant, or showed an arabesque pattern. In all the anterior parts, the osseous tissue was close to maturity. Of the other bones, the proximal epiphysis of the scapula and the outer part of the lumbo-sacral vertebral mass increased in thickness. In them, the osseous tissue presented an arabesque pattern. Medullary cavity: Of the tubular bones, all the areas of the medullary cavities of the coracoid, femur, metatarsus, and third toe were occupied by newly formed bone pieces. In the humerus, ulna, metatarsus, and tibia, the inner surface of the diaphysis was covered by osteogenous tissue with newly formed bone pieces. Of the other bones, the sternum, scapula, lumbo-sacral vertebral mass, and ilium had predominant, hyperplastic, newly formed osseous tissue.

Case 7 (autopsy No. 876) Male 68 days old

Macroscopical: The changes were the same as those in case 4.

Microscopical:—Cortex: The posterior part of the metatarsus increased in thickness. In it the bone column ran aslant and looked like the fish bone. The anterior parts of the metatarsus and tibia increased slightly in thickness. In them, the bone columns showed an indistinct arabesque pattern. In an area near the medullary cavity in the posterior part of the femur, a picture of completed trabecular formation was observed and the primordia of external basic lamellae were recognized. In the other tubular bones, the osseous tissue was close to maturity. Of the other bones, the outer part of the scapula increased somewhat in thickness. In it the osseous tissue tended to be close to maturity. Medullary cavity: Almost all the areas of the medullary cavities of the coracoid, metacarpus and third toe were occupied by osteogenous tissue. In them, bone pieces were small and formed an incomplete network. Of the other bones, almost all the areas of the medullary cavities of the mandibula, cervical vertebral mass, and ilium were occupied by osteogenous tissue. In the sternum and scapula, this tissue was hyperplastic around the trabeculae.

Case 8 (autopsy No. 886) Male 81 days old (Figs. 16~18)

Macroscopical: Both hock joints were swollen. The bone decreased slightly in hardness (this means that the cranium, vertebral column, and sternum could be cut with difficulty with a knife; this statement is applicable to the following description).

Microscopical:—Cortex: The posterior parts of the coracoid and humerus increased in thickness. In them, the bone column ran aslant. In the ulna, metacarpus, femur, tibia, metatarsus, and third toe, the osseous tissue was close to maturity. In the posterior parts, the bone column did not run across and was somewhat irregular-shaped, as compared with that in the anterior parts. Trabecular formation was active in the inner area near the medullary cavity of the femur and tibia. Medullary cavity: Newly formed bone pieces surrounding the osteogenous tissue were hyperplastic within the medullary cavities near the proximal epiphysis of the metatarsus and in the middle portion of the diaphysis of the third toe. Newly formed osseous tissue was hyperplastic, forming trabeculae within the medullary cavities in the middle portion of the diaphysis of the coracoid, humerus, ulna, metacarpus, femur, and tibia. In the other bones, except the cranium and mandibula, newly formed osseous tissue was a little hyperplastic.
Case 9 (autopsy No. 887)  Male  81 days old
Macroscopic:  No deformation was observed in the skeleton.  The bone decreased slightly in hardness.

Microscopic:—Cortex:  The posterior part of the tibia increased in thickness.  In it, the bone columns ran aslant, showing a picture of fish bone.  In both anterior and posterior parts of the coracoid and femur, and the posterior parts of the humerus and metatarsus, trabecular formation was completed in the area near the medullary cavity, and hyperplastic newly formed bone pieces were present coarsely in the outer layers.  External basic lamellae became close to maturity in the anterior part of the metacarpus, while they were close to the mature bone tissue in the humerus, ulna, and metatarsus.  Medullary cavity:  Osteogenous tissue was hyperplastic and formed such remarkable trabeculae that it could be recognized macroscopically in the coracoid.  It was only slightly hyperplastic in any other tubular bone, as well as in the other bones.  A circumscribed osseous tissue (0.5 x 0.2 cm) was seen in an area near the epiphysis of the metatarsus.

Case 10 (autopsy No. 877)  Male  95 days old (Figs. 11 and 12)
Macroscopic:  The keel of the sternum was slightly twisted as though it had been subjected to pressure.  The curvature of the rib presented a very deep bending.  The cartilaginous area was swollen.  The bone decreased in hardness.

Microscopic:—Cortex:  The posterior parts of the femur and the proximal half of the tibia increased in thickness.  Hyperplastic osseous tissue was slender and rod-shaped.  It ran aslant in the femur, and showed a network picture in the tibia.  Moreover, the osseous tissue increased in thickness in some parts (the anterior part of the femur, both anterior and posterior parts of the metatarsus, and the posterior part of the third toe).  Pictures indicating the formation of trabeculae were observed in some areas near the medullary cavity.  The osseous tissue was close to maturity in both anterior and posterior parts of the humerus, ulna, and metacarpus, and the anterior parts of the tibia and third toe.  Medullary cavity:  In the femur, metatarsus, and third toe, all the areas of the medullary cavity, except those in both proximal and distal epiphyses, were occupied by hyperplastic bone pieces.  In the humerus, newly formed osseous tissue covered the inner surface of the medullary cavity near the proximal epiphysis, and almost all areas of the medullary cavity near the distal epiphysis were occupied by hyperplastic bone pieces.  Within the medullary cavities of the ulna and metacarpus, bone pieces were hyperplastic, showing a twig-like appearance.  In the other bones, except the lumbo-sacral vertebral mass, newly formed bone pieces were slightly hyperplastic.

Case 11 (autopsy No. 881).  Male  95 days old (Fig. 19)
Macroscopic:  The right hock joint bent deeply.  The left leg below the metatarsus bent outward (about 90 degrees).  The bone decreased slightly in hardness.

Microscopic:—Cortex:  The posterior parts of the ulna, femur, and tibia increased in thickness.  In them, the bone columns were thick and showed an appearance of fish bone.  In the posterior parts of the coracoid, humerus, and tibia, the bone columns kept running aslant.  Such pictures were also recognized in the anterior part of the tibia.  In the other parts, the osseous tissue was close to maturity.  In both anterior and posterior parts of the metacarpus, and the anterior part of the ulna, the osseous tissue was mature enough to form external basic lamellae.  In the other bones, the diaphyseal tissue was bone-producing.  Medullary cavity:  No hyperplastic figures of osteogenous tissue were observed in the tubular or other bones.  A circumscribed fibrous tissue was recognized in an area near the epiphysis of the humerus.  Such tissue was also present in the cranium and cervical vertebra.

Case 12 (autopsy No. 879)  Female  95 days old (Fig. 13)
Macroscopical: The right tibia was twisted somewhat inward. Both legs below the metatarsus bent slightly outward. The bone decreased slight in hardness.

Microscopical:—Cortex: The posterior part of the tibia increased in thickness. In it, the osseous tissue showed an arabesque pattern. The anterior part of it also increased slightly in thickness. In it, the osseous tissue showed a network picture. In the posterior part of the humerus, there was a difference in histological findings between the inner and the outer layer. The former was close to mature bone tissue, while the latter was inferior to the former in the degree of maturity. In both anterior and posterior parts of the coracoid, ulna, metacarpus, femur, metatarsus, and third toe, the osseous tissue was close to maturity. Medullary cavity: In the coracoid (all the areas of the medullary cavity), in the femur and third toe (except such areas as adjacent to both diaphyses), and in the metatarsus (except an area adjacent to the distal epiphysis), the medullary cavities were occupied by newly formed osseous tissue. In the other bones, newly formed osseous tissue was hyperplastic with bone pieces.

Case 13 (autopsy No. 880) Female 95 days old
Macroscopical: The proximal epiphysis of the right tibia was slightly twisted. The bone decreased slightly in hardness.

Microscopical:—Cortex: In the tubular bones, the osteogenous tissue was close to maturity. In both anterior and posterior parts of the metacarpus and third toe, and the anterior parts of the coracoid and humerus, external basic lamellae appeared in the mature bone tissue. Medullary cavity: The osteogenous tissue was highly hyperplastic in the proximal epiphysis of the metatarsus. In the diaphysis near the distal epiphysis of the coracoid, hyperplasia was seen in osteogenous tissue with trabecular pieces. In the epiphyses of the other tubular bones, slight hyperplasia took place in osteogenous tissue. In the other bones, slight hyperplasia occurred to osteogenous tissue. Such hyperplasia was conspicuous around the trabeculae in the sternum. The medullary cavity of the mandibula was occupied by fibrous osteogenous tissue, without formation of bone pieces.

Case 14 (autopsy No. 860) Female 120 days old
Macroscopical: Both hock joints were slightly swollen. The cartilaginous area was swollen. The bone decreased in hardness.

Microscopical:—Cortex: The osseous tissue of the cortex was bone-producing in all the tubular bones. In the anterior parts of these bones, the osseous tissue was close to maturity. In the other bones, bone-producing figures were also observed. Medullary cavity: The greater part of the coracoid, tibia, metatarsus, and third toe was occupied by newly formed osseous tissue, in which bone pieces anastomosed with one another. Moreover, this tissue was also present mainly in the epiphysis of the ulna and on the inner surface of the diaphysis of the metacarpus and femur. In the other bones, all the medullary cavities of the rib, scapula, lumbo-sacral vertebral mass, and ilium were occupied by newly formed osseous tissue. The low degree of such change in the mandibula and cervical vertebra was observed.

Case 15 (autopsy No. 861) Female 120 days old
Macroscopical: Both hock joints bent deeply. The cartilaginous area was swollen. The bone decreased in hardness.

Microscopical:—Cortex: In the femur, tibia, and third toe, the posterior parts increased in thickness. In them, the lamellar arrangement was irregular. In the anterior parts of these bones, the osseous tissue tended to be close to maturity. In the anterior part of each of the other tubular bones, the osseous tissue was close to maturity, and trabecular formation was conspicuous in areas near the medullary cavity. Medullary cavity: Newly formed osseous tissue was hyperplastic, forming trabeculae and showing
a coarse network picture. These changes were observed in the ulna, metacarpus, femur, and third toe, but not in the middle portion of the diaphysis in the coracoid, tibia, or metatarsus. Newly formed osseous tissue was circumscribed in an area near the distal epiphysis of the humerus. It was slightly hyperplastic in the other bones, except the scapula.

Case 16 (autopsy No. 862) Female 120 days old

Macroscopical: The right hock joint bent deeply. The left leg below the metatarsus was twisted somewhat inward. The cartilaginous area was swollen. The bone decreased in hardness.

Microscopical:—Cortex: The posterior parts of the coracoid and ulna increased slightly in thickness. In areas near the medullary cavity of these bones, a feature of trabecular formation was somewhat conspicuous. In the anterior parts of these bones, and both anterior and posterior parts of the humerus, metacarpus, femur, tibia, metatarsus, and third toe, the osseous tissue tended to be very close to maturity. Medullary cavity: Newly formed osseous tissue was hyperplastic within all areas of the medullary cavity of the coracoid, metacarpus, tibia, metatarsus, and third toe, and wide areas of the middle portion of the humerus, ulna, and femur. In the other bones, hyperplasia also occurred to newly formed osseous tissue.

Case 17 (autopsy No. 863) Female 120 days old (Figs. 1, 14, and 15)

Macroscopical: Both hock joints bent deeply. The cartilaginous area was swollen. The bone decreased in hardness.

Microscopical:—Cortex: In both anterior and posterior parts of the tubular bones, the osseous tissue reached a high maturity. Subsequent hyperplasia was seen in the outer layer of the newly formed thick osseous tissue in the anterior parts of the coracoid and femur, and the posterior part of the ulna. Of the other bones, both inner and outer parts of the scapula presented subsequent hyperplasia of newly formed osseous tissue. Medullary cavity: Almost all areas of the medullary cavity of the coracoid were occupied by newly formed osseous tissue. In the other tubular bones, this tissue was hyperplastic on the inner surface of the medullary cavity of the diaphysis. In the other bones, all the areas of the medullary cavity were occupied by hyperplastic newly formed osseous tissue. The newly formed osseous tissue in the rib was markedly rich in nucleus.

B. Summary of Findings

The particulars of the findings were given with the description of each case and figures. The characteristic change of this disease is summarized as the abnormal development of epiphyseal and diaphyseal osteogenous tissue (this genetic tissue is the periosteum) in the whole body. In the case of the abnormal diaphyseal development, the posterior part was a main affected area in the tubular bones. On the other hand, an abnormal epiphyseal development was observed markedly within the medullary cavities of the tubular bones, as well as of the other bones.

DISCUSSION

No significant changes were observed in 8 of 25 cases examined histologically. For this reason, the other 17 cases were used in this investigation. It is important that the same microscopical changes have been recognized in all of them.

Such macroscopical changes as skeletal deformation, swelling of the cartilaginous area, and a decrease in hardness of the bone are certainly supported by histological findings. The changes in the present cases are apparently unique and different from the medullary bone\(^1\) and thick-leg disease\(^3,4\) which have previously been studied by the present authors and their associates.
In the present investigation, one of the characteristic histological changes was a delay in maturity of the osseous tissue in the normal process of development of the cortex. As to the development of the osseous tissue in the tubular bones, the present authors examined the length and thickness of the bones in addition to the histological investigation. Consequently, it was noticed that the osseous tissue had reached maturity as early as 36 days of age. Namely, external basic lamellae were formed in both posterior and anterior parts of the diaphysis. In the present cases, however, hyperplasia was in progress in the osteogenetic tissue of the diaphysis at 56, 68, 81, and 120 days of age, not to mention 36 days of age. In many cases, the formation of external basic lamellae was markedly delayed or remained incomplete, as shown in some figures (Figs. 2, 4, 7, and 8). In a few cases, external basic lamellae could be pointed out with certainty (Figs. 13~15). A delay in maturity of the osseous tissue was seen mostly in the posterior part of the cortex. It was also certainly recognized in the anterior part of the cortex, but the degree of delay was markedly lower in this part than in the posterior part. This fact can be well understood by the figures of cross sections (Fig. 9).

Another one of the characteristic histological changes is the abnormal development of epiphyseal osteogenetic tissue. Swelling of the cartilaginous area, one of the macroscopical changes, resulted from this histological change (the histological findings of Fig. I are different from those of rickets). Its development varied in degree, but was generally higher in degree than the abnormal development of the osteogenous tissue in the cortex.

As to the cause of this disease, no satisfactory examination has ever been carried out. The various facts mentioned above in the section of Materials and Methods must be taken into consideration. Especially, it is interesting to note that the incidence of this disease has been encountered after such growth-stimulating substance as additive medicine began to be employed for feeding. It was elucidated that this disease gave rise to the following characteristic histological change. In the cortex of the tubular bones, the osseous tissue which may have reached maturity at least once, continued to show osteogenesis. Furthermore, epiphyseal osteogenesis kept on going abnormally in process. Any agent to induce such changes cannot be identified at once. If pathogenesis is taken into consideration, the growth-stimulating substance may be brought forward as one of the responsible agents.

CONCLUSIONS

Histopathological investigation was carried out on bone dysplasia which had occurred naturally and collectively in 17 chickens on a poultry farm. This disease was regarded as a characteristic one, judging from the aspect of occurrence and the macroscopical findings.

A characteristic histological change was the abnormal development of diaphyseal and epiphyseal osteogenetic tissue in the whole body.

As a causal agent, the growth-stimulating substance added to feed was thought to be partially responsible for the pathogenesis.

REFERENCES

鶏骨の Dysplasia について

I. 骨の病理組織像

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著者らは、鶏骨の Dysplasia (the abnormal development of tissue) の集団発生例に遭遇し、それらを病理組織学的に観察した。このような症例の把握は、いまだ見当たらないようである。

検査した材料は25例である。このうち組織変化を示した17例が、本論文に記載されている。それらは、すべて肉用鶏（White Cornish ☀×White Rock ☀）で、日令は、30日より120日にわたっていた。

全症例について、ほぼ全身骨の縦断および横断組織片が観察された。その結果、17症例に、同様の組織変化が見いだされた。

病理組織所見の主像として、全身性骨体性（骨幹性）および間節性骨組織の異常増殖があげられた。前者の場合、管状骨の後頭骨が、おもに病変の巻として選ばれていた。そしてその場合、外胚葉層の悪性変化が、特に指摘された。後者の場合には、管状骨のみならず、他の骨組織においても、骨髄腔内において、造骨組織の異常増殖が極めて顕著で、その程度は、前者の場合よりも高度であった。

以上の所見から、今回の病は、Medullary bone およびThick-leg disease とは明らかに異なり、独自性を持った特発性病であると判断された。

この症例の発生をみた養鶏農家は、自家配合飼料を用い、これに成長促進剤を添加していた。この病の原因発生を考えるに当たり、上記の飼育状態に原因を求めるべきではないかと、少しく考察を試みた。
EXPLANATION of PLATES

All photomicrographs were taken from sections stained with hematoxylin and eosin.

PLATE I

Fig. 1. Left photograph shows apparent swelling of junctions of thoracic vertebrae and vertebral ribs and rib junctions (about red-bean size). Case 1 (autopsy No. 863). Female 120 days old. (Right photograph is a control chicken. Autopsy No. 1007. Female 120 days old.)

Fig. 2. Longitudinal section of third toe. Medullary cavities are occupied by newly formed osseous tissue (see Fig. 3). Both anterior and posterior parts of the cortex increased in thickness. (Microscopically, juvenile trabeculae are luxuriant in inner areas of the cortex. In areas adjacent to the medullary cavity in the cortex, trabeculae are better developed than in inner areas. Primordia of external basic lamellae are dotted.) Case 5 (autopsy No. 874). Female 68 days old. ×1.35.

Fig. 3. Longitudinal section of third toe. This is a control photograph (see Fig. 2). Medullary cavities are observed clearly. The posterior part (lower side) is superior in thickness to the anterior one (upper side). Middle areas of both parts increased slightly in thickness. This case (autopsy No. 878) is not included in this paper. Male 95 days old. ×1.35.

Fig. 4. Longitudinal section of coracoid. The osseous tissue is hyperplastic and high in density in all areas, irrespective of the cortex and medullary cavity. Both anterior and posterior parts of the cortex have increased markedly in thickness. [Microscopically, rod-shaped newly formed osseous tissue runs aslant in the posterior part (lower side) (see Fig. 5). On the other hand, it shows an arabesque pattern in the anterior part of the cortex (upper side) (see Fig. 8). Moreover, a single thin layer composed of mature bone tissue (external basic lamellae) is barely observed in the posterior part of the cortex, and a little distinctly in the anterior part of it. In both parts, trabecular formation is scarce. The medullary cavity is occupied by short rod-shaped pieces of newly formed osseous tissue which are surrounded by thick osteogenous tissue (see Fig. 8). Minute amount of bone-marrow tissue are found here and there.] Case 5 (autopsy No. 874). Female 68 days old. ×1.35.

Fig. 5. Longitudinal section of tibia. The posterior part of the cortex (lower half) has increased in thickness. In it, rod-shaped newly formed bone columns run aslant and parallel to one another. Anastomosing figures are scarcely seen among the columns. A reconstructive (Umbau) phenomenon is observed rarely. On the inner surface of the medullary cavity (upper half), epiphyseal osteogenous tissue is seen with bone pieces anastomosing with one another. Case 4 (autopsy No. 873). Male 68 days old. ×19.

Fig. 6. Longitudinal section of tibia. The posterior part of the cortex has increased in thickness (lower half). In it, newly formed bone columns run aslant and branch often. So that the whole picture is just like that of fish bone. Within the medullary cavity newly formed epiphyseal bone pieces are surrounded by newly formed osteogenous tissue. Case 1 (autopsy No. 882). Female 36 days old. ×27.

PLATE II

Fig. 7. Longitudinal section of ulna. The inner surface of the medullary cavity is covered with newly formed epiphyseal osseous tissue, so that it has become narrow. [Microscopically (see Fig. 8), the posterior part of the cortex (lower half) has increased in thickness. The osseous tissue of the outer layer is inclined to be close to maturity, showing an arabesque pattern. In the inner layer, a picture of trabecular formation is present and primordia of external basic lamellae are dotted in an area adjacent to the medullary cavity. The anterior part of the cortex is thin and composed of mature bone tissue. In newly formed epiphyseal osteogenous tissue which is seen within the
medullary cavity and in epiphyseal areas, newly formed bone pieces have anastomosed with one another, showing a network pattern. Case 5 (autopsy No. 874). Female 68 days old. x1.35.

Fig. 8. Longitudinal section of ulna (high-power magnification of the area indicated by an arrow in Fig. 7). In the outer layer of the posterior part of the cortex (lower half), pictures of newly formed osseous tissue are scarce. The tissue is full, showing an arabesque pattern. In the inner layer of that part, the osseous tissue has been transfigured, showing a picture of trabecular formation. In this tissue, a prominent activation of osteoclasts is seen at a high-power magnification. Primordia of external basic lamellae are seen to form a thin layer in an area adjacent to the medullary cavity (middle area). Newly formed epiphyseal osseous tissue is present on the inner surface of the medullary cavity (upper half), showing a network pattern with slender bone pieces. Case 5 (autopsy No. 874). Female 68 days old. x27.

Fig. 9. Cross section through the middle portion of the diaphysis of femur. The dark-stained layer is the bone tissue of the cortex. On its outer side there is an addition of newly formed diaphyseal osseous tissue, which is hyperplastic at different times. The thickest area (right side) is the posterior part (see Fig. 6). A reconstructive (Umbau) phenomenon is seen in an area near the medullary cavity. On the other hand, there is no addition of newly formed osseous tissue in the anterior part (left side). On the inner side of the dark-stained layer, there is a complete or incomplete trabecular formation composed principally of newly formed epiphyseal osseous tissue. Case 1 (autopsy No. 882). Female 96 days old. x19.

PLATE III

Fig. 10. Longitudinal section through a diaphyseal portion near the distal epiphysis of femur. The posterior part (lower area) has increased in thickness, principally because of a new formation of diaphyseal osseous tissue. The bone columns show a rod-shaped feature that have often increased in thickness with twigs anastomosing with one another. Consequently, there are areas indicating an arabesque pattern. In the inner area there is a thin layer presenting a feeble trabecular formation (a layer running across in the middle area). In this layer, the osseous tissue tends to be close to maturity. Moreover, primordia of external basic lamellae are seen in an area adjacent to the medullary cavity, which is occupied by newly formed epiphyseal osseous tissue. The newly formed osseous tissue has anastomosed with one another, accompanied by the participation of a reconstructive (Umbau) phenomenon. So that it shows an irregular network pattern. Case 6 (Autopsy No. 875). Female 68 days old. x27.

Fig. 11. Longitudinal section of tibia. The medullary cavity is chiefly observed in an area along the anterior part near the proximal epiphysis (upper left area) and in another area near the distal epiphysis (right area). The other cavity is occupied by newly formed epiphyseal osseous tissue. Only an area of the posterior part near the proximal epiphysis (in the neighborhood of the arrow) has increased in thickness. [Microscopically, the cortex has increased in thickness (see Fig. 12).] It is composed of a network of newly formed diaphyseal osseous tissue. Somewhat active trabecular formation is shown in an area near the medullary cavity. The osseous tissue is nearly mature in the other areas of both anterior and posterior parts of the cortex. There is an obscure trabecular formation in an area near the medullary cavity. Primordia of external basic lamellae are observed in an area to the right of the arrow. The medullary cavity is occupied by rod-shaped pieces of newly formed bone tissue which is surrounded by osteogenous tissue. In an area of the medullary cavity observed at a low-power magnification, there is a network of newly formed bone pieces surrounded by osteogenous tissue. Case 10 (autopsy No. 877). Male 95 days old. x1.35.

Fig. 12. Longitudinal section of tibia (high-power magnification of the area indicated by an arrow in Fig. 10). Newly formed diaphyseal osseous tissue (lower half) show a coarse network pattern. In an area near the medullary cavity (middle layer running across), bone columns are thick and tend to be close to maturity. Moreover, a picture of trabecular formation is seen in an area adjacent to the medullary cavity, which is
occupied by newly formed epiphyseal osseous tissue. Case 10 (autopsy No. 877). Male 95 days old. ×19.

PLATE IV

Fig. 13. Longitudinal section through the middle portion of the diaphysis of humerus. The osseous tissue of the posterior part (lower area) reaches to maturity once at least and shows a feature of external basic lamellae (a layer where haversian canals run longitudinally). In its outer layer (lower verge) there is a slight increase of the subsequent osteogenous tissue, which present a marked bone-producing picture. Epiphyseal trabecular tissue has been stretched to some extent into the medullary cavity from the inner surface of the cavity. Case 12 (autopsy No. 879). Female 95 days old. ×27.

Fig. 14. Longitudinal section through the middle portion of the diaphysis of coracoid. A single layer of mature bone tissue, or an external basic lamella, has been formed in the posterior part adjacent to the medullary cavity (a layer running across in the lower area). In its outer area (lower side), coarse bone tissue has been formed. In this tissue, bone columns run aslant and small bone pieces are dotted. The medullary cavity contained a trabecular network composed principally of newly formed epiphyseal osseous tissue. Case 17 (autopsy No. 863). Female 120 days old. ×27.

Fig. 15. Longitudinal section through the cortex near the proximal epiphysis of ulna. The posterior part of the cortex has increased markedly in thickness (lower greater part). In it, bone columns show a network pattern, retaining an appearance of running aslant. In an area near the medullary cavity, there is a single layer composed of mature bone tissue, or an external basic lamella (a layer running across in the upper area). In its upper area, newly formed epiphyseal osseous tissue is hyperplastic in the medullary cavity. The bone columns also show a network pattern, but run longitudinally in direction. Case 17 (autopsy No. 863). Female 120 days old. ×19.

PLATE V

Fig. 16. Longitudinal section of femur. The posterior part (lower side) has increased slightly in thickness. Both epiphyses are occupied by epiphyseal osteogenous tissue. Within the medullary cavity, newly formed epiphyseal osseous tissue is hyperplastic in a thin network pattern. Case 8 (autopsy No. 886). Male 81 days old. ×1.35.

Fig. 17. Longitudinal section of femur (high-power magnification of the area indicated by an arrow in Fig.16). In the posterior part of the cortex (lower area), osteogenesis is not in progress or the degree of ossification is not so high. Namely, the bone columns are close to maturity, but no external basic lamellae have been formed. Anastomoses have been completed among the columns, showing a thick network. The inner surface of the medullary cavity is covered with thin epiphyseal osteogenous tissue. Furthermore, there is an increase in epiphyseal osteogenous tissue with delicate bone pieces within the medullary cavity. Case 8 (autopsy No. 886). Male 81 days old. ×27.

Fig. 18. Cross section through the posterior part of the cortex in the middle portion of the diaphysis of tibia. Bone columns constituting the cortex consist of mature bone tissue. No external basic lamellae have been formed. In most areas of the outer layer of the posterior part, hyperplasia of osteogenous tissue is in progress and a reconstructive (Ümbau) phenomenon is often observed. Thick trabeculae are seen extending toward the medullary cavity. The inner surface of the medullary cavity is covered with epiphyseal osteogenous tissue. Within the medullary cavity, newly formed delicate bone pieces surrounded by osteogenous tissue are interlaced. Case 8 (autopsy No. 886). Male 81 day old. ×27.

PLATE VI

Fig. 19. Longitudinal section through the posterior part of the cortex near the distal diaphysis of tibia. The posterior part has increased markedly in thickness. In it, bone columns
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...tend to be close to maturity, showing an appearance of running aslant, with branches anastomosing with one another. Therefore, they present a picture of fish bone. In an area near the medullary cavity, there is no layer composed of mature bone tissue, or external basic lamella. Within the medullary cavity, there is no increase in epiphyseal osteogenous tissue. Case 11 (autopsy No. 881). Male 95 days old. ×19.

**Fig. 20.** Cross section of lumbo-sacral vertebral mass. In the inner part of the cortex the osseous tissue has come to maturity (upper side). The proper epiphyseal trabeculae have also come to maturity (middle area running across). In the outer part of the cortex (lower side) hyperplasia of diaphyseal osteogenous tissue is in progress. The medullary cavity is occupied by epiphyseal osteogenous tissue, in which delicate bone pieces are still seen. Case 3 (autopsy No. 891). Female 56 days old. ×27.

**Fig. 21.** Cross section through the caput of fifth thoracic vertebra. The medullary cavity is occupied by newly formed osseous tissue composed mainly of rod-shaped bone pieces. The cortex itself (lower verge) shows no significant changes. Case 6 (autopsy No. 875). Female 68 days old. ×52.