STATION BULLETIN 253 JULY, 1929

Congenital Loco in Chicks

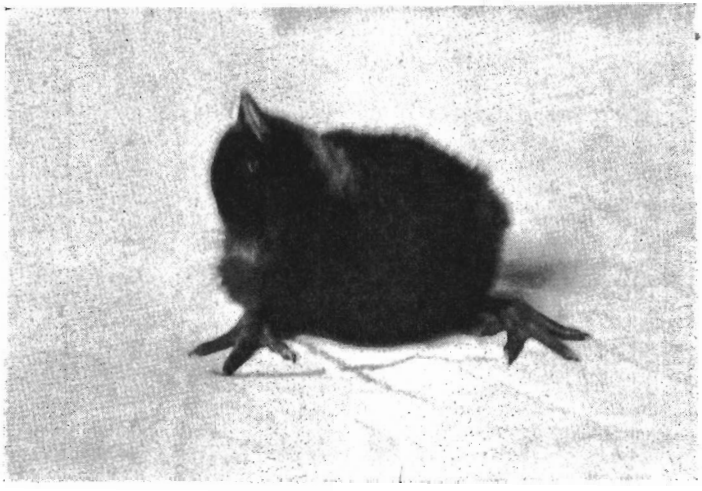

Fig. 1. Chick showing symptoms of Congenital Loco.

Agricultural Experiment Station
Oregon State Agricultural College
CORVALLIS

OREGON STATE BOARD OF HIGHER EDUCATION

Hon. C. C. Colt.....*Portland*
Hon. B. F. Irvine.....*Portland*
Hon. C. L. Starr.....*Portland*
Hon. E. C. Sammons.....*Portland*
Hon. Albert Burch.....*Medford*
Hon. E. C. Pease.....*The Dalles*
Hon. F. E. Callister.....*Albany*
Hon. Aubrey Watzek.....*Portland*
Hon. Herman Oliver.....*Canyon City*

STAFF OF AGRICULTURAL EXPERIMENT STATION

W. J. Kerr. D.Sc., LL.D.....*President*
J. T. Jardine. B.S.....*Director*
E. T. Reed. B.S., A.B.....*Editor*

H. P. Barss, A.B., S.M.....*Plant Pathologist*
F. D. Bailey. M.S....*Asst. Pathologist. Insecticide and Fungicide Bd., U. S. D. of A.*
R. S. Besse, M. S.....*Associate in Farm Management*
P. M. Brandt, B.S., A.M....*Dairy Husband'n*
P. Brierley. M. S.....*Assistant Pathologist. United States Department of Agriculture*
A. G. Bouquet, B.S.....*Horticulturist (Vegetable Gardening)*
E. N. Bressman. M.S.....*Assoc. Agronomist*
G. G. Brown, B.S.....*Horticulturist. Hood River Branch Exp. Station. Hood River*
W. S. Brown, A.B., M.S.....*Horticulturist in Charge*
D. E. Bullis. M.S.....*Assistant Chemist*
A. S. Burrier. M. S.....*Assistant in Farm Management*
Leroy Childs, A.B.....*Superintendent Hood River Branch Exp. Station. Hood River*
G. V. Copson. M.S.....*Bacteriologist*
H. K. Dean, B.S.....*Superintendent Umatilla Branch Exp. Station. Hermiston*
E. M. Dickinson, D.V.M.....*Assistant Poultry Pathologist*
C. R. Donham. M.S., D.V.M.....*Assistant Veterinarian*
W. H. Dreesen. Ph.D.....*Associate Agricultural Economist*
T. P. Dykstra, M.S.....*Assistant Plant Pathologist. U. S. Dept. of Agriculture*
F. M. Edwards. B.S.....*Asst. Animal Husbandman. East. Ore. Br. Exp. Sta., Union*
A. E. Engbretson. B.S.....*Superintendent John Jacob Astor Br. Exp. Sta., Astoria*
L. N. Goodding, B.A., B.S.....*Junior Plant Pathologist. U. S. Department of Agric.*
W. V. Halversen. Ph.D.....*Associate Bacteriologist*
J. R. Haag. Ph.D.....*Chemist*
H. Hartman. M.S.....*Horticulturist (Pom.)*
E. M. Harvey. Ph.D.....*Horticulturist (Physiology)*
D. D. Hill. M.S.....*Assistant Agronomist*
Bertha C. Hite, B.A.....*Scientific Assistant Seed Lab., U. S. D. of A. (Seed Anal't)*
C. J. Hurd. B.S.....*Assistant Agricultural Engineer*
R. E. Hutchinson, B.S.....*Assistant to Supt. of Harney Valley Br. Exp. Sta., Burns*
G. R. Hyslop. B.S.....*Agronomist*
W. T. Johnson. B.S., D.V.M.....*Poultry Pathologist*
I. R. Jones. Ph.D....*Assoc. Dairy Husband'n*
J. S. Jones. M.S.....*Chemist in Charge*
F. L. Knowlton. B.S....*Poultry Husbandman*
G. W. Kuhlman, M.S.....*Assistant in Farm Management*
E. S. Larrahee, B.S.....*Dairy Specialist. In Cooperation with U. S. Dept. of Agric.*
M. R. Lewis. B.S.....*Drainage Engineer. Cooperation Bureau of Public Roads*
A. G. Lunn. B.S.....*Poultry Husbandman in Charge*
A. M. McCapes. D.V.M....*Asst. Veterinarian*
G. R. McGinnis. M.S.....*Field Ag't in Entomology*
M. B. McKay. M.S.....*Plant Pathologist*
J. F. Martin, B.S.....*Jr. Agron. U. S. D. A.*
G. A. Mitchell, B.S.....*Assistant to Superintendent Pendleton Field Sta., Pendleton*
E. B. Mittelman. Ph.D.....*Associate Agricultural Economist*
Don C. Mote. Ph.D.....*Entomologist in Chg.*
M. N. Nelson, Ph.D.....*Agricultural Economist*
O. M. Nelson. B.S.....*Animal Husbandman*
R. K. Norris. B.S.....*Assistant to Superintendent of S. Or. Br. Exp. Sta., Talent*
A. W. Oliver. M.S.....*Assistant Animal Husbandman*
M. M. Oveson, B.S.....*Asst. to Supt., Sherman Br. Sta., Moro*
E. L. Potter. M.S.....*Animal Husbandman in Charge*
W. L. Powers. Ph.D....*Chief. Dept. of Soils*
F. E. Price, B.S.....*Agricultural Engineer*
F. C. Reimer. M.S.....*Superintendent Southern Oregon Br. Exp. Station, Talent*
G. S. Ridgley.....*Laboratory Technician. Poultry Pathologist*
R. H. Robinson. A.B., M.S.....*Chemist*
C. V. Ruzek. B.S....*Assoc. in Soils (Fert'y)*
H. A. Schoth. M.S.....*Associate Agronomist. Forage Crops. U. S. Dept. of Agric.*
C. E. Schuster. M.S.....*Horticulturist (Pomology)*
H. D. Scudder. B.S.....*Chief in Farm Management*
Owen Searcy. B.S.....*Technician. Vet. Med.*
H. E. Selby, B.S.....*Associate in Farm Management*
O. Shattuck. M.S.....*Superintendent Harney Valley Branch Experiment Sta., Burns*
J. N. Shaw. D.V.M.....*Asst. Veterinarian*
J. E. Simmons. M.S.....*Asst. Bacteriologist*
B. T. Simms, D.V.M....*Veterinarian in Chg.*
D. E. Stephens. B.S....*Superintendent Sherman County Branch Exp. Station. Moro*
R. E. Stephenson. Ph.D.....*Associate Soils Specialist*
G. L. Sulerud. M.S.....*Asst. Ag'l Economist*
B. G. Thompson, M.S.....*Asst. Entomologist*
E. F. Torgerson, B.S.....*Assistant in Soils (Soil Survey)*
A. Walker. B.S.....*Assistant Agronomist. Eastern Oregon Br. Exp. Station, Union*
C. F. Whitaker. B.S.....*Assistant Chemist*
E. H. Wiegand. B.S.....*Horticulturist (Horticultural Products)*
Joseph Wilcox. M.S.....*Asst. in Entomology*
Maud Wilson. B.S. .....*Home Economist*
Gustav Wilster, Ph.D.....*Associate in Dairy Manufacturing*
Robt. Withycombe. B.S.....*Superintendent Eastern Oregon Br. Exp. Station. Union*
S. M. Zeller. Ph.D.....*Plant Pathologist*

Newly hatched chicks, unable to stand properly on their feet and showing an apparent lack of control over the muscles of their necks, which are usually bent back over their bodies with heads held in a slightly twisted position, have been named congenital loco chicks. The condition probably is the result of some impairment of the structures controlling equilibrium.

Pedigree records of four generations of birds carrying the congenital loco factor indicate that the condition is hereditary and that the mode of inheritance is probably that of a simple Mendelian recessive.

SUMMARY

1. A distinctive type of cripple chick, which has been named congenital loco, was first noted in the Station hatching work during 1924.

2. Definite pedigree records have been kept on the birds giving congenital loco chicks since April 6, 1926.

3. The principal symptom of congenital loco is an apparent lack of control of the muscles of the neck, resulting in the chick not being able to stand or eat normally.

4. In our experience all chicks showing symptoms of congenital loco have died on or before the ninth day after hatching.

5. The exact cause of the condition is not known, but incomplete work on the problem indicates a possible relation with some impairment of the structures controlling equilibrium.

6. Chicks showing symptoms similar to those of congenital loco were reported as having been observed in 30 states and provinces.

7. In a population of 607 chicks coming from carrier (Ll or heterozygous) parents 24.05 percent showed the symptoms of congenital loco (ll). The expected percentage would be 25.

8. If either parent were pure (LL or homozygous normal) for the factor, no congenital loco (ll) chicks were observed in the resulting progeny.

9. The contamination was probably introduced into the College flock by two males which were brought in during 1921.

10. Congenital loco is of no economical importance to the producer of commercial eggs who never mates his hens, as the carrier (Ll) hens are not affected as to egg production.

11. Congenital loco is of doubtful economical importance, at the present time, to the producer of commercial chicks, as the losses probably would be slight and those can be controlled by the continued use of pure (LL) males.

12. Congenital loco is of great economical importance to the pedigree breeder who must employ a breeding test to eliminate it from his flocks.

Congenital Loco in Chicks

By

FRANK L. KNOWLTON

During the hatching seasons of 1924 and 1925, a few crippled chicks showing very distinctive symptoms, were produced by some Station Barred Plymouth Rocks which were being used in an experiment where individual pedigreeing was practiced. During the season of 1926, additional chicks showing these symptoms were produced. It was then noted that such chicks came only from certain hens, and that in each successive hatch, those hens would have some chicks which were normal in appearance and some showing these symptoms.

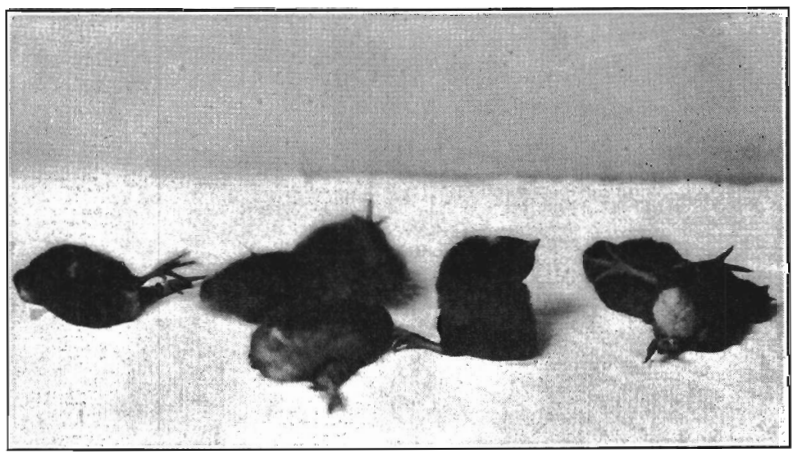

Fig. 2. Congenital Loco chicks in characteristic positions.

Commencing with the hatch which was taken off April 6, 1926, each chick which showed these symptoms was specially recorded in the pedigree records. This recording has been continued through three and one-half seasons, the 1926 season having been half over when it was started. The term "loco chicks" has been employed in these records to denote chicks showing these symptoms. It is now thought that "Congenital loco chicks" would be a more definitely descriptive term, as all chicks that do show symptoms, show them when hatched.

The purpose of this publication is to present the results of a study of the data so far accumulated in connection with these congenital loco chicks.

SYMPTOMS

The symptoms shown by congenital loco chicks are an apparent lack of control of the muscles of the neck. The neck is usually bent upward and backward over the body and not infrequently the head will be held in a

slightly twisted position, somewhat as in wry neck. (See Fig. 1.) The chicks are unable to stand normally on their feet. If placed on their feet, a few of them can retain that position for a short time, if supported also by their abdomen; but in most cases and particularly if they make any attempt to move, they seem able only to push themselves over on their backs or sides, where they remain attempting by jerky motions to right themselves (see Fig. 2). In all other respects the chicks appear normal. Durant has noted (1926) and pictured (1927) a similar condition in Leghorn chicks.

Most of the chicks showing these symptoms were killed as soon as they were taken from the incubators, but on two occasions attempts were made to see if they would recover. Two lots of chicks—twelve in all—were placed in small electric brooders supplied with mash and water. When food or drink was placed in the chicks' mouths they could swallow it, but they did not have and never developed sufficient control over their bodies to find and pick up the food or drink for themselves. Since they were not artificially fed, they grew gradually weaker and weaker and finally died, apparently from starvation. All were dead on or before the ninth day.

PATHOLOGY

Chicks having symptoms of congenital loco, show on autopsy no definite abnormalities that could be said with certainty to be the cause. Since the symptoms are not unlike those exhibited by pigeons in which the sense of equilibrium has been artificially destroyed, it has been thought that the condition may be caused by some deficiency in the structures controlling equilibrium. Normal chicks from a strain that has never indicated any symptoms of congenital loco, upon having their sense of equilibrium destroyed by the severing of the acoustic nerve, destroying the semi-circular canals or damaging the brain root controlling equilibrium, did show typical symptoms of congenital loco. Although this indicates that the cause of this condition probably is associated with an impairment of equilibrium, it does not definitely prove it. More work must be done on this phase of the problem before a definite statement as to the actual cause is warranted.

GEOGRAPHICAL DISTRIBUTION

In an endeavor to determine where the symptoms of congenital loco had been observed, a questionnaire was sent to Experiment Station workers in 44 states and provinces. Forty replies were received, thirty of which reported having observed the symptoms. They were located in all sections of the country, indicating that the condition is not peculiar to any particular locality, but rather widely distributed. The reports stated the symptoms had been observed in the following breeds and varieties: White Leghorns, Rhode Island Reds, Barred Plymouth Rocks, White Plymouth Rocks, White Wyandottes, Anconas.

THE PROBLEM

For a number of years the Station has pedigree bred both S. C. White Leghorns and Barred Plymouth Rocks. These are not infrequently hatched simultaneously in the same incubator, practically always brooded together for the first few weeks, and ranged upon contiguous ranges.

Congenital loco chicks appear in our Rocks but never in our Leghorns. It was believed that this practically removed all possibility of congenital loco chicks being caused by any infectious agent. Since congenital loco chicks had been observed to come in successive hatches from the same hens, a study of the accumulated data was made to determine if the condition were hereditary, and if the mode of inheritance could be shown.

GENETIC PRINCIPLES INVOLVED

If we assume that we must deal with a simple Mendelian recessive and adopt L as the symbol to denote the absence of the congenital loco factor and l as the symbol to denote its presence, the three possible genotypes (each containing two letters—one derived from each parent) would, of course, be as follows:

LL—pure individual (Homozygous normal)
Ll—carrier (Heterozygous)
ll—congenital loco (Recessive)

Since in our experience with respect to the factor to be studied all congenital loco (ll) chicks die and are therefore not available for mating purposes, there would be but three possible combinations of genotypes in any mating, LL x LL, LL x Ll, or Ll x Ll. In the first of these, both parents are pure (LL), and so all the progeny would have to be pure. In the second mating one parent is pure (LL) and the other a carrier (Ll). A mating between these would give progeny 50 percent of which were pure (LL) and 50 percent of which were carriers (Ll) as follows:

LL x Ll (Parents)
LL, Ll, LL, Ll (Progeny)

In the last type of mating between two carriers (Ll), 25 percent of the progeny would be pure (LL), 50 percent would be carriers (Ll), and 25 percent would be congenital loco (ll) as follows:

Ll x Ll (Parents)
LL, Ll, Ll, ll (Progeny)
25% 50% 25%

THE DATA

Table I gives the detailed results of all matings of all hens that have ever given congenital loco (ll) chicks between April 6, 1926, and the conclusion of the normal breeding season of 1929. The arrangement of the table is complicated; so for purposes of illustration take the data given for hen P23 whose number will be found sixth from the top in the column headed "Hens." P23 was mated during 1927 to male Q927. From this mating a total of 25 eggs were set, of which two were infertile, one was a dead germ, 18 hatched into normal appearing chicks; no chicks showed congenital loco symptoms; four died in shell. During 1928, P23 was first mated to male R960. A total of 25 eggs were set with results shown by the entries in the five columns to the right. At least 30 days after the removal of R960 from the pen, P23 was mated to male R956, the hatching results from this mating being shown in the proper columns. During the year 1929, P23 was first mated to S451 and then after 30 days to R956, the hatching results being shown in the proper columns as before.

TABLE I. MATING RESULTS

Hens	1926* Males	Set	Infertile	Dead germs	Hatched: Normal appearing	Hatched: Congenital loco	Hatched: Dead in shell	1927 Males	Set	Infertile	Dead germs	Hatched: Normal appearing	Hatched: Congenital loco	Hatched: Dead in shell	1928 Males	Set	Infertile	Dead germs	Hatched: Normal appearing	Hatched: Congenital loco	Hatched: Dead in shell	1929 Males	Set	Infertile	Dead germs	Hatched: Normal appearing	Hatched: Congenital loco	Hatched: Dead in shell
O632	P484	....	....	....	....	....	....	Q923	4	2	1	....	1	....	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....
O714	P489	13	1	....	11	....	1	Q923	11	1	....	7	2	1	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....
O815	P479	24	9	2	4	1	8	Q928	7	7	....	....	....	....	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....
O831	P477	12	1	1	5	4	1	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....
P20	.....	....	....	....	....	....	....	Q925	12	1	....	7	2	2	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....
P23	.....	....	....	....	....	....	....	Q927	25	2	1	18	....	4	R960	25	3	1	15	2	4	S451	4	4	....	....	....	....
															R956	8	....	1	5	1	1	R956	8	7	1	....	....	....
P39	.....	....	....	....	....	....	....	Q926	13	7	2	2	1	1	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....
P40	.....	....	....	....	....	....	....	Q927	12	....	1	7	....	4	R960	18	1	....	10	2	5	.....	....	....	....	....	....	....
															R956	15	1	5	4	1	4	R956	12	1	2	1	3	5
P80	.....	....	....	....	....	....	....	Q922	11	1	1	6	3	....	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....
P175	.....	....	....	....	....	....	....	Q926	9	....	3	4	1	1	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....
P181	.....	....	....	....	....	....	....	Q921	13	....	....	12	....	1	R954	28	3	3	15	1	6	R956	5	....	3	2	....	....
P194	.....	....	....	....	....	....	....	Q927	24	....	2	21	....	1	R960	37	1	3	24	6	3	.....	....	....	....	....	....	....
															R956	13	....	4	4	1	4	R956	15	....	5	9	1	....
P198	.....	....	....	....	....	....	....	Q927	16	....	....	10	....	6	R960	24	1	....	8	14	1	.....	....	....	....	....	....	....
															R956	8	....	3	5	....	....	R956	15	1	2	7	4	1
P209	.....	....	....	....	....	....	....	Q925	21	1	8	6	1	5	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....
P230	.....	....	....	....	....	....	....	Q922	10	1	....	8	1	....	R957	28	....	2	20	....	5	S456	2	....	....	2	....	....
P334	.....	....	....	....	....	....	....	Q922	12	....	3	8	1	....	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....
P336	.....	....	....	....	....	....	....	Q926	16	....	1	8	1	6	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....
P354	.....	....	....	....	....	....	....	Q927	23	....	1	14	....	8	R960	33	2	4	15	6	6	S451	16	1	1	6	....	8
															R956	12	1	6	....	....	5	R956	15	5	4	3	....	3
P374	.....	....	....	....	....	....	....	Q925	16	....	....	11	4	1	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....
Q483	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....	R959	36	....	1	27	6	2	S451	6	....	4	2	....	....
															R958	14	1	....	9	1	3	R956	15	....	....	7	1	7
Q537	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....	R959	33	1	1	20	11	....	S451	4	....	2	2	....	....
															R958	12	....	....	10	2	....	R956	15	....	....	11	2	2
Q568	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....	R957	41	3	3	31	....	4	S462	3	....	1	1	1	....
																						R956	16	10	1	5	....	....

Q588	R959	37	1	3	23	5	5	S451	14	2	2	10	....	....
	R958	9	....	....	8	1	....	R956	15	....	1	8	3	3
R13								S453	11	1	....	8	1	1
R18								?	19	2	3	2	2	10
R29								R956	14	8	....	4	2	....
								S451	14	....	....	14	....	....
R107								S453	24	16	3	2	1	2
R112								R956	20	1	2	6	2	9
								S451	14	....	....	12	....	2
R118								R956	20	4	4	3	2	7
								S451	15	....	....	12	....	3
R127								R956	13	1	1	7	1	3
								S451	12	1	....	9	....	2
R142								R956	12	....	3	5	2	2
								S451	14	....	....	12	....	2
R145								R956	15	....	2	6	1	6
								S451	8	....	3	1	....	4
R155								R956	12	1	2	4	4	1
								S451	2	....	....	1	....	1
R170								S466	40	4	12	12	2	10
R211								S457	30	3	....	19	2	6
R220								S457	16	....	1	11	1	3
R235								S457	8	....	1	4	1	2
R251								S457	8	....	....	....	1	7
R325								R956	13	....	....	6	5	2
								S451	16	....	3	10	....	3
S910								R958	2	....	....	1	1	....
S911								R958	9	3	2	2	1	1
S912								R958	12	....	....	7	3	2
S913								R958	10	....	4	3	1	2
S915								R958	6	....	....	4	1	1
S916								S464	4	....	....	1	1	2
S924								S464	11	....	1	2	4	4
S927								S464	7	....	....	5	2	....
S931								R960	6	....	2	1	1	2
S934								R960	7	4	....	....	1	2
S936								R960	5	2	....	2	1	....
S941								R960	7	2	2	....	1	2

* Recording started April 6, 1926.

Table II gives the dam and sire for each bird contained in Table I and also the probable genotype of the congenital loco factor in all cases where the evidence in Table I is sufficient to indicate with any clarity.

Table III gives the complete hatching results for the 1928 season from Yards 10 and 14, two yards between which a reciprocal exchange of males was made during the latter part of the season.

Table IV shows the pedigree of the congenital loco (ll) chick pictured in Fig. 1, together with the probable genotypes of those of the ancestors for which that information is given in Table II.

DISCUSSION OF DATA

A study of Table I will reveal that males P489, Q921, Q927, R957 and S451 produced only normal appearing chicks with all the hens to which they were mated, although all of those same hens, when mated to certain other males, produced some congenital loco (ll) chicks. Table III shows that males R956 and R960 did not produce any congenital loco (ll) chicks when mated to the hens in Yard 10, but did produce some from certain hens when placed in Yard 14. In other words, it seems that some males and some hens can prevent the appearance of congenital loco (ll) chicks.

Presumably the five males—P489, Q921, Q927, R957 and S451—prevented the appearance of congenital loco (ll) chicks because they were pure (LL) for the congenital loco factor. All other males and females given in Table I presumably were carriers (Ll) as they had at one time or another been either the fathers or mothers of congenital loco (ll) chicks. Matings between these carriers should result in 25 percent pure (LL) chicks, 50 percent carriers (Ll) and 25 percent congenital loco (ll) chicks. Table I contains a record of 607 chicks hatched from matings between two carriers (Ll). In this population of 607 there were 146 congenital loco chicks (ll) which is 24.05 percent of the total population. The expected percentage was 25.

Since it is impossible to tell a pure (LL) individual from a carrier (Ll) except by means of a breeding test, there being no visible difference between them, it has not been possible to divide the 461 normal appearing chicks in the 607 population into their pure (LL) and carrier (Ll) percentages. We have evidence, however, that both pure individuals and carriers are included. A glance at Table II will reveal many cases of carriers (Ll) coming from parents both of which are also carriers (Ll), and several cases where carriers (Ll) come from one carrier (Ll) and one pure (LL) parent.

The breeding performance of hen Q483 in 1928 is given in Table I. When mated successively to carrier (Ll) males R959 and R958 she gave a total of 36 normal appearing chicks and 7 congenital loco (ll) chicks. Hen Q580 was a full sister to Q483 and was in the same pen with her during 1928. When mated to these same males Q580 gave from them respectively 23 and 8 normal appearing chicks and no congenital loco (ll) chicks. This would indicate that Q580 is pure (LL) although her sister Q483 was a carrier (Ll). Additional examples could be given if space permitted.

The pedigree in Table IV shows that carrier (Ll) hen P354 and pure (LL) male Q927 (see Table I) were mated together in 1927. They produced 14 normal appearing chicks. R956, the sire of chick 2827-T, was one

TABLE II. PEDIGREE DATA AND PROBABLE GENOTYPES FOR THE BIRDS INCLUDED IN TABLE I

Bird No.	Dam	Sire	Bird No.	Dam	Sire	Bird No.	Dam	Sire
O632 Ll	M306 ?	N718-19-20 ?	Q568 Ll	O838 ?	P479 Ll	R954 Ll	P1594 ?	Q926 Ll
O714 Ll	M455 ?	N718-19-20 ?	Q588 Ll	M430 ?	P477 Ll	R956 Ll	P354 Ll	Q927 LL
O815 Ll	M454 ?	N721 ?	Q921 LL	O749 ?	P476 ?	R957 LL	P146 LL	Q920 ?
						R958 Ll	P374 Ll	Q925 Ll
O831 Ll	M337 ?	N718-19-20 ?	Q922 Ll	Q665 ?	P478 ?	R959 Ll	P265 ?	Q905-6-7 ?
P20 Ll	N163 ?	O456 ?	Q923 Ll	O913 ?	P489 LL	R960 Ll	P362 LL	Q922 Ll
P23 Ll	M344 ?	O460 ?	Q925 Ll	N173 ?	P480 ?	S451 LL	Q1556 ?	R952 ?
P39 Ll	N45 ?	O451 ?	Q926 Ll	O913 ?	P489 LL	S453 Ll	P346 LL	R958 Ll
P40 Ll	N64 ?	O460 ?	Q927 LL	O900 ?	P476 ?	S455 LL	P362 LL	R957 LL
P80 Ll	N198 ?	O456 ?	R13 Ll	P50 ?	O452 ?	S457 Ll	P146 LL	R959 Ll
P175 Ll	N136 ?	O451 ?	R18 Ll	N86 ?	Q919 ?	S462 Ll	Q1556 ?	R951 ?
P181 Ll	N167 ?	O451 ?	R29 Ll	P334 Ll	Q922 Ll	S464 Ll	Q537 Ll	R959 Ll
P194 Ll	N64 ?	O460 ?	R107 Ll	P323 ?	O452 ?	S466 Ll	Q541 LL	R956 Ll
						S910 Ll	Q588 Ll	R959 Ll
P198 Ll	N64 ?	O460 ?	R112 Ll	P39 Ll	Q926 Ll	S911 Ll	Q588 Ll	R959 Ll
P209 Ll	N163 ?	O456 ?	R118 Ll	O714 Ll	Q923 Ll	S912 Ll	Q537 Ll	R959 Ll
P230 Ll	N186 ?	O456 ?	R127 Ll	P230 Ll	Q922 Ll	S913 Ll	Q537 Ll	R959 Ll
P334 Ll	N186 ?	O456 ?	R142 Ll	P39 Ll	Q926 Ll	S915 Ll	Q483 Ll	R959 Ll
P336 Ll	N136 ?	O451 ?	R145 Ll	P336 Ll	Q926 Ll	S916 Ll	Q588 Ll	R959 Ll
P354 Ll	N64 ?	O460 ?	R155 Ll	P336 Ll	Q926 Ll	S924 Ll	Q537 Ll	R959 Ll
P374 Ll	N163 ?	O456 ?	R170 Ll	P221 ?	Q920 ?	S927 Ll	P194 Ll	R960 Ll
P477 Ll	N121 ?	O452 ?	R211 Ll	P147 ?	Q919 ?	S931 Ll	P354 Ll	R960 Ll
P479 Ll	N116 ?	O456 ?	R220 Ll	P362 LL	Q922 Ll	S934 Ll	P198 Ll	R960 Ll
P484 ?	M506 ?	O457 ?	R235 Ll	P250 ?	Q926 Ll	S936 Ll	Q588 Ll	R959 Ll
P489 LL	M506 ?	O457 ?	R251 Ll	P250 ?	Q926 Ll	S941 Ll	P198 Ll	R960 Ll
Q483 Ll	O884 ?	P477 Ll	R325 Ll	P374 Ll	Q925 Ll			
Q537 Ll	N29 ?	P477 Ll						

of those 14 chicks. He showed himself to be a carrier (Ll) by producing, when mated to carrier (Ll) hen Q588 in 1929, eight normal appearing chicks and three congenital loco (ll) chicks, one of which was 2827-T. The pedigree shows that the source of contamination for Q588 was her sire, P477, who was known to be a carrier (Ll).

It is possible to trace the contamination back through the pedigrees of those of our birds which carry it, just as has been done with chick 2827-T, without finding a single example which can not be explained in perfect harmony with the expected behavior of a simple Mendelian recessive.

SOURCE OF CONTAMINATION

One naturally wonders how the congenital loco factor got introduced into the College strain of Barred Plymouth Rocks. Since no records were kept of congenital loco (ll) chicks for the first several years, it is impossible to tell with absolute certainty. Keeping in mind, however, the manner in which this factor may be passed unnoted through several generations by carriers (Ll), and then make its presence known by the appearance of congenital loco (ll) chicks as soon as two carriers (Ll) chance to be mated together, it is possible to pick the point in the history of the College flock at which, in all probability, the contamination gained entrance. In 1921, two males, L2021 and L2023, were introduced from a source outside of Oregon. Many of the families now showing congenital loco trace back to these males. Congenital loco was reported in Barred Plymouth Rocks, moreover, in the region from which these males came. These circumstances make it appear very probable that these males were the source of contamination of the College flock.

TABLE III. MATING RESULTS OBTAINED IN YARDS 10 AND 14 WHERE A RECIPROCAL EXCHANGE OF MALES WAS MADE

	Regular hatches 1928							Special hatches 1928						
					Hatched							Hatched		
Hens	Males	Set	Infertile	Dead germs	Normal appearing	Congenital Loco	Dead in shell	Males	Set	Infertile	Dead germs	Normal appearing	Congenital Loco	Dead in shell
Yd. 10														
O907	R956	12	....	3	8	....	1	R960	11	3	3	4	....	1
O948	R956	11	....	....	10	....	1	R960	5	....	....	4	....	1
P164	R956	29	1	2	23	....	3	R960	0	....	....	....	....	....
Q541	R956	40	....	3	34	....	3	R960	8	....	3	2	....	3
Q560	R956	41	1	3	31	....	6	R960	8	....	4	3	....	1
Q587	R956	41	1	2	37	....	1	R960	9	....	1	6	....	2
Q594	R956	43	....	3	35	....	5	R960	12	....	3	9	....	....
Q609	R956	44	2	1	37	....	4	R960	3	1	....	2	....	....
Q610	R956	33	....	28	5	....	....	R960	5	....	1	1	....	3
Q812	R956	24	2	3	17	....	2	R960	7	7	....	....	....	....
Yd. 14														
P23	R960	25	3	1	15	2	4	R956	8	....	1	5	1	1
P40	R960	18	1	....	10	2	5	R956	15	1	5	4	1	4
P56	R960	24	1	4	18	....	1	R956	0	....	....	....	....	....
P66	R960	29	1	3	19	....	6	R956	12	....	6	2	....	4
P103	R960	26	....	5	18	....	3	R956	13	1	5	4	....	3
P194	R960	37	1	3	24	6	3	R956	13	....	4	4	1	4
P198	R960	24	1	....	8	14	1	R956	8	....	3	5	....	....
P238	R960	34	1	4	27	....	2	R956	11	1	5	1	....	4
P354	R960	33	2	4	15	6	6	R956	12	1	6	....	....	5
P396	R960	22	2	5	12	....	3	R956	0	....	....	....	....	....

ECONOMIC IMPORTANCE

It is doubtful if at the present time under commercial conditions the congenital loco factor constitutes a problem of any considerable economic importance. It would be possible by having a flock composed entirely of carriers (Ll) to have 25 percent of their progeny congenital loco (ll) chicks. Since some pure (LL) individuals will result from each mating, however, the condition of having an entire flock composed of carriers (Ll) is almost certain never to happen under commercial conditions. The pure birds in the flock would reduce the number of congenital loco (ll) chicks produced so that even though no attention at all were paid to the congenital loco factor, in all probability the loss in the worst cases would be much below 25 percent.

The carrier (Ll) hens seem to be unaffected as to egg production as indicated by the fact that the average production of the 39 hens in Table I for which the complete first year record is available was 234 eggs. The high hen laid 286 and the low hen 156. It would not matter then if carrier (Ll) hens were present in a flock kept solely for the production of commercial eggs.

To the pedigree breeder, however, the congenital loco factor constitutes a problem of considerable economic importance. In the first place the value of each chick is greater, resulting in a greater loss for each congenital loco (ll) chick produced. If eggs sold for hatching purposes produce congenital loco (ll) chicks, the breeder's reputation will suffer.

TABLE IV. PEDIGREE OF CHICK (2827-T) PICTURED IN FIG. 1

Pedigree of 2827-T..... (ll)	Sire—R956 (Ll)	Sire—O927 (LL)	Sire—P476	Sire—O457 / Dam—M318
			Dam—O900	Sire—N721 / Dam—M452
		Dam—P354 (Ll)	Sire—O460	Sire—N716 / Dam—M318
			Dam—N64	Sire—M826 / Dam—L13
	Dam—Q588 (Ll)	Sire—P477 (Ll)	Sire—O452	Sire—N716 / Dam—M506
			Dam—N121	Sire—J927 / Dam—L44
		Dam—M430	Sire—L2011	Sire—K1701-2-3 / Dam—J158
			Dam—K24	Sire—J916 / Dam—I47

CONTROL MEASURES

Under commercial conditions the only method of controlling congenital loco would seem to be the continued use of males from flocks known to be free from the defect. This type of mating (LL x Ll) will not eliminate the factor but will prevent the appearance of any chicks which show the symptoms of congenital loco. All chicks produced will be either pure (LL) or carriers (Ll).

The pedigree breeder may control the congenital loco factor by the use of pure males, but in his case perhaps elimination should be the objective. Where individual pedigree breeding is practiced, elimination should be possible. Breeding tests will have to be employed. In these tests it will be necessary first to locate several known carriers (Ll) of each sex. The appearance of congenital loco (ll) chicks proves definitely that both the dams and sires of such chicks are carriers (Ll). They can then be so marked.

Having located a carrier (Ll) male, he can be employed to test hens whose genetic composition with respect to the congenital loco factor has not yet been determined. If a mating be made between this male and the hens to be tested, all hens which give congenital loco (ll) chicks will thereby prove themselves to be carriers (Ll). Those hens which do not give congenital loco (ll) chicks when mated to such a carrier (Ll) male, can be relied upon to be pure (LL).

There may be some question as to the number of normal appearing chicks a hen must give before it is certain she would not give congenital loco (ll) chicks if enough eggs were incubated. In theory, from a mating between two carriers (Ll) 25 percent, or one chick in four, should show congenital loco. In practice in an individual case, it is to be expected that the numbers would vary somewhat. To determine just what does happen, a study was made of the results of 42 matings. It was found that in 21 of these matings, congenital loco (ll) chicks appeared in the first hatch. In the other 21 matings from one to eight normal appearing chicks were produced in hatches previous to the hatch in which the first congenital loco (ll) chicks appeared. On this basis it would seem that any hen, properly mated, which gives 10 or 12 normal appearing chicks with no congenital loco (ll) chicks, can be relied upon to be pure (LL). Such a hen, when mated to a pure (LL) male, will give only pure (LL) progeny.

The testing of a male can be accomplished in less time than the testing of a female, by mating the male to several carrier (Ll) hens at the same time. One hatch should produce enough chicks to determine the correct classification of the male. If he be a carrier (Ll), some congenital loco (ll) chicks will be produced with some of the carrier (Ll) hens in the first hatch, provided, of course, several hens are used and at least six or eight eggs are set from each.

To avoid possible confusion, it might be well to state that all the progeny from these test matings will contain some carriers (Ll) and should not be used without being tested. At least one parent will always be a carrier (Ll), and consequently, half the chicks will be carriers (Ll). There should be some pure (LL) individuals, but testing would have to be resorted to in order to identify them.

The necessity for very careful and absolutely accurate pedigree work cannot be over emphasized. In order to show what may happen if extreme care be not taken, it is desired to describe in detail an error that was made this past season with some of the College birds. It will be noted that no male is given in Table I as having been mated to hen R18. Male S455 was in the yard to which R18 was assigned. Male S455 is a son of hen P362 and male R957 (see Table II). Table I shows R957 to be pure. Hen P362 was mated to carrier male Q922 in 1927. From that mating 21 normal appearing chicks and no congenital loco (ll) chicks were produced. That number is more than sufficient to prove P362 pure (LL). If she were pure (LL) and

the male to which she was mated were pure (LL), their son, S455, should be pure (LL). If S455 were pure (LL) no congenital loco (ll) chicks should result from a mating between him and R18, regardless of whether R18 were pure (LL) or not. In the first hatch of 1929, R18 produced two congenital loco (ll) chicks. In subsequent hatches, only normal appearing chicks appeared. A new trapnest man had been employed a short time before eggs were saved for the first hatch. On questioning him, he reported that shortly after he had come to work he found, one day, several hens out of their yard and in another yard. He had repaired some damage done to the fence by a storm, returned the hens to their proper yard, but failed to make a record of the hen numbers or, at the time, report the case. The probabilities are that R18 was one of those hens and that S455 was not the sire of her congenital loco (ll) chicks. The yard in which these hens were found was headed by a carrier (Ll) male.

Not being satisfied to guess at this case, at the conclusion of the normal hatching season, male S455 was mated to ten known carrier (Ll) hens and three test hatches run. From these hatches a total of 70 chicks was produced, all of which were normal in appearance. As a further test, 12 full sisters of S455 were mated to carrier (Ll) males, R958 and S457. These matings were continued for four hatches, which gave 152 chicks all of which were normal in appearance. These results would seem to indicate beyond doubt that S455 was pure (LL) and therefore incapable of being the sire of congenital loco (ll) chicks, so the two produced by R18 must have been sired by another male. This case illustrates how one error can reverse the conclusions drawn from the test matings in connection with the congenital loco factor.

CONCLUSIONS

The congenital loco factor is hereditary.

The mode of inheritance, in all probability, is that of a simple Mendelian recessive.

ACKNOWLEDGMENTS

Acknowledgment is made to Doctor Nathan Fasten for assistance with the genetic phase of the problem, to Doctor E. M. Dickinson for work on the pathology of the chicks and to Doctor B. T. Simms, Doctor W. T. Johnson, and Professor A. G. Lunn for helpful suggestions.

LITERATURE CITED

Durant, A. J. Inherited Inco-ordination of Muscles in Newly Hatched Chicks. Missouri Agricultural Experiment Station Bulletin No. 244, pp. 60-61. (1926.)

Durant, A. J. Inherited Inco-ordination of Muscles in Newly Hatched Chicks. Missouri Agricultural Experiment Station Bulletin No. 256, p. 102. (1927.)