

CONGENITAL DEFECTS IN CATTLE .

by

HAROLD J. GREENE

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Joseph W. Leopold
Major Professor

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INTRODUCTION

Few studies have been undertaken of the nature and cause of congenital defects in cattle, and still fewer have dealt with a classification of these defects. To date, it is most difficult to compare the results of surveys of bovine birth defects as the data is presented differently by each author.

The purpose of the present study was:

1. to classify congenital defects according to the body system primarily involved and to tabulate the breed incidence
2. to classify the systemic defects further into specific morphologic or etiologic entities
3. to review the literature on the congenital defects of each body system
4. to describe the gross and microscopic findings of the most frequently seen defects and to pick out the main trends.

PAPER 1

CONGENITAL DEFECTS IN CATTLE

INTRODUCTION

Congenital anomalies are defined as defects of structure and/or function present at birth; and the causes are hereditary, environmental, or the interaction of both environmental and genetic factors. A hereditary defect is a pathological or pathophysiological result determined by a mutant gene. These defects are produced in any pertinent environment and may be lethal, semi-lethal or compatible with life. In terms of the inheritance pattern, most defects in cattle are due to single pairs of recessive genes, but dominant genes as well as multiple gene inheritance are known to occur. Environmental defects are those anomalies produced in any genotype by one or more environmental factors in the critical phase of embryonic development. Vast numbers of environmental agents causing malformations in laboratory animals are known but little knowledge is at hand for cattle. The third group, genetic and environmental defects is produced by specific environmental factors in a special genotype.

The study of congenital defects is complex and presents a wide variety of diversified lesions. The central nervous system may be affected with conditions such as hydrocephalus, cerebellar hypoplasia, and anencephaly. Some common malformations of the skeletal system are taillessness in its various patterns and syndactylism in Holsteins. The muscular system is

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involved in arthrogryposis, muscular hypertrophy and others. The skin of calves may be affected by hairlessness. The internal organs have a wide array of defects such as ventricular septal defects of the heart. Genital malformations are common and may cause breeding problems: uterus didelphys and segmental aplasia of the Mullerian duct system are examples. Defects may occur alone or in association with other anomalies. As an example, a syndrome in Hereford calves is characterized by cleft palate, scoliosis, kyphosis and contractures of the limbs. Well documented cases of congenital disorders of physiological functions are rare in cattle; porphyria is an example.

This report documents the various classes of congenital defects encountered during a 22-year survey in Kansas.

REVIEW OF LITERATURE

Congenital defects are abnormalities of structure or function present at birth resulting from genetic or environmental causes or their interaction. Bovine neonatal losses are reported to be over six percent (4, 12).

Incidence of bovine congenital defects is reported to range from 0.2 to 4.4 percent of all calves born (1, 2, 3, 4, 5, 7, 8, 10, 13, 14). These figures represent only a part of the defects that occur. In a study of cleft palate in man, the incidence in aborted fetuses was 76 times greater than that found in neonates (9). In addition, associated defects of diverse nature were found in the fetuses. In a survey of 6,409

calvings in Aberdeen Angus cows, 4.4 percent of the calves born were defective (3). In another survey, the incidence of defective calves was 0.25 percent; 40 percent were stillborn; 0.21 percent were severely disfigured and 0.5 percent had undesirable characteristics (8). A British study found a perinatal mortality of 4.9 percent, 6.8 percent of which were grossly defective (14). In Germany, the majority of stillborn calves was attributed to fetal asphyxiation or infection, but 6.9 percent of these were found to be grossly defective (5).

In the United States, the most common defect in 6,455 congenitally defective calves was umbilical hernia (12). In Germany, the frequency of body system involvement was: central nervous system, 21.6 percent; combined skeletal defects, 18.5 percent; anomalous twins, ten percent; systemic defects, 9.7 percent; defects of large body cavities, 9.3 percent; alimentary tract, 4.3 percent; urogenital system, 4.3 percent; circulatory system, 2.7 percent; skin defects, two percent; and others, 1.7 percent (5). Distribution in 2,081 defective calves in New Zealand was: skeletal defects, 56.2 percent; soft tissues of the head, thorax and abdomen, 27.5 percent; skin, hair and muscle, 8.9 percent; reproductive tract, 5.9 percent; and mammary gland, 1.5 percent (1). Angiologic and neurologic defects were the most common in 103 different defects found during routine dissection of 139 calves for anatomy instruction (15).

MATERIALS AND METHODS

The cases were taken from a collection of congenital defects initiated at Kansas State University in 1950. Technicians at the University owned Artificial Breeding Station were requested to report on both anomalous and normal calves born in patron's herds. Initially only dairy cattle were involved; later, both dairy and beef breeds were studied. Approximately 45,000 cattle per year were involved, and anomalous calves were rarely encountered. Reporting of the rare anomalous calves was apparently successful; however, the additional voluntary work expected from technicians in reporting normal calves proved unreasonable.

A number of defective calves were purchased or collected and dissected. Each was euthanized by intravenous administration of sodium pentobarbital and necropsied immediately. The affected tissues were fixed in ten percent buffered neutral formalin, routinely processed and stained by hematoxylin and eosin.

RESULTS

A total of 1,275 defects from 588 herds were encountered (Table 1). The systems most commonly involved were: skeletal, 476 (37.3%); organs of special sense, 238 (18.6%); muscular, 190 (14.9%); and central nervous, 155 (12.1%).

Skeletal defects were subdivided according to the anatomic region involved (Table 2), the majority of which involved the

axial skeleton (48.7%). The skeletal defects are classified in Table 2. Organs of special sense were defective 238 times. Most of these were ocular defects, details of which are illustrated in Table 3. Nine calves had microtia. Although the muscular system was defective 190 times, in all but two cases the nature of the anomaly was similar, the animals being arthrogryptic with or without associated defects in other body systems. Umbilical hernia, 50 cases, and schistosomus reflexus, 13 cases, were classified as defects of large body cavities. The sex of the schistosomus reflexus calves was recorded for nine cases and all were male. Table 5 summarizes the defects of the central nervous system.

Six cases of white heifer disease were encountered (Figure 5). Freemartinism was rarely seen and occurred in three Holsteins and one Brown Swiss calf. Figure 4 illustrates the hypoplastic cord-like uterine horns of a free martin.

Various parts of the body were affected with epitheliogenesis imperfecta. The hoofs and ears were denuded most commonly (Figure 6); however, the defect also occurred on the tongue of Brown Swiss calves. Defects of the digestive system were relatively rare and were seen 36 times (Table 9). The Holstein was the only breed affected with atresia ani, 12 cases were recorded (Figure 7). Eight of these were tailless and another one had a short tail. Twenty-five defects of the circulatory system were classified, Table 10 (Figure 8). Seven oversized calves constituted all the endocrine defects; six

were Holsteins and one was an Ayrshire. Congenital porphyria was the only metabolic defect detected.

Embryonic duplications were recorded separately (Table 11) and consisted of two acardius (free asymmetrical twins); 12 diplopagus (attached symmetrical twins); ten heteropagus (attached asymmetrical twins); the remaining cases were one each of double anus and polyotia.

DISCUSSION

The economic losses due to the decreased reproductive capacity, lesser fertility, perinatal loss of defective calves and losses due to obstetrical problems illustrate the importance of congenital anomalies in cattle. Research in this area could profitably be aimed at the development of clinical and pathological methods for the detection of unwanted properties in sires. Research on malformations in cattle may provide models for comparative pathology.

Congenital defects in man occur in one to three percent of all births, and reports of bovine defects are more variable, 0.2 to 4.4 percent (11). It is reasonable to suggest that with accurate reporting, the incidence of genetically-induced defects in cattle should be higher than in man due to the greater degree of inbreeding in cattle.

Heredity, environment, infectious agents and their interactions all play an important role as etiologic factors in congenital defects. Consequently the frequency of a

particular defect varies due to environmental variations and prevalent breeds and lines of breeding stock used in different geographic locations. The interest of investigators is also reflected in the frequency of reported cases. As there is no universally accepted system of classifying birth defects, comparison of frequencies is difficult. However, in our study, the high incidence of skeletal and central nervous defects compares with reports from Germany, but the 56 percent incidence of skeletal defects reported from New Zealand is much higher than our 37.3 percent.

Umbilical herniation accounted for few of our cases in contrast to another American report which indicated that it was the most common defect (12). One bull which sired six calves with umbilical hernia also sired at least one schistosomus reflexus calf, indicating a possible relationship of those defects.

The higher incidence of spina bifida (eight out of 15) in Aberdeen-Angus suggests a possible breed predilection for this apparently rare cattle defect in the United States.

SUMMARY

Twelve hundred and seventy five congenital defects are reported. Each defect was classified according to the body system primarily involved. The systems most commonly affected were skeletal (37.3%), special sense organs (18.6%), muscular system (14.9%), and central nervous system (12.1%).

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Table 1. Classification of Bovine Congenital Defects in 1122 Calves According to Body System Primarily Involved.

Body System	Number of cases	Number of herds	Percentage of total number of defects
Skeletal System	476	231	37.3
Organs of Special Sense	238	68	18.6
Muscular System	190	85	14.9
Central Nervous System	155	75	12.1
Peritoneum and Large Body Cavities	63	27	4.9
Reproductive System	31	21	2.4
Skin	25	14	1.9
Upper Digestive System	24	19	1.9
Lower Digestive System	12	9	0.9
Circulatory System	25	20	1.9
Endocrine System	7	7	0.5
Metabolic Defects	1	1	0.0
Duplication Defects	28	11	2.2
Total Number of Defects	1275		
Total Number of Calves	1122	588	

The difference between the number of defects and the number of affected calves is due to the double entry of 123 calves in the skeletal and muscular systems and the triple entry of 15 cases of spina bifida in muscular, skeletal and central nervous systems.

Table 2. Summary of 476 Regional Defects of the Skeletal System.

Defect	No. of Here- Calves ford	Angus	Charo- lais	Short- horn	Mixed	Hol- stein	Guern- sey	Ayr- shire	Brown Swiss
<u>Generalized</u>	<u>95</u>								
Chondrodystrophy	60	22	18	1	2	6	8	2	1
Persistent pri- mary spongiosa	32	-	32	-	-	-	-	-	-
Persistent secon- dary spongiosa	3	3	-	-	-	-	-	-	-
<u>Face</u>	<u>67</u>								
Campylognathia	17	11	-	-	-	-	4	-	1
Roman Nose	2	-	-	-	-	-	2	-	-
Schistoprosopus	2	-	-	-	-	-	2	-	-
Palatoschisis	46	18	-	16	-	1	2	-	3
<u>Mandible</u>	<u>28</u>								
Agnathia	8	-	2	-	-	-	3	-	3
Brachygnathia inferior	20	1	2	-	1	1	5	2	5
<u>Axial Skeleton</u>	<u>232</u>								
Atlanto occipi- tal fusion	1	-	-	-	-	-	1	-	-
Torticollis	16	2	-	2	3	5	2	1	1

Table 2. (continued)

Defect	No. of Here- Calves ford	Angus	Charo- lais	Short- horn	Mixed	Hol- stein	Guern- sey	Jer- sey	Ayr- shire	Brown Swiss
Short spine lethal	3	-	1	-	-	2	-	-	-	-
Scoliosis	12	2	7	2	-	1	-	-	-	-
Kyphosis	16	-	-	-	-	15	1	-	-	-
Kyphoscoliosis	29	14	-	9	-	4	-	-	-	-
Spina bifida	15	4	8	2	-	1	-	-	-	-
Perosomus elumbis	2	2	-	-	-	-	-	-	-	-
Wry tail	34	4	2	-	6	12	-	-	-	10
Anury	104	5	2	8	11	66	2	7	1	2
<u>Appendicular Skeleton</u>	54									
Polydactyly	6	2	-	-	-	3	1	-	-	-
Monobrachia	3	1	-	-	-	-	2	-	-	-
Adactyly	2	1	-	-	-	-	1	-	-	-
Ectrodactyly	2	1	1	-	-	-	-	-	-	-
Syndactyly	34	-	1	-	-	33	-	-	-	-
Hip dysplasia	7	5	1	1	-	-	-	-	-	-

Table 3. Summary of 229 Ocular Defects.

Defect	No. of Here- Calves ford	Angus	Charo- lais	Short- horn	Unknown or mixed	Hol- stein	Guern- sey	Jer- sey	Ayr- shire	Brown Swiss
Incomplete albinism	86	86	-	-	-	-	-	-	-	-
Complete albinism	11	-	-	10	-	-	1	-	-	-
Heterochromida iridis	23	12	-	-	-	3	1	-	7	-
Retinal Dysplasia	15	-	-	15	-	-	-	-	-	-
Bilateral anteri- or senecchia	1	-	-	-	1	-	-	-	-	-
Blindness	37	3	-	1	2	14	3	12	-	2
Strabismus	2	-	-	-	-	2	-	-	-	-
Dermoid	4	-	3	1	-	-	-	-	-	-
Anophthalmia	30	-	-	-	26	3	-	1	-	-
Microphthalmia	16	2	-	8	-	6	-	-	-	-
Exophthalmus	2	1	-	-	-	-	-	1	-	-
Hydrophthalmia	1	1	-	-	-	-	-	-	-	-
Cyclops	1	1	-	-	-	-	-	-	-	-

There were also 9 calves with microtia: 6 Ayrshire, 2 Holstein and 1 Hereford.

Table 5. Summary of 155 Defects of the Central Nervous System.

Defect	No. of Here- Calves ford	Angus	Charo- lais	Short- horn	Mixed	Hol- stein	Guern- sey	Jer- sey	Ayr- shire	Brown Swiss
Hydrocephalus	97	11	1	3	2	8	-	-	2	-
Hydranencephaly	1	1	-	-	-	-	-	-	-	-
Anencephaly	2	-	-	-	-	2	-	-	-	-
Encephalocele	2	-	-	-	-	-	-	-	-	-
Cerebellar hypoplasia	10	-	-	1	1	8	-	-	-	-
Epilepsy	1	-	-	-	-	-	1	-	-	-
Spastic Paresis	15	1	8	5	-	-	-	-	-	-
Neonatal Spasticity	10	-	-	-	-	-	1	-	-	-
Crampiness	2	-	-	-	-	2	-	-	-	-
Spina bifida*	15	8	-	2	-	1	-	-	-	-

*Also indexed in the skeletal and muscular system.

Table 6. Summary of 63 Defects of the Peritoneum and Large Body Cavities.

Defect	No. of Here- Calves ford	Angus	Charo- lais	Short- horn	Mixed	Hol- stein	Guernsey	Jersey	Ayr- shire	Brown Swiss
Umbilical herniation	50	-	-	-	-	49	1	-	-	-
Schistosomus reflexus	13	1	1	-	5	5	1	-	-	-

Table 7. Summary of 31 Defects of the Reproductive System.

Defect	No. of Here- Calves ford	Angus	Charo- lais	Short- horn	Mixed	Hol- stein	Guern- sey	Jer- sey	Ayr- shire	Brown Swiss
Supernumary teats	8	-	-	-	-	-	-	-	-	8
Fused teats	1	-	-	1	-	-	-	-	-	-
Mummified fetus	6	-	-	1	-	3	2	-	-	-
Hydramnion	3	-	-	-	-	3	-	-	-	-
White heifer disease	6	-	-	6	-	-	-	-	-	-
Inter sex (Freemartinism)	4	-	-	-	-	3	-	-	-	1
Hypospasia	2	-	-	-	-	1	-	-	-	1
Cryptorchidism	1	-	-	1	-	-	-	-	-	-

Table 8. Summary of 25 Skin Defects.

Defect	No. of Here- Calves ford	Angus	Charo- lais	Short- horn	Mixed	Hol- stein	Guern- sey	Jer- sey	Ayr- shire	Brown Swiss
Epitheliogenesis imperfecta	12	-	-	8	-	-	-	-	-	4
Alopecia	7	2	-	-	3	2	-	-	-	-
Hypertrichosis	5	2	1	-	-	1	-	-	1	-
Graying	1	-	-	-	-	1	-	-	-	-

Table 9. Summary of 36 Defects of the Digestive System.

Defect	No. of Here- Calves ford	Angus	Charo- lais	Short- horn	Mixed	Hol- stein	Guern- sey	Jer- sey	Ayr- shire	Brown Swiss
Cheiloschisis	12	3	-	3	1	2	2	-	1	-
Palatoschisis	3	2	-	-	-	1	-	-	-	-
Epitheliogenesis imperfecta (smooth tongue)	3	-	-	-	-	-	-	-	-	3
Tongue loller	4	-	-	-	-	4	-	-	-	-
Partial anodontia	1	-	-	-	-	1	-	-	-	-
Microdontia	1	-	-	-	-	1	-	-	-	-
Atresia ani	12	-	-	-	-	12	-	-	-	-

Table 10. Summary of 25 Defects of the Circulatory System.

Defect	No. of Here- Calves ford	Angus	Charo- lais	Short- horn	Mixed	Hol- stein	Guern- sey	Ayr- shire	Brown Swiss
Ectopia cordis cervicalis	10	1	3	-	3	1	-	-	-
Congenital edema	9	1	4	-	-	-	-	3	1
Interventricular septal defect	3	-	-	-	-	2	-	-	1
Patent ductus arteriosus	2	1	-	-	-	1	-	-	-
Interatrial septal defect	1	-	-	-	-	1	-	-	-

Table 11. Embryonic Duplications in Cattle Encountered in Kansas over a 22-year Period.

I.	<u>Acardius</u> - free asymmetrical twins	2
	Holoacardius amorphus	1
	Holoacardius acormus	1
II.	<u>Diplopagus</u> - attached symmetrical twins	12
	Diprosopus	5
	Dicephalus	5
	Siamese twins - unclassified	2
III.	<u>Heteropagus</u> - attached asymmetrical twins	13
	Dipygus	1
	Notomelia	6
	Teratomas	3
	Desmiognathus	1
	Epignathus	1
	Abdominal cavity	1
IV.	<u>Other</u>	2
	Two ani	1
	Polyotia	1
	TOTAL	29

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Fig. 1. Cross section through the brain of a Shorthorn calf with internal hydrocephalus. Note the dilated lateral ventricles (arrow).

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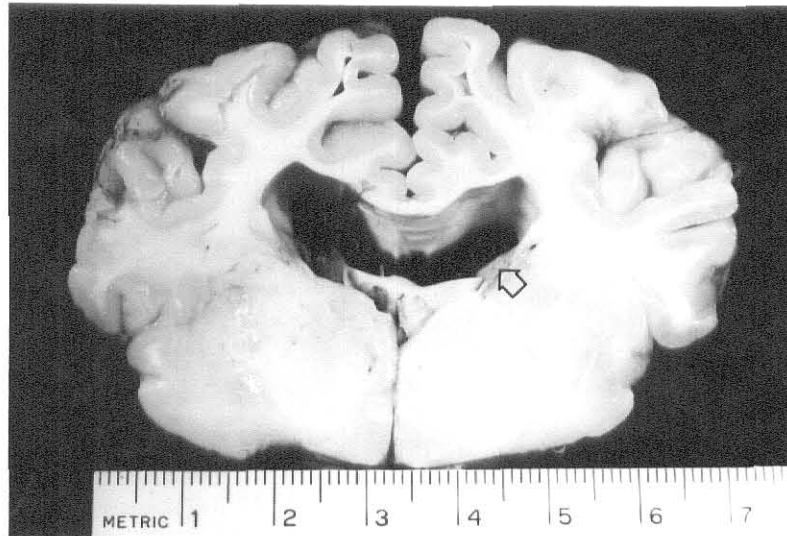


Fig. 1

Fig. 2. Anencephaly in a Holstein calf. Calvarium has been removed. Note the occipital condyles (a) and the brain stem anteriorly (b). There is lack of development of cerebral hemispheres and cerebellum.

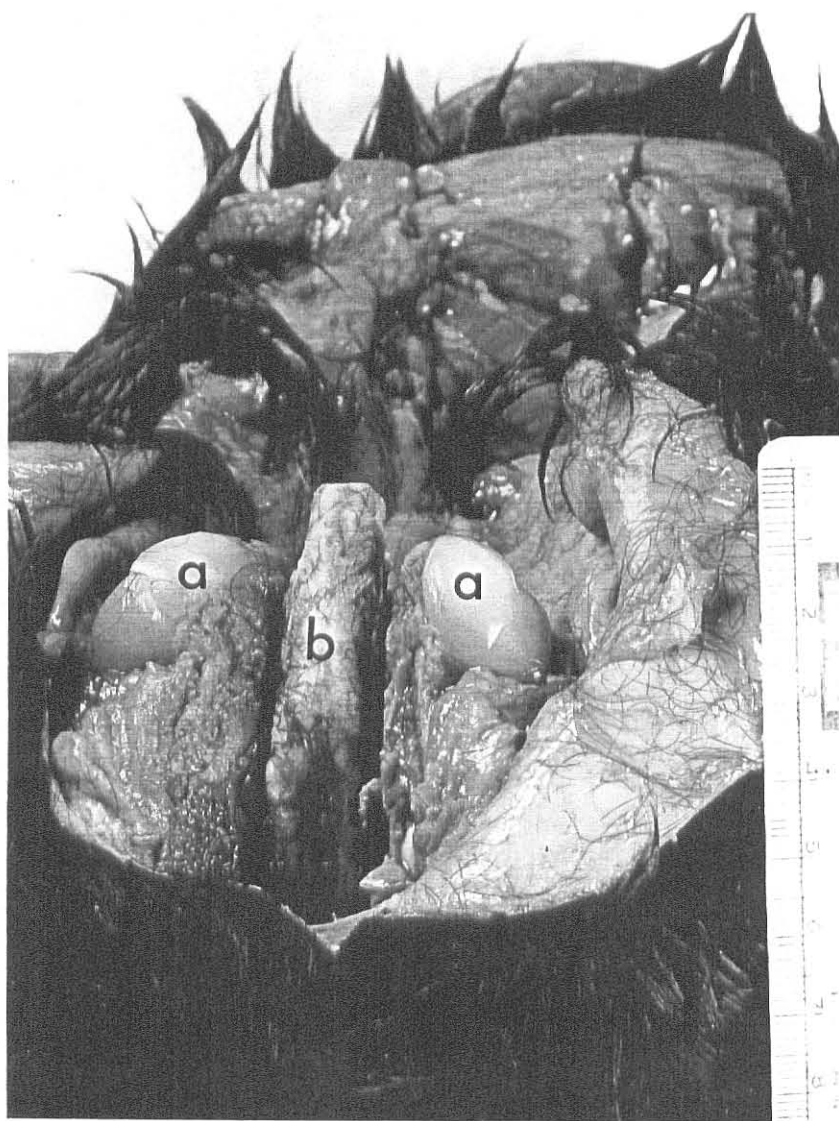


Fig. 2

Fig. 3. Bulged forehead due to encephalocele (arrow) in a Hereford calf. The calf was unable to rise after birth.



Fig. 3

Fig. 4. Reproductive tract from a freemartin calf with Short Vagina (a), hypoplastic cord like uterine horns and body (b), also hypoplastic ovaries (c).

Fig. 5. Reproductive tract of a Shorthorn heifer affected with segmental aplasia (white heifer disease) of the mullerian duct system. Note normal ovaries (a) and balloon like distentions of normal uterine structures cranial to segmental aplasia (b).

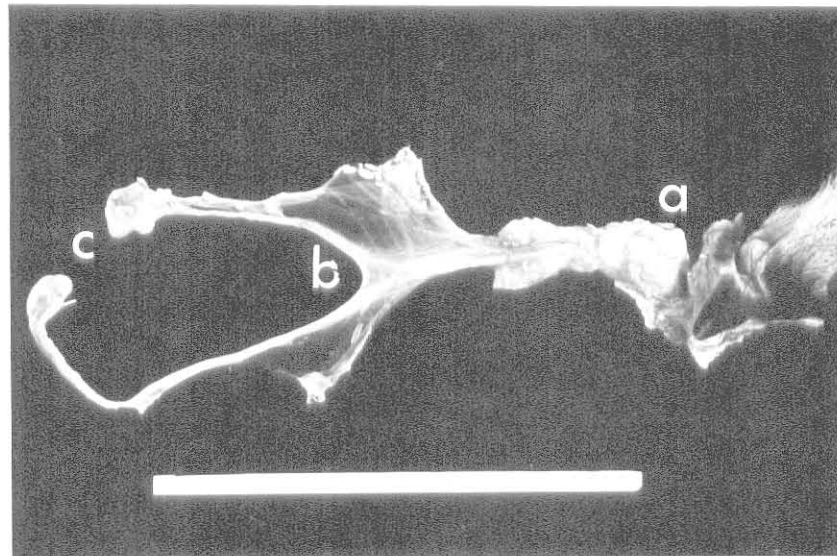


Fig. 4

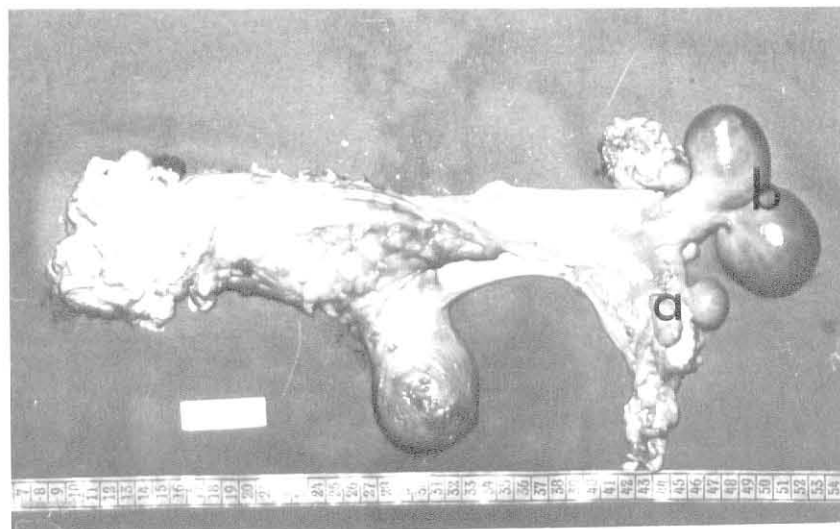


Fig. 5

Fig. 6. The feet of a calf affected with epitheliogenesis imperfecta. Note the absence of epidermis on the hooves and adjacent area (arrow).



Fig. 6

Fig. 7. Atresia ani in a Holstein calf. Note that the colon and rectum (arrow) are distended with meconium.
(Scale in inches)

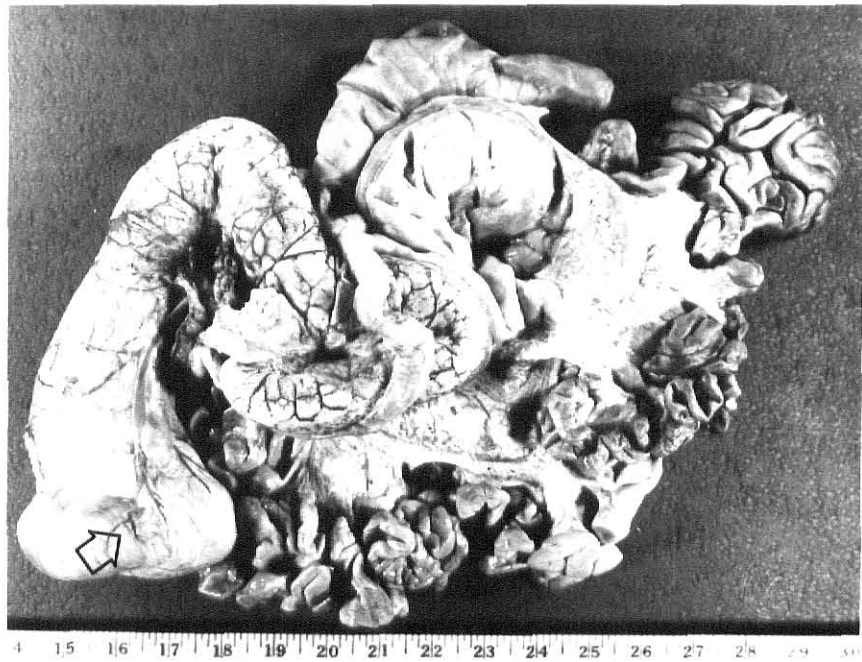


Fig. 7

Fig. 8. High interventricular septal defect (arrow) in a calf.

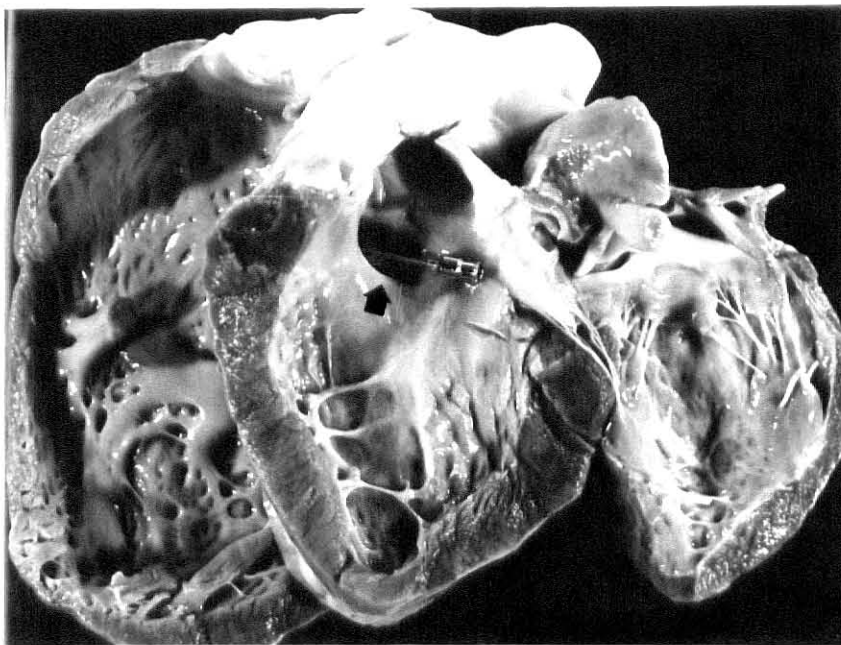


Fig. 8

PAPER 2

COMPLETE ALBINISM IN BEEF SHORTHORN CALVES

INTRODUCTION

Several specific types of albinism have been reported in cattle (4-6, 8-15). These ranged from ocular albinism (3) over incomplete and partial albinism (4-6) to complete albinism (8). The occurrence of albinism in Shorthorn calves is reported here in connection with a long-term study of the nature and cause of congenital defects in cattle which methods have been outlined previously (2, 7).

HISTORY

Four albino calves were observed among nine paternal half sibs in a Kansas herd which comprised 28 registered and grade Shorthorn cattle. Two of the affected calves were females and were examined clinically, two affected males had previously died. The eyes of the affected female calves were subsequently salvaged from the slaughter house, fixed in ten percent neutral buffered formalin and processed routinely.

The four albino calves occurred in a group of nine paternal half sibs; the remaining five calves were normal (Figure 1). This was the first calf crop of the bull E (Figure 1). Their dams were nine paternal half sibs, daughters of bull D. The grand dams were unrelated. The sire of the albinos, bull E, and the grand sire, bull D, were maternal half sibs (Figure 1). All parental animals on the farm (cows III, 1-6 and 9; cows IV,

1-9 and bull E, Figure 1) had red coat color. The pedigrees listed bulls A and B as roans, bulls C and D as red, Cow II-1 as roan and cows I-1 and I-2 as red.

Calf 1

The calf in bright light showed blepharospasm and photophobia. Although vision was normal, shaded areas were preferred by the calf during the daylight hours. Nystagmus was present. The light pupillary responses were exaggerated indoors and the calf reacted violently to bright light.

The irises were faint blue in the pupillary areas and white in the iridal bases. The smooth corpora nigra of the irides were smaller than normal. Radiating iridal blood vessels and parts of the highly tortuous circulus vasculosus irides major could be detected. The irides were thinner than normal and permitted passage of light reflected from the ocular fundi.

The ocular fundus reflections were red, when the eye was turned ventrally, and yellow, when the eye was deviated dorsally. The ocular fundi were photographed in a darkened room.

Ophthalmoscopic examination revealed yellow tapetum lucida and nonpigmented tapetum nigra. The well-developed tapetum lucida had prominent stars of Winslow. The tapetum nigra were devoid totally of pigment and the large choroid blood vessels were distributed normally in this structure. The normal optic papillae were situated primarily in the tapetum

nigra. The dichotomous retinal blood vessels were normal in size, number and distribution.

The eyes were devoid of pigment (Figures 2-5). The irides were structurally normal but posterior layers were devoid of pigment. Likewise the ciliary processes were non-pigmented.

Calf 2

The ophthalmologic findings of the older female calf were similar to the first calf. The thinned irides were the same color but the corpora nigra were more noticeable. The iridal blood vessels could be detected throughout its anterior surface. The ocular fundi had normal yellow tapetum lucida and the tapetum nigra were devoid of pigmentation. The position of the optic papillae in both eyes was at the junction of the tapetum lucida and tapetum nigra. The red stars of Winslow were distributed in a uniform fashion in the tapetum lucida.

Microscopic findings were essentially similar to those described for Calf 1.

DISCUSSION

Albinism in cattle may conveniently be classified into partial, incomplete, and complete types (10). In partial albinism, the color of the iris is blue and white centrally and brown peripherally, and the coat color is usually characteristic of the breed or a dilute color (1, 4, 6). A form of partial

albinism is illustrated by the recessively inherited Chediak-Higashi syndrome, which besides its albinotic features, includes abnormally large, membrane-bound organelles in various cells and an increased susceptibility to infection (12).

Incomplete albinism, inherited as an autosomal dominant characteristic, is characterized by pure white coat color; a few animals may have small pigmented areas of the body. The iris may vary from blue to gray to white and may contain brown sectors. Incomplete albinos have colobomas of the nontapetal fundus and tapetal fibrosum hypoplasia (1, 4-6).

Complete albinism, inherited as a simple autosomal recessive trait, is characterized by pure white hair coat color and white to pink irides but a normal tapetum lucidum. Complete albinism has been reported in Holstein-Friesian (11, 13); in a Guernsey calf (8), in a Murbodner calf (14) and in European Brown Swiss (15). The occurrence of the complete albino calves in this herd of Shorthorn calves is compatible with an autosomal recessive gene. The defective calves were from normal parents and occurred only when inbreeding was practiced (Figure 1).

SUMMARY

Complete albinism occurred in four Shorthorn calves. Two albino calves examined exhibited photophobia, blepharospasm and nystagmus. Two albino heifers revealed histologically non-pigmented irides and ciliary processes.

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Fig. 1. Genealogy of complete albinism in a Shorthorn herd. Grand dams of albino calves were unrelated, all dams were half sibs being daughters of bull D. Bull E sired all albino calves and he and bull D were maternal half brothers.



Normal female.



Normal male.



Albino calf, female.



Albino calf, male.

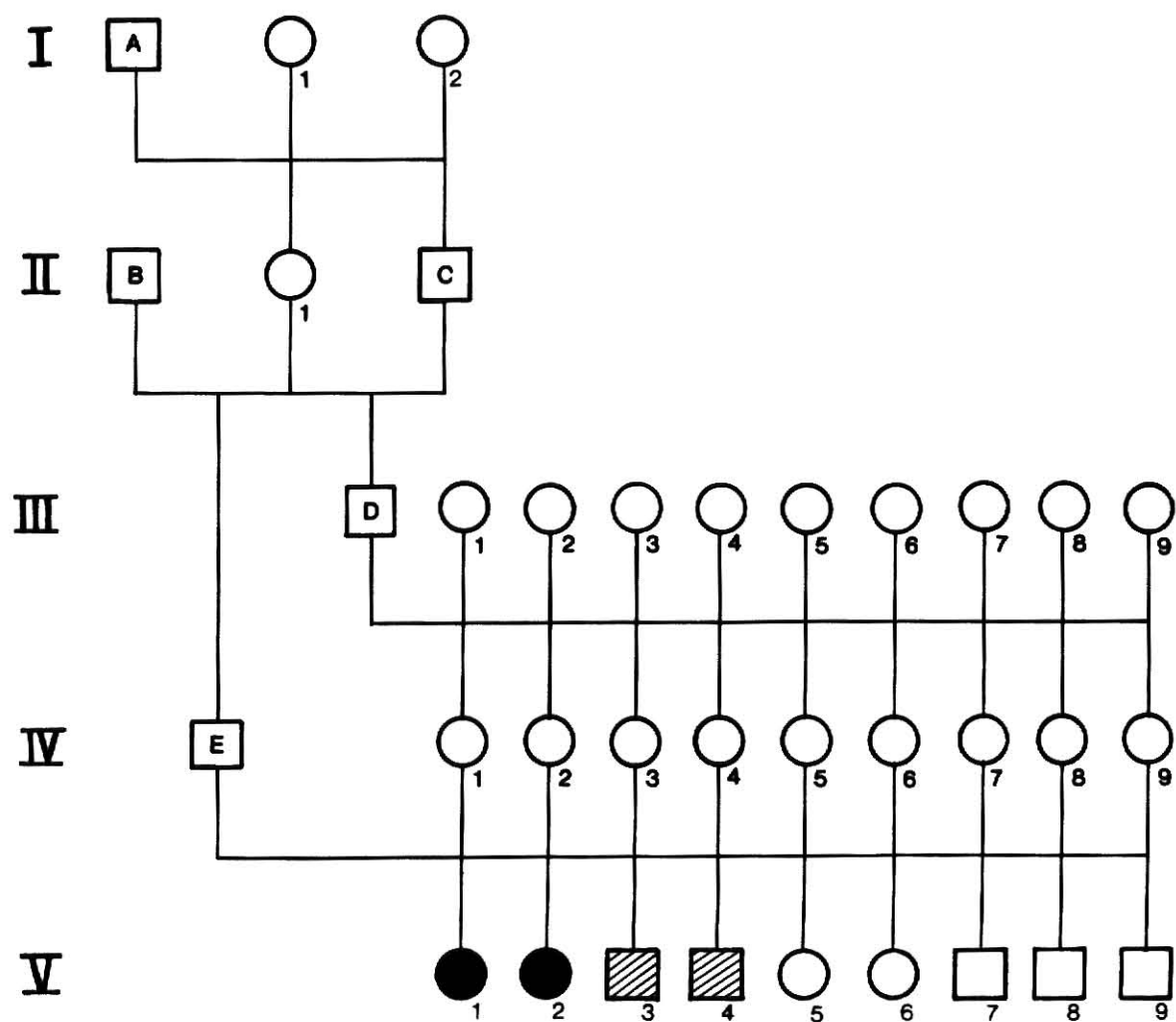


Fig. 1

Fig. 2. Fundus of an albino calf. Note lack of pigmentation.

Fig. 3. Posterior aspect of iris and ciliary body (arrow) of an albino calf. Note lack of pigmentation.

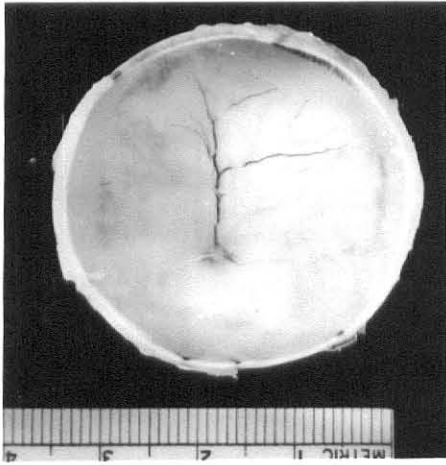


Fig. 2

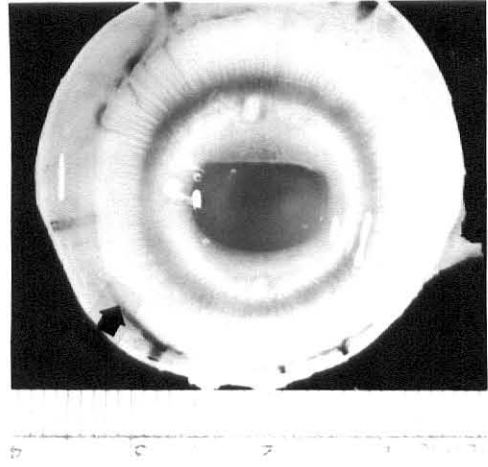


Fig. 3

40
41

Fig. 4. The iris of a complete albino Shorthorn calf. There is complete absence of pigmentation in all layers of the iris. (H and E 120X)

Fig. 5. Ciliary process of a complete albino Shorthorn calf. There is complete absence of pigmentation. (H and E 120X)

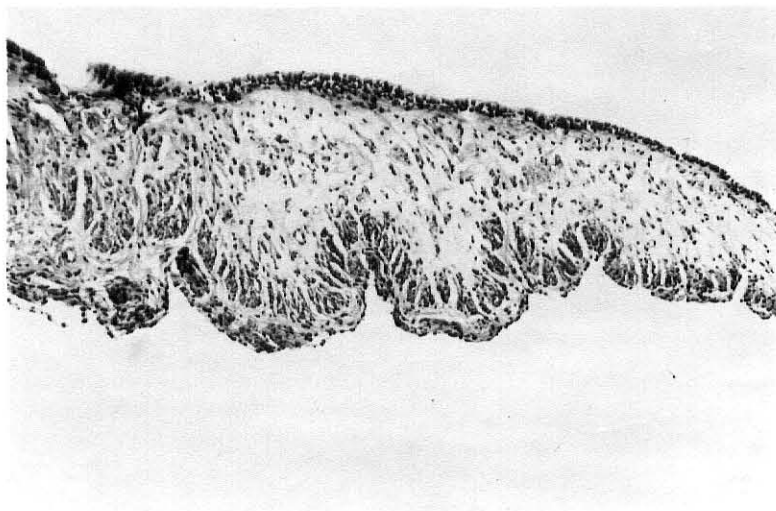


Fig. 4

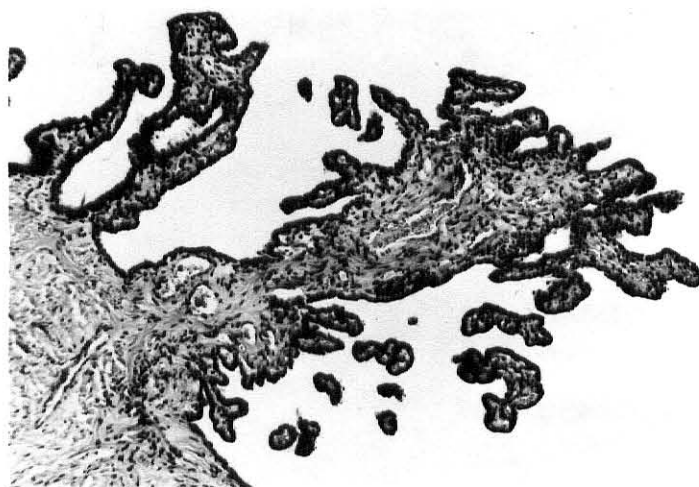


Fig. 5

PAPER 3

CONGENITAL DEFECTS OF THE SKELETAL SYSTEM IN CATTLE

INTRODUCTION

Congenital defects have always been recognized but for many years inadequately studied. Defects generally are classified by the body system primarily involved. The entire skeleton or a localized region may be involved and the defect may be single or multiple or may be associated with congenital defects of other organs or systems. This paper reports congenital skeletal defects in calves examined at Kansas State University over a 22 year period.

REVIEW OF LITERATURE

Many different types of systemic, skeletal, congenital diseases have been studied in man (49), but in cattle few have been described and still fewer have been well studied (39). In cattle chondrodystrophy, osteopetrosis, crooked calf disease and acroteriasis congenita have been described (39). Various types of dwarfism such as short-headed, long-headed, and Telemark were described and were considered to result from homozygosity of simple autosomal recessive genes (15). In addition, the Dexter, compest and compact mutants, are generally considered to be dominants, and part of a complex of conditions from more than one locus. They appear to be related to the simple autosomal recessive types (15-17).

Osteopetrosis in black and red Aberdeen Angus calves is characterized by small size and birth weight, brachygnathia

inferior with impaction of the lower molar teeth, misshapen coronoid and condyloid processes, open fontanelle, thickened cranial bones, agenesis or hypoplasia of major foramina of the skull, and lack of bone marrow cavities due to persistence of the primary spongiosa (30, 33). Crooked calf disease was shown to be caused by ingestion of lupines (Lupinus sericeus and Lupinus caudatus) (51). A similar skeletal deformity of arthrogryposis, kyphosis, torticollis, scoliosis, and cleft palate, was due to homozygosity of recessive genes (52, 53). Acroteriasis congenita, a simple recessive defect, has been reported in Europe and consisted of low birth weight, amputation of all four legs, defects of the facial skeleton, cleft palate, brachygnathia inferior, microtia, and hydrocephalus (6, 48).

Single defects of the skeletal system were conveniently classified according to body region affected (39). A number of isolated case reports have been described (1, 7, 9, 23, 43, 45, 56, 58) but studies of overall incidence and etiology are missing (10, 18, 44, 50, 57). Palatoschisis occurred as an isolated defect or may be associated with other defects such as arthrogryposis (32). Cheilognathoschisis reported in Shorthorn cattle was inherited as a simple autosomal recessive trait (55).

Several congenital defects of the jaws have been described such as compylognathia, the lateral deviation of the face (42). Brachygnathia inferior (reduction of the length of the mandible) (14), has also been reported to be caused by chromosomal aberration (19). Inferior brachygnathia was also a feature of

systemic congenital osteopetrosis (33). Agnathia or aplasia of the mandible is rarely observed in cattle (5, 8, 46). Craniofacial dysplasia in the French Limousine breed involved deficient ossification of the frontal sutures, convex profile of the nose, inferior brachygnathia, bilateral exophthalmus, scoliosis of the upper jaw, macroglossia, and associated defects of omasum and heart (3).

"Short spine lethal" is a rare defect of the axial skeleton, characterized by reduction and fusion of ribs (36). Likewise, perosomus elumbis, the agenesis of the spinal column caudal to the thoracic area, is a rare defect (39). Other reported defects of the spinal column include kyphosis (dorsal deviation), lordosis (ventral deviation), scoliosis (lateral deviation), and their combinations. These skeletal defects are commonly associated with arthrogryphotic deformities (32, 39). Spina bifida associated with posterios bimelic arthrogryposis of the hind legs has been reported in German breeds of cattle and once in an Angus calf in the United States (41, 39). Agenesis (anury) and partial agenesis (brachyury) of the caudal part of the spinal column are common defects of unknown cause in cattle and often associated with congenital defects of eye and heart (20, 39, 47). Wrytail has been described in cattle as a simple autosomal recessive trait (2).

Congenital defects of the leg include duplication of whole limbs. Polymelia has been reported rarely (26, 37, 38). Adequate studies of osteologic embryonic duplications are

rare (34, 35). Agenesis of extremities is referred to as amelia; abrachia and apodia refer to absence of front and rear legs, respectively (12, 13). Calves with abrachia had dysplasia of the spinal cord segment corresponding to leg defect (13). Hypoplasia of the appendicular skeleton is referred to as micromelia, whereas peromelia is the failure of the distal appendicular parts to develop; phocomelia refers to absence of the proximal appendicular parts with distal parts developed (11).

Other defects described were tibial hemimelia, a recessive lethal (59), reduced phalanges, also a lethal recessive (22), ectrodactyly, partial or complete absence of phalanges (27), and adactyly, a recessive lethal in Shorthorn calves (31). Polydactyly, the development of additional digits, has been infrequently described (25, 38). In contrast, syndactyly is a common genetic defect in Holstein-Friesian cattle in the United States (28). Syndactyly has also been described in an Angus calf in the United States and exotic breeds in other countries (24, 29, 39). During dissection of 139 calves, seven osteologic congenital deviations were identified; these included deviations in number of ribs and absence of fovea capitis femoris (54).

MATERIALS AND METHODS

All data reported here was taken from records of a continuing study of nature, cause, and effect of bovine

congenital defects in Kansas. The methods of study have previously been outlined (20). All cases had been examined clinically and 36 were examined pathologically and histopathologically.

RESULTS

Out of a total of 1275 congenital defects, 476 (37.3%) were classified as defects of the skeletal system.

Three congenital systemic bone diseases were encountered; chondrodystrophy, osteopetrosis and persistence of secondary spongiosa.

Dwarfism affected both sexes and occurred most frequently in Herefords and Angus, but six other breeds were also affected (Figures 1-3). Associated defects were rare; one Hereford dwarf had polydactyly, and artresia ani was observed twice in calves of mixed breeding.

Osteopetrosis was observed in 32 Angus calves (Figures 4-8). These were all aborted and were characterized grossly by low birth weight, small size, brachygnathia inferior with impaction of molar teeth and lack of bone marrow cavities. Histologic examination of bones revealed persistence of the primary spongiosa (Figures 7 and 8).

Persistence of secondary spongiosa was diagnosed in three Hereford calves from two herds. These calves revealed grossly visible islands of solid bone in the medullary cavities of the long bones and two had internal hydrocephalus. Micro-

scopically there was persistence of secondary spongiosa throughout the epiphyses and diaphyses of the long bones.

Three hundred and eighty-one calves had localized or regional skeletal defects. The facial bones or mandible were affected in 95 calves (Table 1). Forty-six calves had palatoschisis and arthrogryposis also. Agnathia occurred as a single isolated defect in two Angus and three Holstein calves. Three Brown Swiss calves had agnathia and arthrogryposis. Brachygnathia inferior was compatible with life in 19 calves of beef and dairy breeds, and in one Jersey calf arthrogryposis was associated with brachygnathia. Atlanto-occipital fusion was encountered once and has been described previously (40). Torticollis was seen either as the only defect observed or combined with arthrogryposis. Short spine lethal was encountered in one Angus and two Holstein calves. Various scoliotic and kyphotic deformities and their combined defects were observed either isolated or associated with arthrogryposis. Wry tail and anury were common defects.

Defects of the appendicular skeleton were rare with the exception of syndactyly in Holstein calves. Defects of the joint included seven cases of hip dysplasia, five in Herefords, one in an Angus, and one in a Charolais bull (Figures 9 and 10).

DISCUSSION

In a survey of 1275 congenital defects, 476 were classified as defects of the skeletal system. Three systemic

defects were encountered: dwarfism, osteopetrosis and persistence of secondary spongiosa.

Axial skeletal defects and palatoschisis (Table 1) are most frequently associated with other defects, notably arthrogryposis. The cases described were single defects and could not be attributed to heredity as the numbers were small and many sires involved. Worthy of note is the relatively large number of spina bifida as there was only one previously described in the U. S. Of particular interest was anury, previously considered a rare defect (20). In the present study, it proved the most common defect and was frequently associated with ocular, uro-genital, gastrointestinal, lumbosacral, cardiovascular, central nervous and facial defects. Some of these observations have previously been made (20).

Defects of the appendicular skeleton are rarely seen, however, syndactyly is common in Holstein-Friesians in the United States (28). Syndactyly is characterized by fusion or non-division of functional digits and affected cattle succumb to high environmental temperatures. The Aberdeen Angus calf had a morphologically different manifestation of syndactyly. Seven cases of hip dysplasia were observed (Table 1); all were males. The condition in Herefords is familial (4). This report adds the occurrence of hip dysplasia in Charolais.

SUMMARY

Bovine skeletal defects are discussed and tabulated according to body region affected. Defects are divided into five categories: systemic, facial, mandibular, axial and appendicular skeletal defects. The number of skeletal defects was 476. A review of the literature is included.

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Table 1. Summary of 476 Congenital Defects of the Skeletal System.

Defect	No. of Animals	Here- ford	Angus	Charo- lais	Short- horn	Mixed	Hol- stein	Guern- sey	Jer- sey	Ayr- shire	Brown Swiss
<u>General</u>	<u>95</u>										
Chondrodystrophy	60	22	18	1	2	6	8	2	1	-	-
Persistent pri- mary spongiosa	32	-	32	-	-	-	-	-	-	-	-
Persistent secon- dary spongiosa	3	3	-	-	-	-	-	-	-	-	-
<u>Face</u>	<u>67</u>										
Campylognathia	17	11	-	-	-	-	4	-	1	1	-
Roman Nose	2	-	-	-	-	-	2	-	-	-	-
Schistroprosopus	2	-	-	-	-	-	2	-	-	-	-
Palatoschisis and arthrogryposis	37	12	-	16	-	-	-	-	6	-	3
Palatoschisis sco- liosis internal hydrocephalus arthrogryposis	3	1	-	-	-	-	2	-	-	-	-
Palatoschisis scoliosis arthrogryposis	1	1	-	-	-	-	-	-	-	-	-
Palatoschisis kyphoscoliosis polycystic kid- neys arthrogry- posis	4	4	-	-	-	-	-	-	-	-	-

Table 1. (continued)

Defect	No. of Animals	Here- ford	Angus	Charo- lais	Short- horn	Mixed	Hol- stein	Guern- sey	Jer- sey	Ayr- shire	Brown Swiss
Palatoschisis microphthalmia arthrogryposis	1	-	-	-	-	1	-	-	-	-	-
<u>Mandible</u>	<u>28</u>										
Agnathia	5	-	2	-	-	-	3	-	-	-	-
Agnathia arthrogryposis	3	-	-	-	-	-	-	-	-	-	3
Brachygnathia inferior	19	1	2	-	1	1	5	2	-	2	5
Brachygnathia inferior arthrogryposis	1	-	-	-	-	-	-	-	1	-	-
<u>Axial Skeleton</u>	<u>232</u>										
Atlanto-occipital fusion	1	-	-	-	-	-	1	-	-	-	-
Torticollis	4	-	-	-	-	-	2	1	1	-	-
Torticollis arthrogryposis	12	2	-	2	3	-	5	-	-	-	-
Short spine lethal	3	-	1	-	-	-	2	-	-	-	-
Scoliosis	1	-	-	-	-	-	1	-	-	-	-
Kyphosis	16	-	-	-	-	-	15	1	-	-	-

Table 1. (continued)

Defect	No. of Animals	Here- ford	Angus	Charo- lais	Short- horn	Mixed	Hol- stein	Guern- sey	Jer- sey	Ayr- shire	Brown Swiss
Kyphoscoliosis	1	-	-	-	-	-	1	-	-	-	-
Scoliosis arthrogryposis	3	1	-	-	2	-	-	-	-	-	-
Kyphoscoliosis arthrogryposis	24	13	-	2	9	-	-	-	-	-	-
Perosomus elumbis arthrogryposis	2	2	-	-	-	-	-	-	-	-	-
Wrytail arthrogryposis	1	-	-	-	-	1	-	-	-	-	-
Anury arthrogryposis	1	-	-	-	1	-	-	-	-	-	-
Scoliosis microphthalmia arthrogryposis	7	-	7	-	-	-	-	-	-	-	-
Scoliosis intern- al hydrocephal- us arthrogryp- osis	1	1	-	-	-	-	-	-	-	-	-
Kyphoscoliosis brachygnathia inferior arthrogryposis	1	-	-	-	-	-	1	-	-	-	-

Table 1. (continued)

Defect	No. of Animals	Here- ford	Angus	Charo- lais	Short- horn	Mixed	Hol- stein	Guern- sey	Jer- sey	Ayr- shire	Brown Swiss
Spina bifida											
meningo-	15	4	8	-	2	-	1	-	-	-	-
myeloschisis											
arthrogryposis											
Kyphoscoliosis											
wrytail	3	1	-	-	-	-	2	-	-	-	-
arthrogryposis											
Wrytail	33	4	2	-	-	5	12	-	-	-	10
Anury	103	5	2	-	7	11	66	2	7	1	2
Appendicular Skeleton	54										
Polydactyly	6	2	-	-	-	-	3	1	-	-	-
Monobrachia	3	1	-	-	-	-	-	2	-	-	-
Adactyly	2	1	-	-	-	-	-	1	-	-	-
Ectrodactyly	2	1	1	-	-	-	-	-	-	-	-
arthrogryposis											
Syndactyly	34	-	1	-	-	-	33	-	-	-	-
Hip dysplasia	7	5	1	1	-	-	-	-	-	-	-

476 single or multiple skeletal defects are tabulated.

355 cases were primary skeletal defects.

121 cases were also arthrogrypotic and considered primary muscular defects, one chondrodystrophic Charolais was also arthrogrypotic.

Fig. 1. The lumbar vertebrae from chondrodystrophic dwarf calf showing compression of the ventral border line of the vertebral bodies (arrow).

Fig. 2. A chondro dystrophic dwarf (a) compared to a normal Hereford calf (b).

Fig. 3. Hereford calf affected with Kyphosis (arrow).

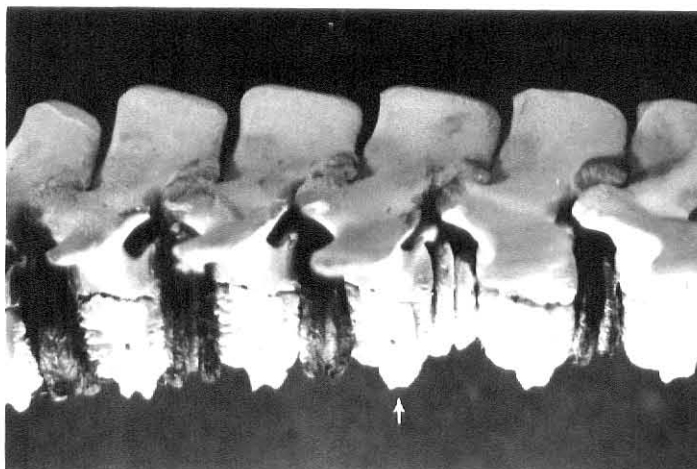


Fig. 1

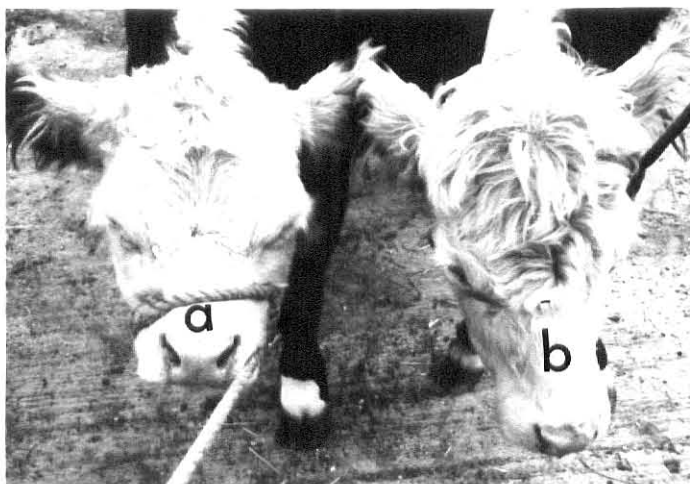


Fig. 2



Fig. 3

Fig. 4. Longitudinal section through the head of an osteopetrotic calf. Note short lower jaw (a); thickened parietal bone (b) and persistent primary spongiosa of occipital (c); and sphenoid bones (d).

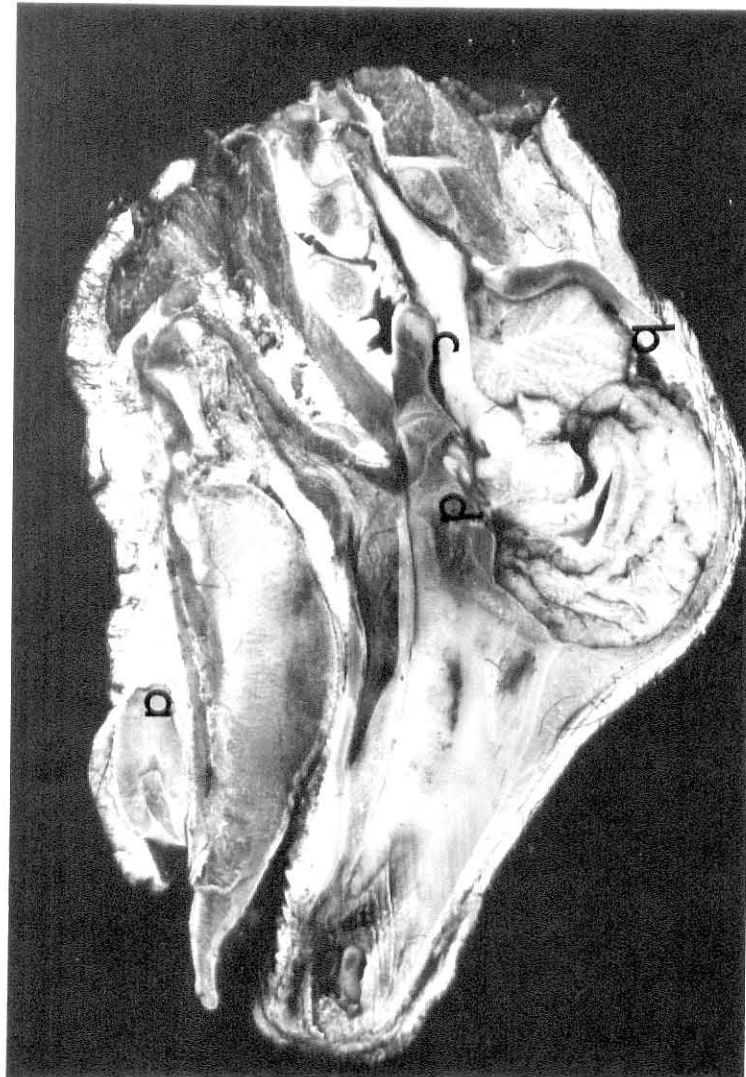


Fig. 4

Fig. 5. Longitudinal bisection of lumbar vertebrae of an osteopetrotic calf showing U shaped areas of persistent primary spongiosa in the vertebral body (b) ventral to the spinal cord (a).

Fig. 6. Humerus from an osteopetrotic calf showing solid areas of primary spongiosa (arrow).

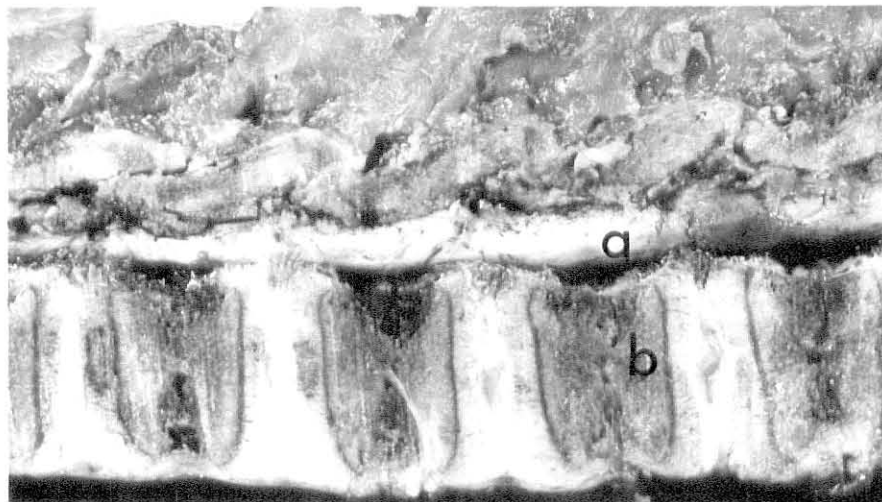


Fig. 5

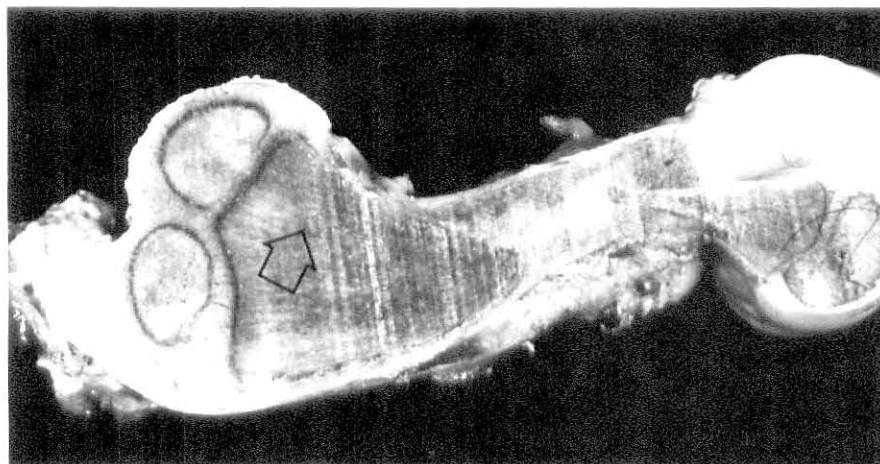


Fig. 6

Fig. 7. Photomicrograph of cross section of metaphyseal area in the humerus of a calf affected with osteopetrosis. Note persistence of primary spongiosa and lack of development of bone marrow.

Fig. 8. Photomicrograph of a cross section of tibia at mid shaft. Note persistence of primary spongiosa (a). (H and E 120X)

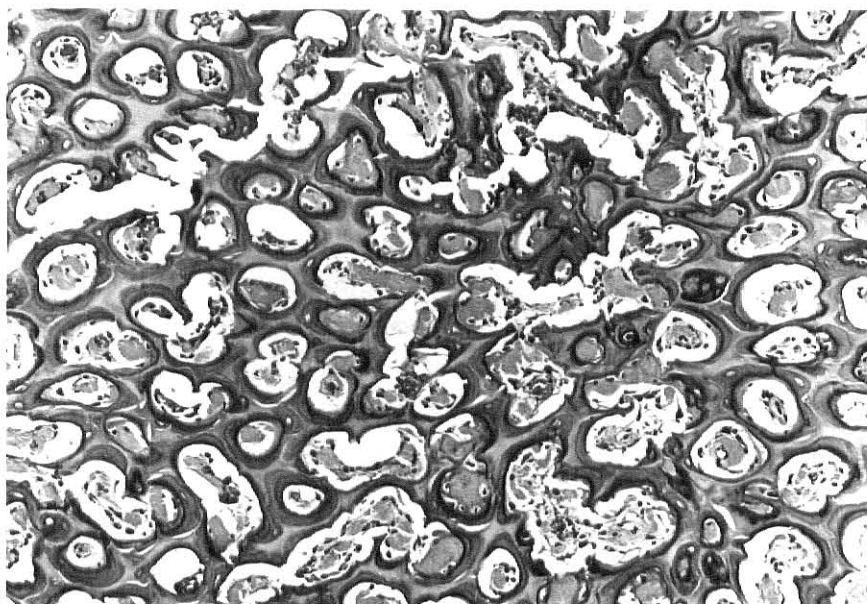


Fig. 7

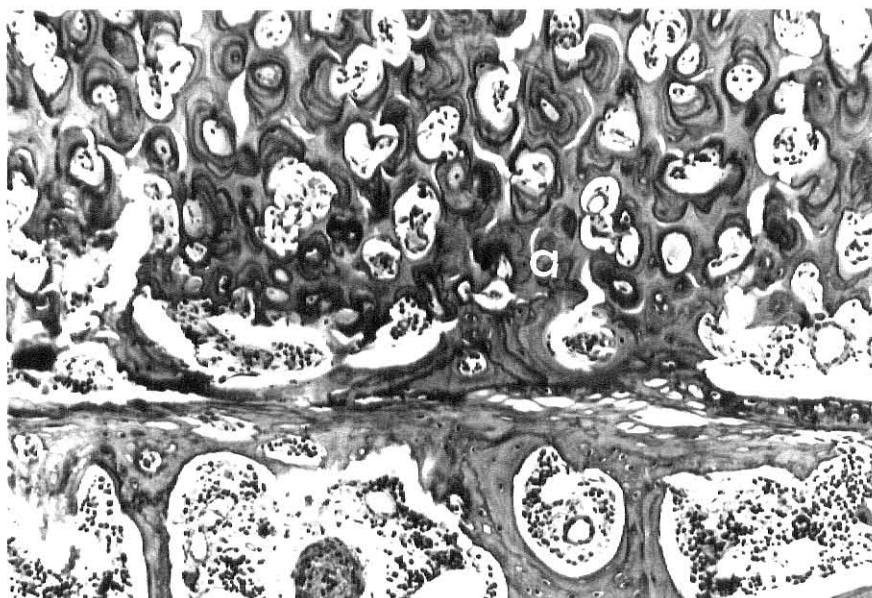


Fig. 8

Fig. 9. Head of a femur from a Charolais calf with hip dysplasia. Note the erosion of articular cartilage (arrow). .

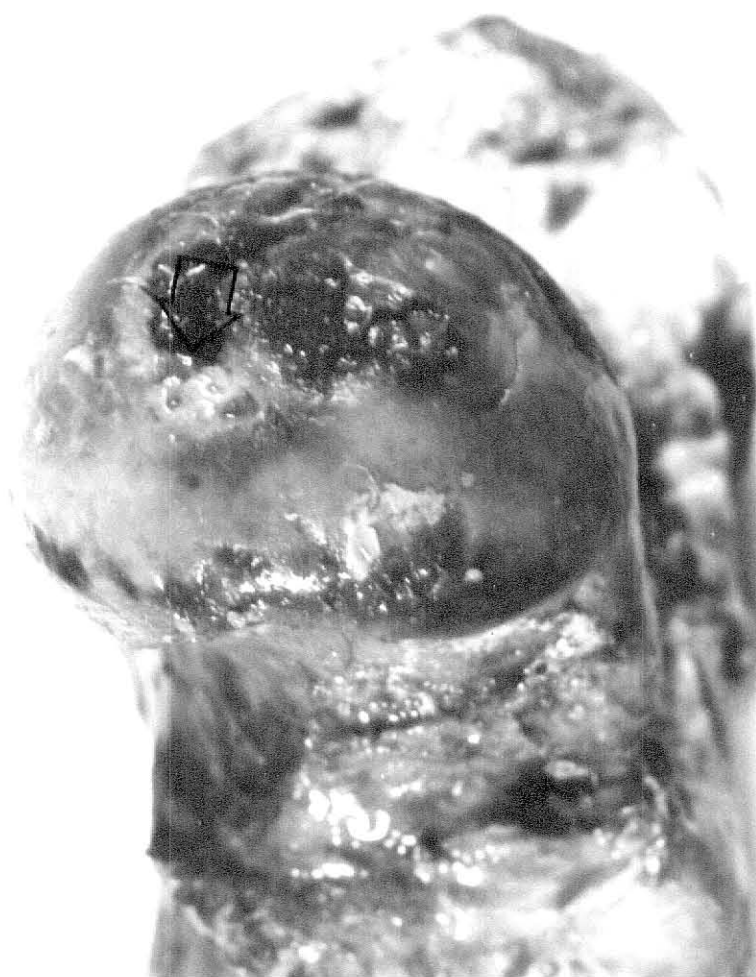


Fig. 9

Fig. 10. The acetabulum (arrow) of the Charolais bull with hip dysplasia is shallow and the articular cartilage (a) is eroded and the joint capsule is thickened (b).

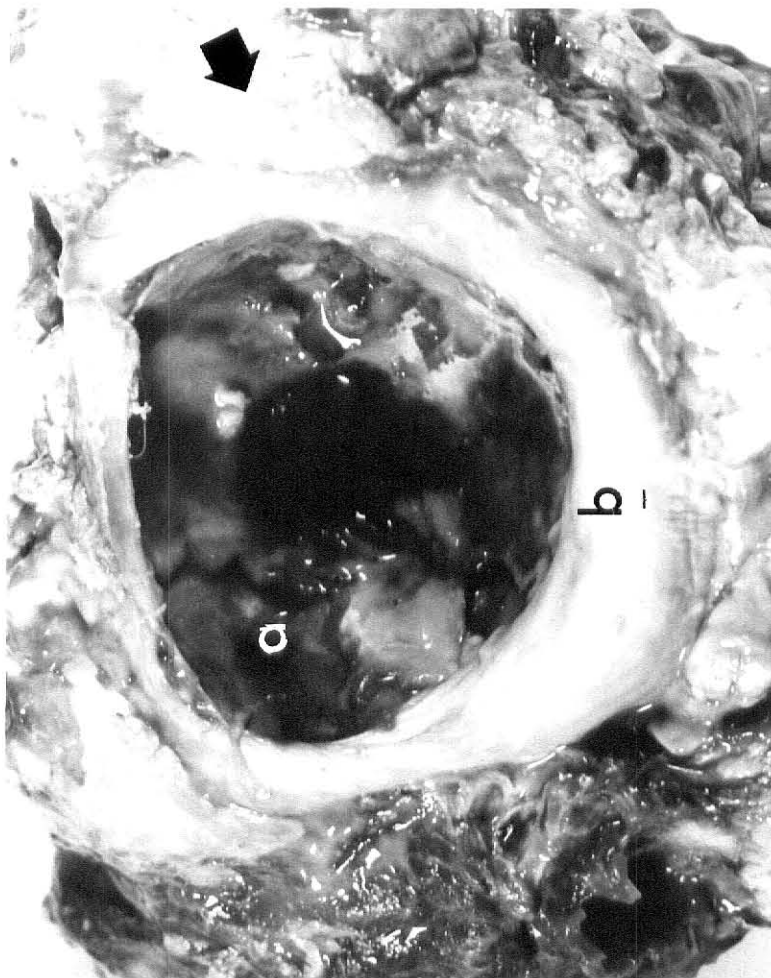


Fig. 10

PAPER 4

TAILESSNESS IN CATTLE

INTRODUCTION

During embryogenesis of calves, there is ample opportunity for occurrence of developmental errors. In particular, the posterior aspects of the spinal column may be affected with congenital defects including agenesis in its various types. This study reports the lack of tail development in calves encountered during an investigation into nature and frequency of congenital defects in cattle. The results of a breeding trial are included.

REVIEW OF LITERATURE

Coccygeal, sacrococcygeal and more complicated types of posterior spinal column agenesis and associated defects have been described in two studies of calves (1, 4). Reference was made in one paper to anophthalmia and microphthalmia stressing the association of congenital defects in the caudal portions of the spinal column with ocular defects (2). Other papers on the subject are largely case reports (3, 5). The cause of caudal appendage agenesis is unknown (1, 4).

MATERIALS AND METHODS

This material is from data collected in a continuing study of the nature, cause and effect of congenital defects in progress at Kansas State University, portions of which have

been reported previously (1, 2). A breeding experiment was conducted using one bull and two cows, each with agenesis of the caudal appendage.

RESULTS

Agenesis of the caudal part of the spinal column involved 104 calves representing all popular beef and dairy breeds in Kansas (Hereford, 5; Angus, 2; Shorthorn, 8; Mixed, 11; Holstein, 66; Guernsey, 2; Jersey, 7; Ayrshire, 1; and Brown Swiss, 2).

Holsteins were most frequently affected, 66 cases, while a single Ayrshire was reported. Ninety-five herds were involved, demonstrating that the defect was of sporadic occurrence. Figure 1 depicts osteologic changes of a typical case. Twin males, both affected, were twice seen in Holsteins; on one occasion an affected calf was born co-twin to a normal calf. There were more affected females, 49, than males, 27; however, the sex of 28 was not determined. Associated defects were seen in 35 calves; 23 of these were single defects; artresia ani being the most frequent (Table 1). Ten of the twelve calves with multiple associated defects exhibited different syndromes. Two calves were blind and hypospadiac (Table 2). Ten of these twelve were Holstein calves. Figure 2 illustrates the findings of the breeding trial.

DISCUSSION

The paucity of reports on tailless cattle indicates that this sporadic defect has been infrequently investigated. The 104 cases reported here is the largest number in the literature. This defect appears unlikely to occur more frequently than one per 3,000 births (1). A variety of concurrent defects were observed, but 70 were not reported to have an associated defect. Atresia ani, nine cases, was the most common associated defect. Ocular defects were seen in 14 cases with anophthalmia accounting for nine of these. Defective male reproductive organs in seven cases, female six and renal defects, three were seen. As their developmental relation to anury is not obvious, they may have been etiologically unrelated.

The etiology is unknown. In the breeding trial, true did not breed true, thus implying that a genetic basis was lacking in this investigation.

SUMMARY

The Holstein breed was found to be most commonly affected with anury in a study of 104 cases. Seven other breeds, in addition to ten cattle of mixed breed, were represented. Associated defects occurred in 34 cases; atresia ani, ocular defects, urogenital abnormalities, and absent vertebrae were most common. The etiology was not determined. An anurous bull bred to two similarly affected cows produced normal calves.

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Table 1. Summary of 23 Anury Cases with One Single Associated Defect.

Defect	No. of Calves	Holstein	Hereford	Jersey	Guernsey	Brown Swiss	Mixed Breed
Atresia ani	4	4	-	-	-	-	-
Atresia ani and vagina	2	2	-	-	-	-	-
Dorsal vulval displacement	1	1	-	-	-	-	-
Wry face	1	1	-	-	-	-	-
Anophthalmia	6	-	1	3	1	-	1
Microphthalmia	1	-	-	-	-	-	1
Heterochromia iridis	1	1	-	-	-	-	-
Blind	1	1	-	-	-	-	-
Posterior paralysis	2	2	-	-	-	-	-
Arthrogryposis	1	1	-	-	-	-	-
Brachygnathia inferior	1	-	-	-	-	1	-
Hypospadia	2	2	-	-	-	-	-
TOTAL	23	15	1	3	1	1	2

Table 2. Summary of 12 Anury Cases with Multiple Associated Defects.

Defect	No. of Calves	Holstein	Shorthorn	Jersey
Hypospadia and anophthalmia	1	1	-	-
Hypospadia and blind	2	2	-	-
Hypospadia, arthrogryposis, perosomus elumbis	1	1	-	-
Renal aplasia. High ventricular septal defect and trans-position of great vessels	1	1	-	-
Renal aplasia unilateral, atresia ani, cryptorchid, absence of sacrum	1	1	-	-
Atresia ani, recto-vaginal fistula absence of lumbar vertebra 6	1	1	-	-
Atresia ani, recto-vaginal fistula, polycystic kidneys	1	1	-	-
Dorsal vulvar displacement and posterior paralysis	1	1	-	-
Anophthalmia and brachygnathia inferior	2	1	-	1
Cataract of left eye and hypoplastic optic nerve	1	-	1	-
TOTAL	12	10	1	1

Fig. 1. Macerated specimen from a typical tailless bovine. Note the absence of coccygeal vertebrae and the presence of hemi-vertebrae in lumbar sacral area (arrow).

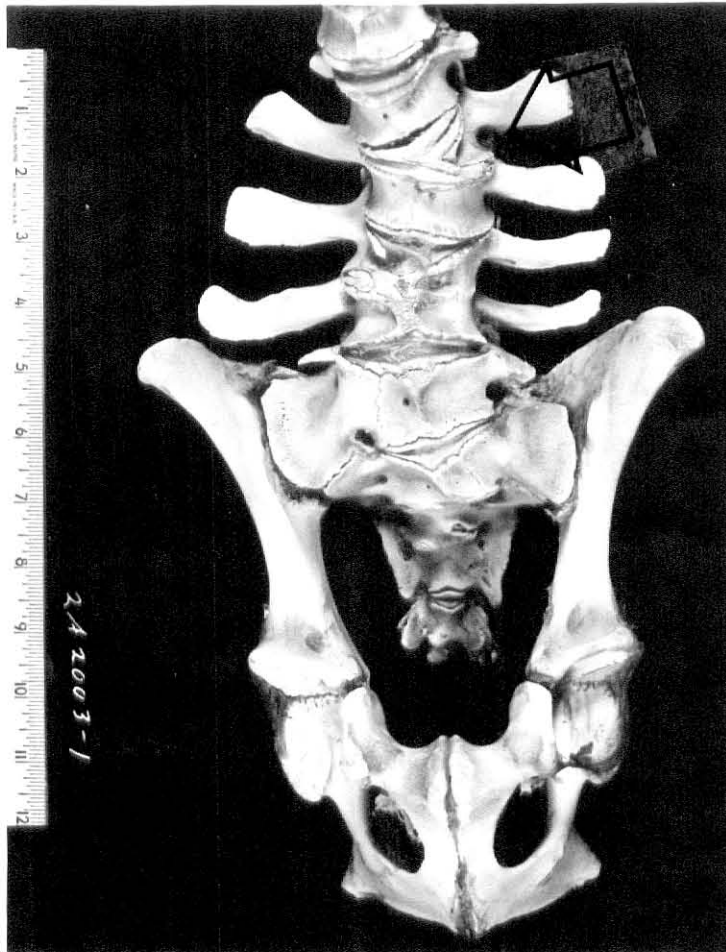


Fig. 1

Fig. 2. Pedigree to show results of breeding one tailless bull with two tailless cows (shaded symbols). The progeny in two generations were normal (clear symbols).

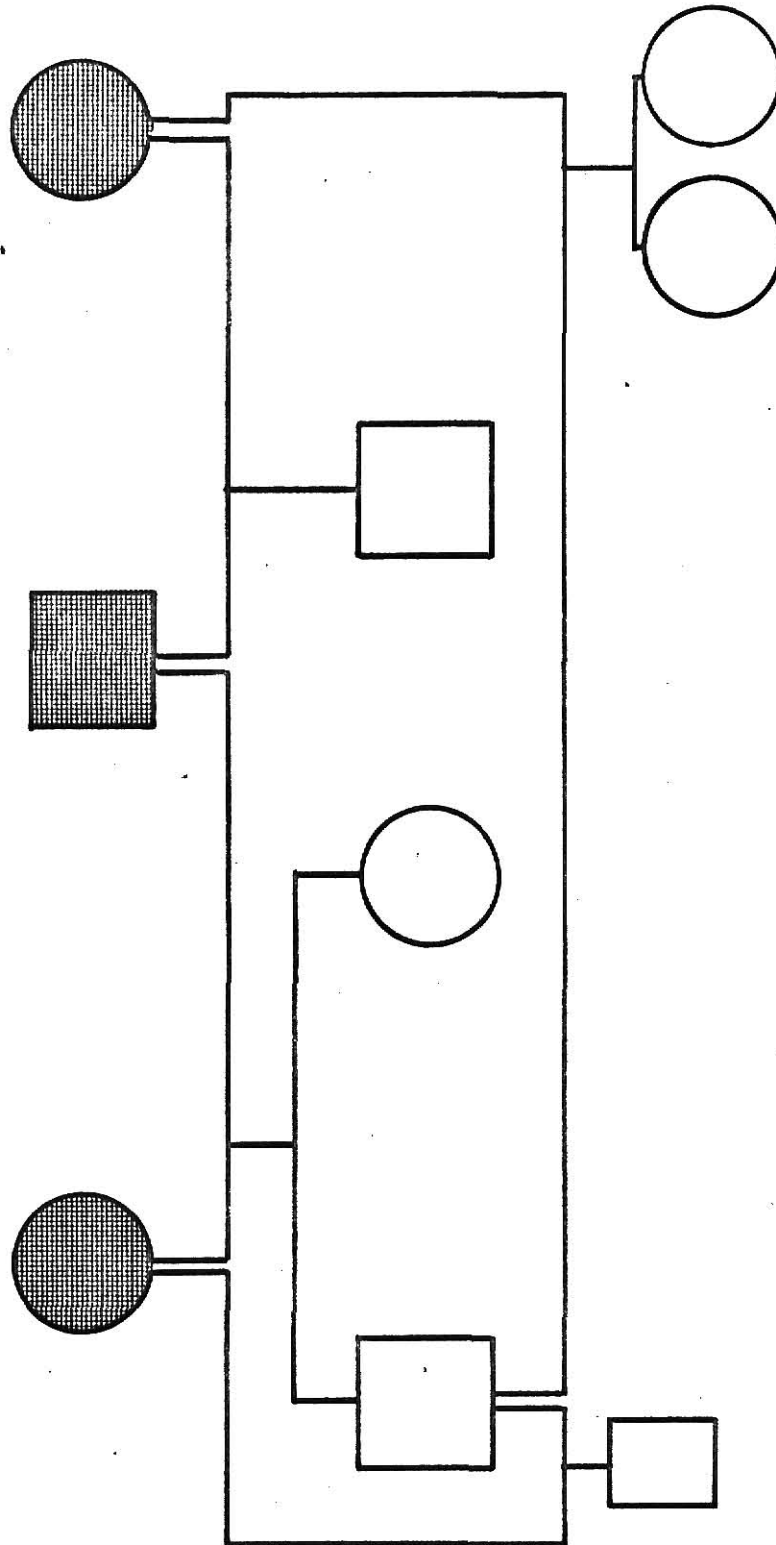


Fig. 2

PAPER 5

ARTHROGRYPOSIS AND ASSOCIATED DEFECTS IN CALVES

INTRODUCTION

Arthrogryposis is characterized by congenital contracture of the joints of one or more extremities and has been described frequently in calves. However, description of associated defects and lesions are sparse. This paper reports arthrogrypotic calves examined in Kansas from 1950 to 1972.

REVIEW OF LITERATURE

This defect has been described in veterinary and human pathology under terms such as arthrogryposis, neuromyodysplasia congenita, myodystrophia fetalis, amyoplasia and crooked calf disease (1, 5, 8, 11, 25, 36, 37). Arthrogryposis has frequently been described in children (25, 37), various breeds of cattle (13), in foals (26), lambs (17), piglets (3), and chickens (22).

Arthrogryposis in calves is worldwide in distribution and has been reported in Scandinavian Red cattle (13), Swiss Black Spotted (40), German Black Pied (5, 36), German Red Pied (5), Simmental (4), Shorthorn (13), Hereford (33, 34), Jersey (35), Friesian (18, 28, 30), Ayrshire (13), Guernsey (13), and Charolais (8, 9, 11, 12).

Despite the numerous general descriptions, there were few detailed reports of gross, microscopic, and associated changes of arthrogryposis in calves. Arthrogryposis may affect front or hind legs (bimelic) or all four legs (tetramelic).

Absence of ventral horn cells of the spinal grey matter and hydranencephaly were reported for calves affected with arthrogryposis in Australia (41). Muscle sections of these calves revealed neurogenic atrophy (41). Spina bifida was the central nervous system lesion of posterior bimelic arthrogryposis in a series of German (5) and Scandinavian calves (13) and one Angus calf in the United States (16). Two other calves described in Germany with posterior bimelic arthrogryposis had segmental aplasia of the lumbar spinal cord (23). Charolais calves affected with tetramelic arthrogryposis had hydromyelia, syringomyelia and degenerative changes of the spinal cord. Muscle samples of these calves revealed neurogenic atrophy (11, 12). A recent study of the hydranencephaly-arthrogryposis syndrome in Israel confirmed dysraphic changes of the spinal cord and neurogenic atrophy of muscle (20).

Arthrogryposis in calves was the only observed defect in certain studies, but it has also been observed together with other changes thus forming a congenital syndrome. Deformities of the axial skeleton such as torticollis, scoliosis and kyphoscoliosis have been described by several authors (5, 7, 11, 14). Palatoschisis occurred together with arthrogryposis in German Yellow Pied (4), German Black Pied (36), Hereford (33), Jersey (35), and Charolais (14). Dyschondroplasia was associated with arthrogryposis of Swiss Black Spotted Cattle (40). Short-horn calves with arthrogryposis had insufficiently calcified

teeth. Generalized hydropic amnion was also observed in calves affected with arthrogryposis (18).

Many earlier reports on bovine arthrogryposis proposed homozygosity of a simple recessive gene as the cause of arthrogryposis in cattle (28, 29, 32, 34, 35). Arthrogryposis has occurred after the maternal ingestion of lupines such as Lupinus sericeus and Lupinus caudatus between the 40th and 70th day of pregnancy (32). Virus infections have also been considered as possible causes in the discussion of etiology of arthrogryposis in cattle (15, 42).

MATERIALS AND METHODS

Malformed calves were received as part of a long-term study of nature and cause of congenital defects in cattle; methods have been outlined previously (6, 10). All arthrogryptic calves were examined clinically and 43 underwent necropsy examination. Associated defects and clinical and pathological findings were also recorded. Sections of brain, spinal cord and muscles were fixed in ten percent buffered neutral formalin, embedded in paraffin, cut at 6 u, and stained with hematoxylin and eosin (H and E).

RESULTS

One hundred and eighty-eight calves of both sexes affected with arthrogryposis were observed in common beef and dairy breeds in Kansas (Table 1). Tetramelic arthrogryposis

involved 131 calves, compared to 57 calves with either front or hind legs involved (Table 1). Eighty-five calves had one associated defect; 37 calves affected with arthrogryposis had two or more congenital defects of other body systems (Tables 2 and 3).

Eighty-three Hereford calves were affected with arthrogryposis, eight had arthrogryposis of the front legs while five had involvement of the hind legs only (Table 1). The majority of the cases, 70 calves, had tetramelic arthrogryposis. Single or multiple associated congenital defects were also observed in Hereford calves with tetramelic arthrogryposis. Hereford calves with bimelic arthrogryposis of front or hind legs had no associated defects.

Hereford calves with tetramelic arthrogryposis without associated congenital defects had a typical clinical appearance (Figures 1-3). Calves were unable to rise after birth and were in sternal recumbency. The joint contractures were bilaterally symmetrical and little passive mobility was possible. The scapulo-humeral joints, humero-radial, radio-carpal, carpal and metacarpophalangeal joints were flexed. In addition, the whole leg was rotated and the toes would touch in the midline (Figure 1). The joints of the hind leg were also fixed in flexion (Figure 1). Necropsy examination of four such affected calves revealed distorted and hypoplastic joint surfaces involving all the major joints of the extremities (Figures 2 and 3). Other internal organs were normal. Central nervous system and muscular tissue were normal upon histological examination.

Twelve Hereford calves affected had tetramelic arthrogryposis and one or multiple associated defects, such as palatoschisis (Table 2) and one calf affected with palatoschisis and scoliosis of the lumbar-thoracic area and four Hereford calves with palatoschisis, kyphoscoliosis of the thoraco-lumbar area and cystic kidneys (Figures 4-6).

The remaining calves with one or more associated defects had in 24 cases abnormalities of the axial skeleton and two cases involving the distal extremities with ectrodactyly (Tables 2 and 3). One of the two cases of perosomus elumbis underwent necropsy examination and the description was as follows.

A male Hereford calf weighing 18 kg was delivered dead by cesarean section from a purebred Hereford cow, the mother of five normal calves previously. The calf was the only defective one in a herd of 120 Hereford cows.

Externally its head, neck, and left front leg were normal. The right front leg lacked a scapula and humerus but had three digits (Figure 7). The hind limbs were fixed in flexion, appeared sickle-shaped with toes pointing cranially. The vertebral column was absent caudal to the last thoracic vertebra. Pelvic bones were present but hypoplastic and connected to the anterior half of the body by soft tissue only. The tail was missing. Additional defects were absence of ten ribs on the right side. The spinal cord terminated at the last thoracic vertebra. The muscles of the hind legs were atrophic

and pale. Histologic examination revealed empty sacrolemmal sheaths and fatty replacement. Brain and internal organs were normal.

Fifteen Angus calves were examined which had in eight cases bimelic arthrogryposis involving the hind legs and were also affected with spina bifida and meningomyeloschisis. Seven calves had tetramelic arthrogryposis combined with scoliosis of the thoraco-lumbar spinal area and moderate to severe bilateral microphthalmia.

The eight Angus calves affected with spina bifida underwent necropsy examination. The head, neck, thorax, and internal organs of these calves were normal. The hind legs revealed contracture of all joints in flexion, the muscles of the hind legs were reduced in bulk and pale. The lumbar area of the spinal column revealed a defect in continuity of skin over the dorsal arches of lumbar and sacral spines ranging from 4 to 6 cm in diameter. The meninges protruded through this skeletal defect (Figures 8-10). The lumbar spinal cord was reduced to half its normal diameter.

Histologic examination of spinal cords revealed in all cases an irregularly arranged gray matter and a reduced and degenerated white matter. In addition, the central canal was abnormal being only partially clad by ependyma and being abnormal in shape and location (Figure 11). Some muscle samples of the hind leg revealed only marked differences in fiber diameter. Most muscle samples, however, had widespread

replacement by lipomatous tissue and very few muscle fibers which were undergoing atrophy (Figures 12 and 13). Some smaller caliber blood vessels were surrounded by focal areas of histiocytes (Figure 13).

Sixteen Charolais calves were submitted for necropsy examination. Fifteen of these have been described previously (14). One neonatal Charolais has been encountered since and is described here because it had upon necropsy examination, features not present in the other calves. The male Charolais calf was stillborn (Figure 4). The fetus was disproportionately dwarfed and resembled chondrodystrophic dwarfs (Figure 15). The head measured 16 cm anteroposteriorly, 18 cm laterally, and palatoschisis was marked. All cranial bones were thicker than normal, thereby reducing the size of the cranial vault, as a consequence of which the brain was flattened dorsoventrally. The thoracic cavity was reduced in size and the normal sized aorta was kinked to accommodate itself in the smaller space. All limb joints were contracted in flexion and bones were reduced in size comprising proximal and distal articular cartilages and a short communicating bridge of osseous tissue.

Radiographic examination disclosed the following osteologic changes. The maxilla was greatly shortened and all of the facial bones compressed. The mandible was of normal size and shape. The cranium was somewhat enlarged. The cervical vertebrae as viewed on these radiographs were abnormal and appeared compressed. The bodies of the thoracic and lumbar

vertebrae were greatly compressed and did not have the normal epiphyses. The bones of both the fore and hind legs were so abnormal that it was almost impossible to identify the bones (Figure 15). The scapula was normal. The humerus was completely abnormal as were the radius and ulna. The carpal bones were normal; however, the metacarpals and phalanges were quite abnormal except for the 3rd phalanges. In the rear leg, the femur, tibia, fibula, tarsal bones, and 1st and 2nd phalanges were abnormal and were impossible to recognize. The 3rd phalanx was abnormal but was at least recognizable.

Only six Shorthorn calves were observed with arthrogryposis, four of which had associated axial defects such as torticollis and kyphoscoliosis and two were affected with spina bifida. Three mixed beef calves with arthrogryposis were encountered.

All common modern dairy breeds were affected with arthrogryposis. There were 30 Holstein calves with arthrogryptic deformities of the legs (Figures 6-17). Fifteen of these had associated congenital defects of the axial skeleton; an additional six calves had more than one associated defect (Table 3). Guernsey, Jersey, Ayrshire and Brown Swiss calves were similarly involved (Table 1). There were five cases in Guernsey calves, two of which had associated defects. Eleven Jersey calves were encountered, six of which had palatoschisis besides arthrogryposis. Ten out of 11 Ayrshire calves had tetramelic arthrogryposis but none of these had associated structural defects.

A total of eight Brown Swiss calves had arthrogryposis, three had palatoschisis; three others were affected with agnathia.

DISCUSSION

In all domestic species, congenital defects most commonly affect the musculo-skeletal system. In cattle, one of the most frequently reported defects of the musculo-skeletal system is arthrogryposis, either as a single defect or as a syndrome combined with other congenital defects (4, 13, 15). The term arthrogryposis, first used by Stern (1923), is defined as a syndrome of permanent joint contracture present at birth (37).

Arthrogryposis neither implies a specific pathologic entity nor a specific etiologic cause. Arthrogryposis may be myogenic or neurogenic (1). Most congenital contractures described in numerous reports in veterinary literature, are dissimilar in pathologic changes or etiology. Arthrogryposis combined with cleft palate in Charolais calves was attributed to homozygosity of a single autosomal recessive gene (8, 9). The same cause was postulated in Jersey calves and by various authors reporting on this defect in German breeds of cattle (29, 30, 36).

A skeletal deformity in Hereford calves associated with cleft palate was considered to be hereditary (33). On the other hand, crooked-calf syndrome, also associated with cleft palate, may be reproduced by feeding lupine to the dam during the critical period of development (32). Skeletal abnormalities

combined with harelip, low birth weight, and anomalies of the reproductive system have also been reported (39). Congenital contractures combined with various deformities of different body systems have been described in the Italian Romagnol breed and was found to be due to a chromosomal abnormality in one abnormal Romagnol bull (27). Spina bifida has been identified as the neurologic defect in bilateral arthrogryposis of the hind legs of calves in Scandinavian and German breeds of cattle (5, 19).

The peripheral nervous system has also been examined in cases of posterior arthrogryposis (31). Another report listed segmental aplasia of the lumbar cord as the basic neurologic defect in a calf affected with arthrogryposis involving the hind legs (23). Hydranencephaly combined with arthrogryposis has been described in several breeds of cattle (15, 20, 41, 42). From the occurrence of the arthrogryposis and hydranencephaly syndrome, it was concluded that an infective agent was involved (15). A variety of causes may result in arthrogryposis in man including hereditary factors and viral infection (38).

From this study of bovine arthrogryposis, it has been concluded that most associated defects involved the skeletal system (Tables 2 and 3). The most common skeletal defects are those of the axial skeleton and palatoschisis. Palatoschisis occurred in 46 calves out of 188 cases, and axial skeletal defects occurred in 79 calves. Other skeletal defects such as brachygnathia inferior or agnathia of the mandible were rare and only two cases of appendicular skeletal defects occurred.

Defects of other body systems were likewise rarely encountered, such as microphthalmia in eight calves, polycystic kidneys four times and internal hydrocephalus in two cases.

The cause of arthrogryposis is in doubt possibly because many syndromes exist and each distinct syndrome could be etiologically different. Present evidence suggests that in the Charolais breed a central nervous system lesion is primary defect with resultant neurogenic muscular atrophy. The Charolais syndrome of arthrogryposis with cleft palate is an entity of which the most severe expression is the stillborn dwarfed individual. Among Herefords, a similar syndrome occurs, 12 cases (Table 2). However, this condition differs from that of Charolais by lacking the central nervous system and muscular lesions. Another syndrome exists in Herefords in which the fore limbs are laterally rotated from the humero-radial joint, while the scapulo-humeral, humero-radial, carpal and pastern joints are all contracted in flexion. The result is a calf in sternal recumbency having both toes pointing medially in front of the body (Figure 1). The rear limb joints are contracted to a lesser degree. No cleft palate or microscopic lesions occurred. This type of arthrogryposis appears to result from arthrodysplasia of articular surfaces which were variably flattened and distorted. The Angus cases present two syndromes which appear to be confined to this breed.

Other syndromes observed were sporadic and numbers were too small to draw any conclusions. It seems reasonable to

assume that some rarely seen associated defects are merely incidental findings and probably not etiologically related to the arthrogryposis.

Perosomus elumbis is characterized by a lack of lumbar, sacral and coccygeal vertebrae. Perosomus elumbis in cattle is considered to result primarily from agenesis of the lumbo-sacral spinal cord with secondary musculo-skeletal changes due to neurogenic atrophy. Rieck classified perosomus elumbis as an extreme form of taillessness (24). Perosomus elumbis of Herefords differed from the usual bovine perosomus elumbis by right front leg defects (lack of scapula and humerus, and polydactylia) and ten ribs absent on the right side (2).

SUMMARY

One hundred and eighty-eight calves affected with arthrogryposis were observed. Tetramelic arthrogryposis was encountered in 131 calves, the front legs were affected in 33 calves, whereas the hind legs revealed arthrogryposis in 24 calves. Eighty-five calves had one additional associated defect, 37 additional calves had two or more associated congenital defects.

The most frequently encountered skeletal defect involved the axial skeleton with torticollis, kyphoscoliosis, scoliosis or spina bifida followed by defective development of the palatine shelves.

Several rare syndromes were described such as arthrogryposis combined with polycystic kidneys, spina bifida in Angus calves and perosomus elumbis in Herefords.

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Table 1. Summary of 188 Arthrogryptic Calves.

Breed	Number of Calves	Sex M.	F.	Bimelic Front	Rear	Tetra- melic	Single Associated Defect	Multiple Associated Defects
Hereford	83	41	37	8	5	70	32	12
Angus	15	7	7	-	8	7	-	15
Charolais	16	8	6	-	1	15	15	1
Shorthorn	6	4	2	2	2	2	4	2
Mixed Breed	3	1	2	2	-	1	-	1
Holstein	30	12	18	7	3	20	15	6
Guernsey	5	1	4	2	1	2	2	-
Jersey	11	3	7	9	1	1	11	-
Ayrshire	11	5	6	1	-	10	-	-
Brown Swiss	8	5	3	2	3	3	6	-
TOTAL	188	87	92	33	24	131	85	37

Table 2. Summary of 85 Calves Affected with Arthrogryposis and One Associated Defect.

Associated Defect	No. of Calves	Hereford	Charolais	Shorthorn	Holstein	Guernsey	Jersey	Brown Swiss
Palatoschisis	36	12	15	-	-	-	6	3
Brachygnathia inferior	1	-	-	-	-	1	-	-
Agnathia	3	-	-	-	-	-	-	3
Torticollis	12	2	-	2	3	-	5	-
Scoliosis	3	1	-	-	2	-	-	-
Kyphoscoliosis	24	13	-	2	9	-	-	-
Perosomus elumbis	2	2	-	-	-	-	-	-
Wrytail	1	-	-	-	-	1	-	-
Anury	1	-	-	-	1	-	-	-
Ectrodactyly	2	2	-	-	-	-	-	-
TOTAL	85	32	15	4	15	2	11	6

Table 3. Summary of 37 Calves Affected with Arthrogryposis and Multiple Defects.

Associated Defect	No. of Calves	Hereford	Angus	Charolais	Short-horn	Mixed	Holstein
Chondrodystrophy Palatoschisis	1	-	-	1	-	-	-
Palatoschisis Scoliosis Internal Hydrocephalus	3	1	-	-	-	-	2
Palatoschisis Scoliosis	1	1	-	-	-	-	-
Palatoschisis Kyphoscoliosis Polycystic Kidneys	4	4	-	-	-	-	-
Palatoschisis Microphthalmia	1	-	-	-	-	1	-
Scoliosis Microphthalmia	7	-	7	-	-	-	-
Scoliosis Internal Hydrocephalus	1	1	-	-	-	-	-
Kyphoscoliosis Brachygnathia Inferior	1	-	-	-	-	-	1
Spina bifida Meningomyeloschisis	15	4	8	-	2	-	1
Kyphoscoliosis Wrytail	3	1	-	-	-	-	2
TOTAL	37	12	15	1	2	1	6

Fig. 1. Tetramelic arthrogryposis in a Hereford calf.

Fig. 2. Distorted distal humeral head. Head from the arthrogrypotic calf in Figure 1.

Fig. 3. Distorted proximal humeral head from the arthrogrypotic calf in Figure 1.



Fig. 1

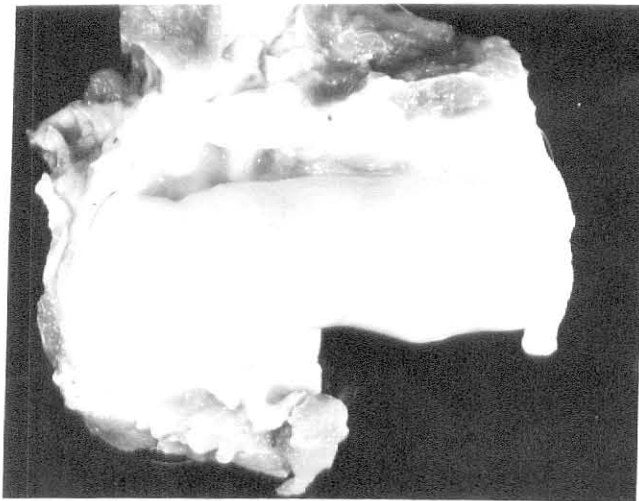


Fig. 2



Fig. 3

Fig. 4. Palatoschisis (arrow) as an associated defect with arthrogryposis.

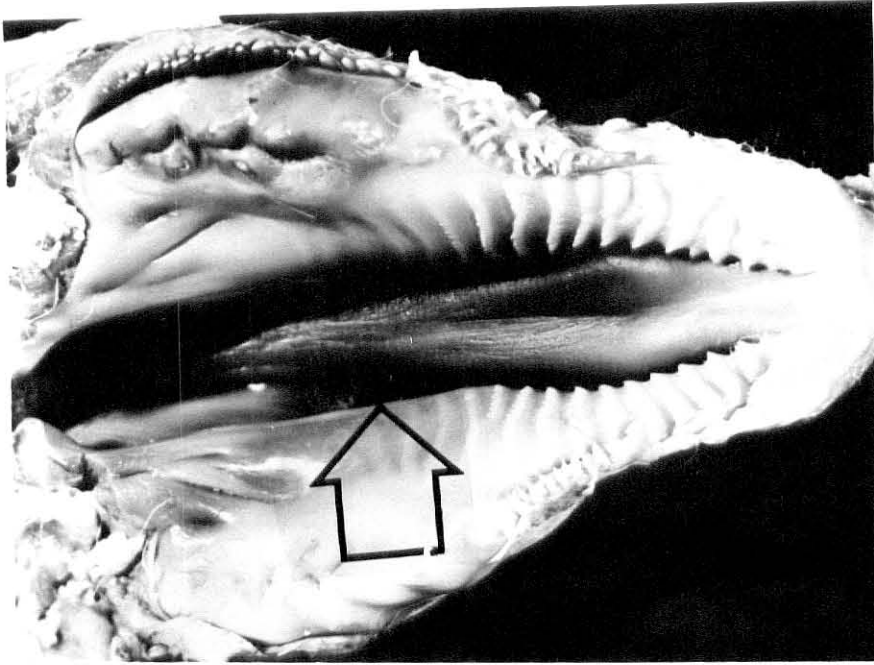


Fig. 4

Fig. 5. Kyphoscoliosis of the thoraco-lumbar area associated with arthrogryposis in a Hereford calf.



Fig. 5

Fig. 6. Polycystic kidneys as an associated defect in an arthrogrypotic Hereford calf.

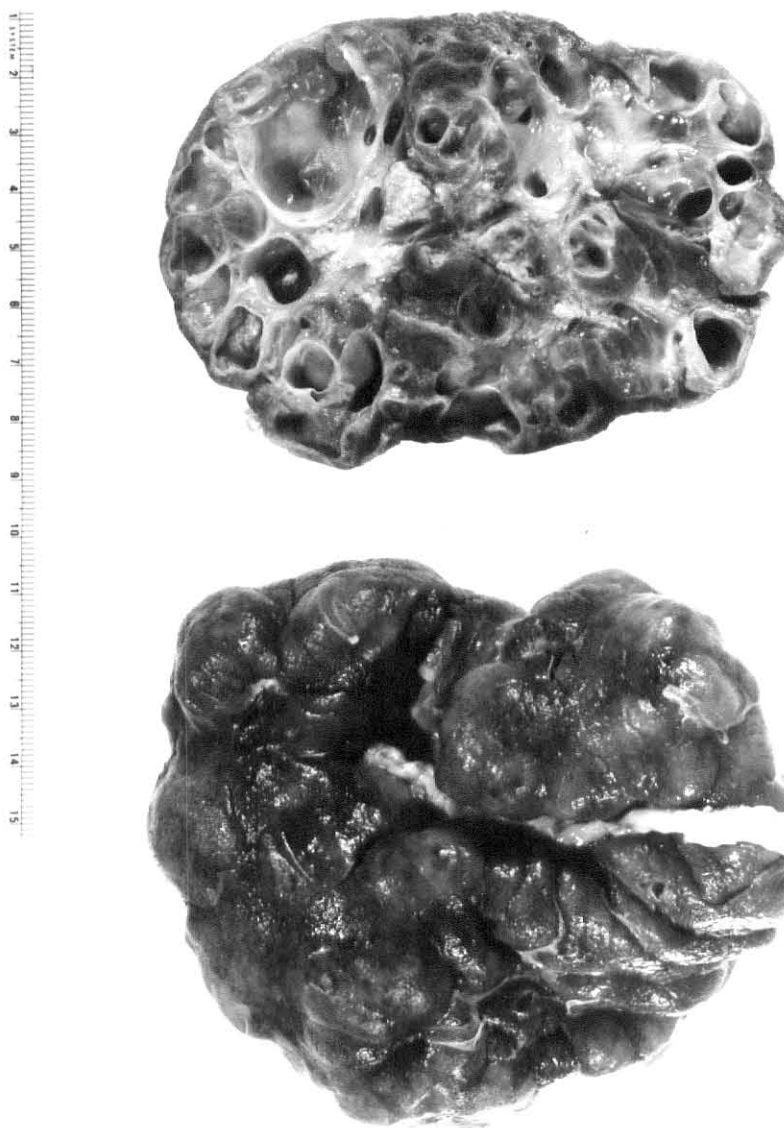


Fig. 6

Fig. 7. *Perosomus elumbis* calf with arthrogryposis. The right foreleg had three digits, the joints of the rear legs were fixed in flexion and rotated.



Fig. 7

Fig. 8. Spina bifida in an Angus calf. Note meninges protruding from the lumbar area and posterior arthrogryposis.

Fig. 9. Dorso-ventral radiograph of lumbar vertebrae showing aplastic dorsal arches in an Angus calf with posterior arthrogryposis.

Fig. 10. Lateral radiograph showing reduction in size of the vertebral column in the lumbar area and kyphotic deformity.

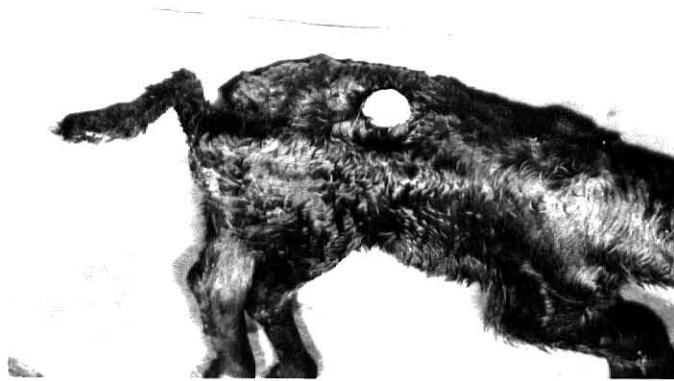


Fig. 8

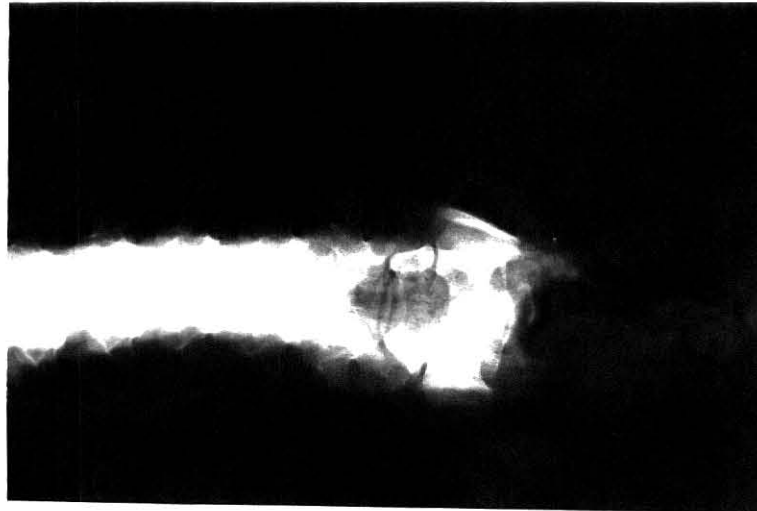


Fig. 9

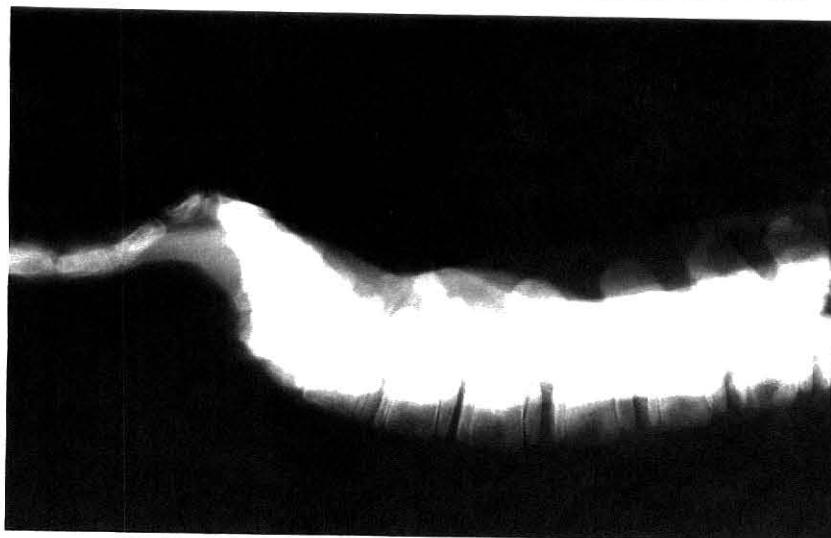


Fig. 10

Fig. 11. Degenerate white matter and abnormal central canal of an Angus calf with Spina bifida. Lumbar spinal cord cross section, H and E, 60X.

Fig. 12. Skeletal muscle (near leg). Few muscle fibers remain. The bulk of muscular tissue was replaced by lipomatous tissue. Spina bifida Angus calf. Cross section, H and E, 60X.

Fig. 13. Longitudinal section of quadriceps muscle of calf affected with Spina bifida. Note replacement of muscle fibers by fat cells. H and E, 200X.



Fig. 11

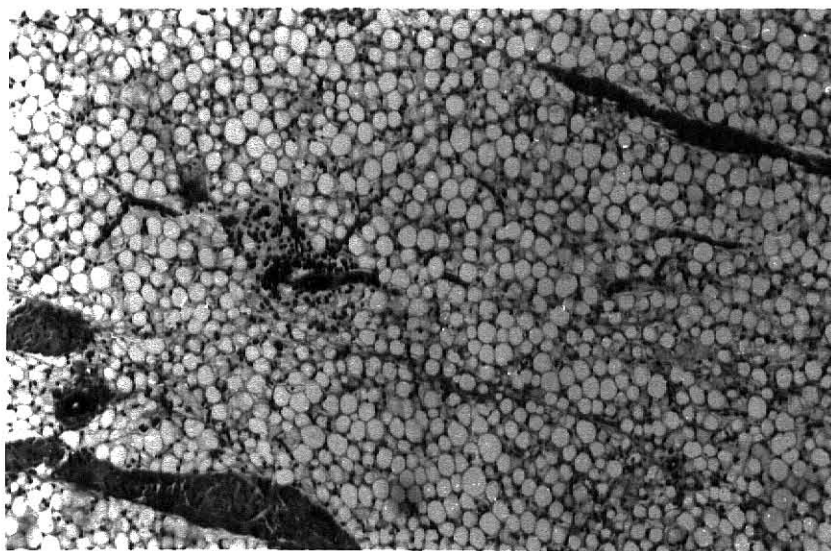


Fig. 12

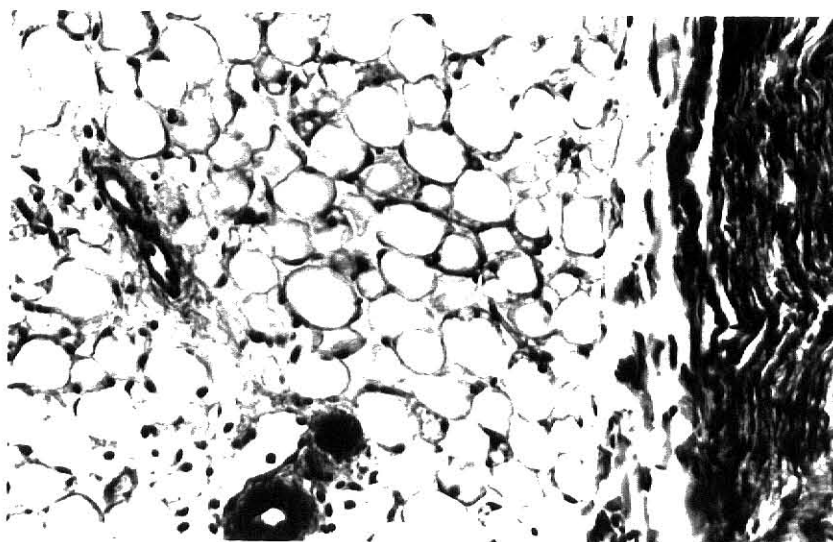


Fig. 13

Fig. 14. Stillborn dwarfed Charolais calf with arthrogryposis.

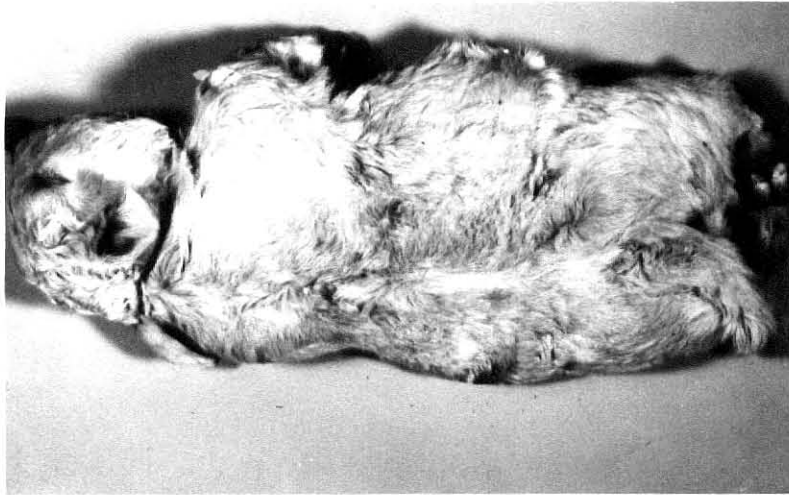


Fig. 14

Fig. 15. Radiograph of left hind leg of dwarfed arthrogrypotic Charolais calf. Proximal bones are not recognizable.



Fig. 15

Fig. 16. Typical Holstein arthrogryptic calf. Note lateral deviation of the head, and bilaterally symmetrical fore limb contractures.



Fig. 16

Fig. 17. Arthrogrypotic calf. Posterior view of discordant right and left intervertebral condyles.

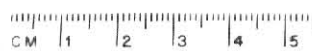
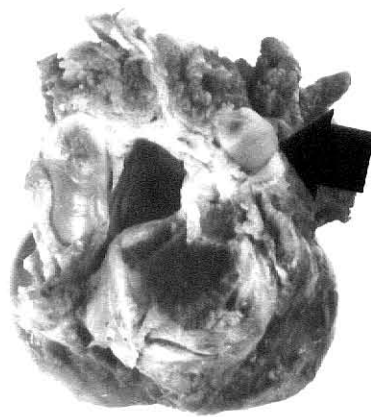


Fig. 17

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CONGENITAL DEFECTS IN CATTLE

by

HAROLD J. GREENE

M.V.B., M.R.C.V.S. University College, Dublin, 1962

Postgraduate Diploma in Veterinary Pathology,
University of Saskatchewan, 1972

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Congenital anomalies have always aroused the curiosity of man and affected individuals have been known as freaks or monsters and etiologically related to the wrath of God. In more recent times, emotion has been replaced by logic and some progress has been made in the study of birth defects. Congenital defects by definition are those anomalies present at birth and may or may not be recognizable at that time. These defects may be structural or functional in nature and can be caused by either genetical or environmental factors or a combination of these. The most severe types are due to chromosomal aberration and are incompatible with embryonic life. When congenital defects are of the type which permit fetal development, all degrees of severity are possible and range from the lethal or semi-lethal conditions to those mild defects which are entirely compatible with life. Frequently, the primary defect is in one body system and is accompanied by secondarily induced or anatomically unrelated associated defects of the same or other body systems.

Available reports on the incidence of bovine congenital defects indicate that between 0.2 percent and 4.4 percent of all neonates are defective. Previous studies indicated that the most commonly affected body system was the central nervous system in Germany; the skeletal system in England, while in the United States umbilical hernia affecting large body cavities was most common. In the present study, 1275 defects were seen.

The most frequently affected systems were the skeletal system, 476 defects; organs of special sense, 238; muscular system, 190; and the central nervous system, 155. Although the total number of defects was 1275, the number of affected calves was 1122. The difference was accounted for by the double entry of some calves which had defects of more than one body system.

Of the 476 skeletal defects, 232 (48.7%) affected the axial skeleton; of these, 104 were affected with previously considered rare defect, taillessness. Seventy-nine of the axial skeletal defects were associated with the muscular defect arthrogryposis, 188 cases of which were reported. Ocular defects made up 229 of the 238 defects of the special sense organs. The most frequently seen conditions were: incomplete albinism, 86; blindness, 37; anophthalmia, 30; and heterochromia irides, 23. Hydrocephalus, 97 cases, accounted for the majority of the central nervous system defects while spastic paresis 15, spina bifida 15, and cerebellar hypoplasia ten cases were relatively common. Umbilical herniation, 50 cases, was rare when compared to a previous American study when it was found to be the most common defect. Schistosomus reflexus was seen 13 times, and every case of known sex was male. Defects of the skin and reproductive system did not present any unusual features. Atresia ani was associated with anury in eight out of 12 cases. Ten cases of ectopia cordis cervicalis were seen, and an interventricular septal defect was once associated with microtia

in a Holstein. Embryonic duplications (28) representing 2.2 percent of all defects comprised 24 free or attached symmetrical or asymmetrical twins, and one each of polyotia and double anus.