COW SERUM AS A SUBSTITUTE FOR COLOSTRUM IN NEW-BORN CALVES.

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In a former communication\(^1\) it was shown that if new-born calves are divided in two groups, one of which receives colostrum from the dam and the other not, and if both groups are removed promptly from the surroundings of the herd, placed in individual stalls, and fed raw milk, the calves fed colostrum survive and develop as normal calves, while of the calves from which colostrum has been withheld the greater number die within the 1st week as a result of the invasion and multiplication of intestinal bacteria, chiefly *Bacillus coli*, throughout the body. Those that survive may develop lesions in or about certain joints, more rarely foci of sclerosis in both kidneys.

**EXPERIMENTAL.**

The rapid absorption into the blood of agglutinins towards *Bacillus abortus* ingested in the colostrum\(^2\) indicated that the immunity of the calves receiving colostrum is due to the protective antibodies which tend to accumulate in the colostrum up to the time of parturition. If this inference is true the blood of the adult cow should also contain these various antibodies and might protect calves not fortified by colostrum. To test this hypothesis, three groups of calves were treated with the blood serum of the same cow in slightly different ways.

Calves of which it was certain that they had not suckled the dam were brought to the animal quarter of the Department soon after birth, thoroughly washed with water of about body temperature, and

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dried by rubbing with towels. Each calf was placed in a separate stall and fed milk from cows in about the middle of the lactation period. The milk was at first fed from bottles or other receptacles through nipples and after the 1st week from pails.

The serum used throughout was obtained from the same cow at intervals during the experiment. The animal was a grade Guernsey, in milk when purchased from the Middle West November, 1920. She was chosen at random mainly because easily controlled. The blood was drawn from a jugular vein under aseptic conditions and allowed to clot. The serum was withdrawn after 2 days, passed through a Berkefeld filter, and stored at 38–40°F. without an antiseptic.

No efforts beyond isolation in individual stalls and ordinary cleanliness were made in rearing the calves. Owing to the nature of the experiment and the many uncontrolled factors entering into it, it has seemed best to record certain details which may be of significance in the interpretation of results. These are given in the notes on the individual calves.

The first group of five calves received serum both into the jugular vein and the subcutis immediately after the cleansing bath. On the following day serum was again injected into the subcutis. The following notes furnish the chief details.

_Calf 901._—Guernsey bull, born Mar. 10, 1.15 p.m., of a native cow in her second pregnancy. Removed from dam immediately after birth. Received at Department 2.45 p.m. Washed in water at 100°F. containing a little soda. Dried off by gentle friction with bath towels. Calf quite weak after the cleansing. Kept warm with blankets. Receives into jugular vein 20 cc. serum and 20 cc. into subcutis in three different places. 5 p.m. Fed 1½ lbs. milk. 11 p.m. Second feeding of ⅔ lb. milk.

Mar. 11. Meconium discharged during the night. Calf received about 2 lbs. milk. Urine collected has a specific gravity of 1,008. Contains no abnormal products. At noon calf received into subcutis 20 cc. serum. Diarrhea started late today. Temperature normal. Total amount of milk taken about 4 lbs.


Mar. 13. Feces consistent, orange to yellow. 7½ lbs. of milk taken.

Mar. 16. Calf is fed from pail. Takes about 7½ lbs. of milk.

Apr. 12. Calf has progressed normally, taking slightly more milk each week. Today 12 lbs. consumed. Since Apr. 4 and 5 a little hay and grain were placed in the stall each day.
Apr. 13. Calf killed today. Weight 102 lbs. Autopsy negative with exception of cecum in which there is a wide meshed pigmentation over the submucous vessels.

_Calf 538._—Holstein bull, born 12.40 p.m., Mar. 16, of a cow in her third pregnancy. Brought to Department at 1.15 p.m. Washed in the same way as described for Calf 901. 2 p.m. Fed ½ lb. of milk. 2.15 p.m. 18 cc. of serum injected into jugular vein and 22 cc. into subcutis. Fed milk at 5 and 10.30 p.m. Calf weak and able to stand only a short time.

Mar. 17. Begins to discharge meconium during the day. Takes milk from bottle readily, about 4 lbs. in all taken today. Stronger, moves about stall. Receives 20 cc. serum into subcutis at 3.30 p.m. Late in the evening calf was quite weak, scarcely able to stand. Extremities cold. Mucous membranes pale. Able to take only a little food at 11 p.m.

Mar. 18. Dies at 2.30 a.m. Weight after death 66 lbs. The autopsy showed no gross lesions to account for death. The fourth stomach contained over a liter of milky fluid and curds. The latter made up about one-third of the total. Mucosa was sprinkled over with deep and superficial petechiae. In the small intestine occasional congested areas. In the large intestine the longitudinal folds form dark red streaks of congestion and hemorrhage. Cultures containing bits of tissue from spleen, liver, and kidneys remain sterile. From several segments of the small intestine _B. coli_ isolated as the chief type present.

_Calf 485._—Guernsey heifer, born Mar. 24, 9.15 a.m., of a native cow in her third pregnancy. Removed immediately and brought to Department. Washed and dried. 10.27 a.m. Injected 20 cc. serum into jugular vein and 20 cc. into subcutis. Calf rather weak. 1.45 p.m. Receives the first dose of milk from bottle. Fed again at 5 and 11 p.m. Calf active. Rather dry meconium voided.

Mar. 25. Feces growing soft, liquid later in the day. In the evening the calf loses its activity and takes its milk more slowly. Feces very soft and somewhat fetid; light yellow in color. Took in all about 3 lbs. of milk.

Mar. 26. Has been scouring during the night and continues during the day. Fed five times today, the calf taking only small amounts. Very weak late at night.

Mar. 27. Calf very weak, unable to get up. Takes a few ounces of milk. Temperature 37.2°C. Extremities growing cold. Chloroformed later in the afternoon and refrigerated. Calf weight 49 lbs.


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Agar slant containing a bit of kidney tissue remains sterile. One plus spleen tissue develops only around the bit of tissue. Subcultures from this contain besides B. coli a small diplococcus (enterococcus). A tube containing a bit of liver tissue also develops growth only about the tissue. Subcultures show only B. coli. The same type of B. coli was isolated from two segments of the small intestine in pure culture. This type is characterized by marked viscosity of the growth and large involution forms. Occasional motile elements detected.

_Calf 767._—Holstein heifer, first calf of native cow, born 11.15 a.m., Mar. 24. Removed at once from dam, taken to Department, washed, dried, and blanketed. 11.55 a.m. Receives 20 cc. serum into a jugular vein and 20 cc. into the subcutis. Fed first milk at 3.15 p.m., next at 11.10 p.m. Calf, weak after cleansing, was stronger at night.

Mar. 25. Voids a large amount of dark greenish meconium. At 11 a.m. 20 cc. serum injected into subcutis. Fed three times today, in all about 3 lbs. of milk.

Mar. 26. Feces becoming softer and fluid late in the day, yellowish in color. Fed three times, in all 3½ lbs. of milk.

Mar. 27. Weaker today. Feces still fluid. Took only 3½ lbs. of milk.


Mar. 29. Calf unable to stand. Has to be held when taking food. Fed four times. Took 3½ lbs. in all.


Apr. 19. Since Mar. 30 the calf has improved steadily and continued to take larger quantities of milk. Today 11 lbs. taken. The calf is emaciated and shows stiffness, without localized joint lesions, in the hind limbs. For several days (Mar. 30 and 31) there was a slight conjunctivitis.

Apr. 20. Calf killed today. Weight 78 lbs. No lesions were found. Cultures made with bits of spleen, liver, kidneys, and several drops of fluid from both knee and tarsal joints remained sterile.

_Calf 948._—Female Holstein calf, born of a heifer in her first pregnancy, at 1.30 p.m., May 3. Calf weighs 88½ lbs. Labor difficult and calf delivered in the last stage by traction. Removed at 3.50 p.m. to the Department, washed, and dried. 4.40 p.m. 40 cc. serum injected into jugular veins and 20 cc. into subcutis. 7.50 p.m. First meal of 2 lbs. of milk. Fed again at 10.30 p.m. and 1 a.m.

May 4. Receives into subcutis 40 cc. serum. Fed four times today, the last meal at 10 p.m. Drank in all about 8 lbs. of milk.

May 5. Feces becoming soft and observed to be very watery and ejected in a stream at 1.15 p.m. Calf weak, growing thin. Eyes sunken. Has taken only about 6 lbs. of milk today.

May 6. Calf weaker; still able to stand but gait unsteady. Feces fluid during the day, light yellow in color. Takes in all about 4 lbs. of milk.
May 7. Temperature is 40.2°C. this morning. Feces continue fluid. Calf unable to stand. Takes but little milk when fed at 11 a.m. 48 cc. of cow serum injected subcutaneously. Calf dies this afternoon. Body chilled with cold water and refrigerated till next morning.

May 8. From the autopsy notes the following may be mentioned. The fourth stomach contains a small amount of a thick, viscid material plus small curds. Hemorrhagic blotches scattered through leafy portion. In the small intestine there is moderate congestion in patches above which increases in intensity downwards. In the ileum the mucosa is dark red and overlaid with a surface film of orange-colored mucoid material suggesting superficial necrosis. The large intestine is congested along summits of the longitudinal folds. Films from small intestine contain many rods, like \textit{B. coli}.

Bits of spleen and kidney in agar slants remain sterile. In the liver tube one colony of \textit{B. coli} appears. The dilution cultures from the small intestine contain colonies of \textit{B. coli} only.

It will be noted that two of the five calves died in about 48 hours after birth. A third was chloroformed, moribund, when 3½ days old. A fourth calf was very sick when 3 days old, but recovered. The fifth calf passed through a period of diarrhea lasting nearly 2 days, but continued to take its food and made a good recovery.

Of the three calves that died, the organs of one were sterile. In the second case, the kidneys were sterile but growth appeared about the bit of liver and spleen tissue, indicating the presence of very few bacteria as compared with the condition of the same organs in controls not receiving either colostrum or serum. In the third both spleen and kidneys were sterile and the liver tube contained one colony.

A second group of five calves received the bovine serum not only intravenously and subcutaneously but also in the milk of the first two meals. The following notes of these cases supply the individual data.

\textit{Calf 768.}—Holstein bull, born 5.45 p.m., Apr. 10, of a native cow in her third pregnancy. Weighs between 85 and 90 lbs. Removed immediately to the Department, washed, and dried. 7.20 p.m. 20 cc. serum injected into subcutis and 20 cc. into jugular vein. 10.10 p.m. Fed nearly 2 lbs. of milk plus 60 cc. serum mixed with it. 2.30 a.m. Fed milk and 60 cc. serum.

Apr. 11. Considerable meconium passed during the night. 20 cc. serum injected subcutaneously at 9.45 a.m. Takes in all 8 lbs. of milk today.

Apr. 12. Diarrhea during night and this morning. Takes food as usual.
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Apr. 13. Feces soft and grayish yellow. Calf takes 8 lbs. of milk today.

Apr. 30. The calf has been progressing normally since the preceding date. Took 11 lbs. of milk today.

May 1. Killed and found normal.

Calf 905.—Holstein bull, born Apr. 7, at 10.30 a.m., of a native cow in her fourth pregnancy. Weighs 114 lbs. Taken to the Department immediately after birth, washed, and dried. 11.40 a.m. 20 cc. serum injected into a jugular vein and 20 cc. into subcutis. 2 p.m. Received first meal of milk, 1½ lbs. plus 60 cc. serum. 5.40 p.m. Fed the same quantity of milk and serum. 10.35 p.m. Fed 2 lbs. of milk.

Apr. 8. Receives 20 cc. serum into subcutis at 10 a.m. Considerable dark greenish meconium discharged today. Feces soft late at night.


Apr. 11. Feces still slightly tinged with blood.

Apr. 13. Takes in all 11 lbs. of milk. Lameness in right fore leg without local signs.


Calf 906.—Holstein female, born 9.30 a.m., Apr. 11, first calf of a native heifer. Calf small, weighing 65 lbs. Received at Department at 10.30 a.m., washed, and dried. At 11.10 a.m. 20 cc. serum injected into a jugular vein and 20 cc. into the subcutis. 2 p.m. Fed 2 lbs. of milk to which were added 60 cc. serum. 5.35 p.m. The same dose repeated. 10.30 p.m. Fed 2 lbs. of milk.

Apr. 12. Receives into subcutis 20 cc. serum. Meconium passed during the night. Calf active and takes its food well.


Calf 932.—Holstein bull, born of a western cow, at 7.20 a.m., Apr. 17. Calf weighs 100 lbs. Taken to Department, and washed and dried. 10 a.m. Receives 20 cc. serum into a jugular vein and 20 cc. into the subcutis. Refuses food at noon. Takes 2 lbs. of milk at 4.50 p.m. to which 60 cc. serum had been added. At 10.15 p.m. this dose was repeated.


Apr. 19. Feces fluid, light yellow in color, later in day nearly colorless. Takes milk normally.

Apr. 20. Feces still soft.

Apr. 21. Takes 9 lbs. of milk in all. Some blood discharged on feces.
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Calf 953.—Guernsey female, born May 20, 9.15 a.m., of a cow in her fourth pregnancy. Calf rather thin, weighs 70 lbs. Received at the Department at 10.15 a.m. Simply dried off, without preliminary washing, with bath towels. Calf able to stand and move about. 10.40 a.m. Received into jugular vein about 39½ cc. of serum and 20 cc. into subcutis. 11 a.m. Fed 2 lbs. of milk plus 55 cc. serum. 4.20 p.m. The same feeding repeated. 11.15 p.m. Fed 2 lbs. of milk.

May 21. Calf very eager for food. 2 lbs. of milk taken. 9.30 a.m. 20 cc. serum injected into subcutis. Urine collected at this time. No fluid feces observed today. Fed in all 6 lbs. of milk.


May 26. Slight diarrhea today. For several days past, the feces have been rather light in color but of normal consistency. Today the calf took 8 lbs. of milk.

May 27. Feces slightly softer than normal, light yellow. Urine collected early shows 0.06 per cent albumin (Esbach), specific gravity 1.010, slightly acid, pale yellowish, and faintly clouded. Sediment slight, containing some short hyaline casts filled with amorphous granules.

May 28. Feces normal. Only a trace of albumin in urine today.


Two of these five calves manifested a slight diarrhea associated with hemorrhage which soon disappeared. Four were killed when 14, 21, 24, and 20 days old respectively. No abnormalities were noted. The fifth is still alive.

A third group of five calves received the serum in the milk of the first and second meals. Whatever protection was afforded by it had to be exerted through the digestive tract.

Calf 772.—Small Guernsey calf, born at 12.10 p.m., Apr. 19, of a native heifer in her first pregnancy. Weight 50 lbs. Taken away before it had suckled the dam, received and cleansed at 2 p.m. Calf very weak, unable to stand. Large amount of dark, soft meconium voided. 4.45 p.m. First feeding of 1 lb. of milk to which 100 cc. of serum had been added. 10.30 p.m. Calf fed 1½ lbs. of milk to which 100 cc. of serum had been added. Still unable to get up.

Apr. 20. Calf continues weak. Fed milk at four intervals during the day. During the last feeding at 10.15 p.m. the calf failed to take its food. Meconium voided during the day, now yellowish.
Apr. 21. Calf died at 4 a.m. Considerable diarrhea preceding death. Autopsy next morning presents the following abnormalities.

Fourth stomach contains a handful of white, rather firm curds and some milky fluid. Mucosa normal. Mucosa of small intestine deeply congested throughout. Large intestine less so.

Endocardium of left ventricle raised in the form of linear ridges by subendocardial hemorrhages.

Kidneys deeply and uniformly congested throughout. Urine taken from bladder shows only a trace of clouding when slightly acidified with acetic acid and heated to boiling.

Cultures prepared by adding bits of tissue from spleen, liver, and kidneys to slanted agar remained sterile. Cultures from successive dilutions of contents of small intestine contain colonies of B. coli and some colonies of smaller size, probably enterococci.

*Calf 935.*—Holstein female, weighing about 85 lbs., born 6.30 a.m., Apr. 21, of a heifer. Calf not allowed to suckle dam. Received at Department at 9.40 a.m., washed, dried, and blanketed. 11.40 a.m. Received first meal of 2 lbs. of milk plus 100 cc. serum. 4.30 p.m. The same dose repeated. 10.20 p.m. Fed 2 lbs. of milk.

Apr. 22. Dark meconium passed during night. Feces grew liquid towards noon, yellowish in color. Calf took 4½ lbs. of milk in all today.

Apr. 23. Scouring a little early in the day. No movements later. Fed four times and took about 7 lbs. of milk.

Apr. 24. Calf improving and quite active. Fed three times, in all about 7 lbs. of milk. Urine caught is normal, specific gravity 1.012.

May 15. Has been taking 15 lbs. of milk daily. In good condition. Sold to butcher today. The organs appear normal with exception of kidneys. On close scrutiny there are seen in many of the lobes groups of feebly accentuated grayish areas less than 1 mm. in diameter. On section these correspond to narrowly triangular pale areas passing radially to medulla.

*Calf 936.*—Large Holstein bull, weighing about 100 lbs., born 9.20 a.m., Apr. 21, of a heifer (first pregnancy). Owing to its large size calf had to be delivered by traction in the last stage. Calf kept from suckling dam and taken to Department at 11 a.m., washed, dried, and blanketed. Milk refused by calf until 4.35 p.m. when it took 1½ lbs. plus 100 cc. serum. A little of this mixture was lost in feeding. 10 p.m. Fed about 2 lbs. of milk plus 100 cc. serum. The calf has been rather weak all day.

Apr. 22. Large amount of meconium passed during the night. Feces becoming fluid during the day. Takes but little milk.

Apr. 23. Calf more active and feces firmer, yellowish in color. Fed four times, taking in all about 8 lbs. of milk.


Apr. 29. Slight swelling and lameness of left tarsal joint. Left fore leg shows lameness but no recognizable swelling. Receiving 12 lbs. of milk.
May 15. Temperature 40°C. Killed today. The only abnormality found is in the kidneys. Multiple foci varying from 2 to 8 mm. in diameter; from two to twelve in a lobe. These are firm, smooth, and glistening white on section. They are broadly triangular with base at the surface and apex at junction of cortex with medulla. No reactive zone around them.

*Calf 940.*—Large Holstein heifer, weighing about 110 lbs., born 2.20 p.m., Apr. 25, of a native cow in her second pregnancy. Treated in the usual way. Calf weak and unable to stand. 4.40 p.m. Received the first food, 2 lbs. milk plus 100 cc. serum. 11 p.m. Fed 2.5 lbs. milk plus 100 cc. serum. Dry meconium discharged.

Apr. 27. Diarrhea checked. Calf active and hungry.
Apr. 29. Takes 11 lbs. of milk.
May 3. Takes 14 lbs of milk.
May 15. This calf has been normal, taking 17 lbs. of milk since May 11. Killed today. Organs normal.

*Calf 951.*—Holstein female, born May 8, at 4.30 p.m., of a heifer. Parturition normal. Calf weighs 77 lbs., rather thin. Taken to the Department at 5 p.m., washed, dried, and removed to a single stall. 7.10 p.m. Fed the first meal of milk plus 100 cc. cow serum. 11.40 p.m. Received 2 lbs. of milk plus 120 cc. serum. Moves actively about stall.
May 9. Fed 2 lbs. of milk plus 120 cc. serum. Calf takes the mixture readily. This is the last serum fed. Milk taken at 5 and 10 p.m. Calf has been constipated. Meconium passed during the night.
May 10, 8.15 a.m. Temperature slightly elevated (39.4°C.). Diarrhea sets in. Calf feeds slowly and shows signs of depression. Grows weaker during the day while diarrhea continues. Feces tinged with blood. Temperature at 11 p.m. 39.6°C.
May 11. Calf dies at 5 a.m. Chilled with cold water and refrigerated until 9.30 a.m. Of the autopsy notes, the following are significant. Fourth stomach contains a small amount of milky fluid and some curds, totalling a mass 4 to 5 cm. in diameter. Mucosa covered with a thin layer of mucus. Minute hemorrhagic points, deep, faded, and superficial appear in two dense groups covering a total area about 10 cm. in diameter. Small intestine congested throughout in streaks and patches, the congestion increasing downwards. Large intestine congested along longitudinal folds.
Medulla of kidneys deeply congested. Bladder distended with 775 cc. urine. No obstruction found to account for the retention. Specific gravity of urine 1,010. Faintest trace of albumin present.
Marked fatty degeneration of liver cells. Orange pigment granules present. Bits of liver and kidney in agar tubes remain sterile. In the spleen tube in place of \textit{B. coli} about fifteen colonies of an enterococcus present. \textit{B. coli} appears in cultures from the small intestine as in earlier cases.

It will be noted that two of this group died. One was small and weak from the start, unable to get up, and lived less than 2 days. The spleen, liver, and kidneys were sterile, however. Since the organs of all control calves thus far contained numerous bacteria, it may be assumed that the serum was responsible for this condition.

The second calf which died lived 2½ days. The liver and kidneys were sterile but in the spleen tube about fifteen colonies of enterococcus appeared.

Since in the former series such a high percentage of calves from which colostrum had been withheld died, only two additional calves were treated in a similar way as controls during the period of this experiment. These died within 2 days. Spleen, liver, and kidneys were flooded with bacilli of the \textit{Bacillus coli} type.

**Calf 945.**—Female, born of a native heifer Apr. 30, 10.20 a.m. Weighs 79½ lbs. Not allowed to suckle the dam and taken to the Department buildings at 10.40 a.m. Washed and dried and removed to a single stall. Calf fed at 1 p.m. Drinks with difficulty and takes only 10 ounces. 6 p.m. Takes about 1 lb. of milk very slowly. Fed again about 1½ lbs. at 10 p.m. During the day considerable meconium was discharged.

May 1. Takes about 8 lbs. of milk during the day. Bright and active early in the day. Feces become watery later in the morning and continue so during the day. Later tinged with blood.

May 2. Calf died during the night. Autopsied early this morning. Externally nothing abnormal. The fourth stomach somewhat dilated. It contains several firm white curds, the size of an egg, and considerable milky fluid. The entire mucosa has a deep red color. In the small intestine the mucosa is diffusely and deeply congested in the middle portion, in upper and lower segments less so. Films show many bacilli resembling \textit{B. coli}.

Beneath endocardium of left ventricle there are many hemorrhages. The blood in general is in soft, dark clots, filling the large vessels with large molds. The liver contains much fat and orange pigment. The kidneys are uniformly congested to the tips of papillae. Urine from bladder contains a trace of albumin; clear, yellow, specific gravity 1,032.

Films from spleen, liver, and kidney tissue contain scattering colon-like rods in every field. Cultures from these organs indicate presence of large numbers of bacteria. Only after one dilution of a bit of tissue in 6 cc. of bouillon are colonies
discrete on agar slants. The bacteria resemble *B. coli*. Dilution cultures from a segment of the middle zone of the small intestine show *B. coli* and enterococci.

_Calf 947._—Holstein bull calf, delivered by mechanical help, May 3, 10 a.m. Presentation normal. Mother a native heifer. Weight of calf 86 lbs. Taken to Department at 11.50 a.m. and treated as the others. It was noted when cleansing calf that the umbilical cord had been torn away during delivery. Raw surface treated with boric acid. 2 p.m. Received first meal of 2 lbs. of mixed milk. Fed again at 5.20 and 10.20 p.m. Received in all 6 lbs. of milk.


May 5. Feeding continued at intervals during the night and day. Symptoms as yesterday. Calf grows weaker, takes but little food. Dies towards evening. Refrigerated until next morning.

The autopsy showed few differences between this case and Calf 945. There were many superficial hemorrhagic points in the fourth stomach. The small intestine and the kidneys showed very little congestion. The liver contained considerable fat and orange pigment. The bacteriology of the organs and the small intestine was almost identical with that of Calf 945 and a description of the cultures is therefore superfluous.

During this same period two calves were placed under observation which had been permitted to take colostrum. One of these died after 5½ days. This was the first colostrum-fed calf to die in our hands. The other developed normally after a short period of diarrhea. The dead calf's organs were sterile.

_Calf 949._—Holstein bull calf, weighing 99 lbs., born of a native heifer, May 3, 5.15 p.m. Labor prolonged from 11 a.m. Presentation normal. Traction applied to fore legs in the last stage. Calf allowed to suckle dam for 15 minutes, then removed to Department, washed, dried, and bedded in clean stall.


May 5, 10.30 a.m. Large amount of meconium and yellowish feces passed. Diarrhea started in afternoon. Respirations accelerated. Temperature 39.6°C. at 5 p.m.

May 6. Feces continue fluid. Light yellow in color. Calf appears sick. Temperature 40.1°C. at 10 p.m. Has been taking food regularly until night.

May 7. Diarrhea continues through the day. Calf growing thin. Temperature 40.2°C. at night. Took about 7 lbs. of milk today.

May 8. Calf growing weaker and unable to stand up and swallow its food late at night. Diarrhea continues.

May 9. Calf died at 4.30 a.m. Refrigerated until 9.30 a.m. Weight 76 lbs. From the autopsy notes, the following conditions are noteworthy.
The fourth stomach was distended with about 2 liters of a milky fluid and few curds. The mucosa was overlaid with mucus and congested. The small intestine was slightly congested above. The congestion increased downward and was severe in the ileum. The large intestine was congested along summits of longitudinal folds. The other viscera showed nothing unusual.

Tubes of agar containing bits of spleen, liver, and kidney remain free from growth. In dilution cultures of the middle region of the small intestine, *B. coli* was present as in preceding cases.

**Calf 769.**—Holstein bull calf, born Mar. 29, 8.15 a.m., of a native cow in her second pregnancy. Calf weighs about 100 lbs. 10.30 a.m. Placed with dam and allowed to suckle. Removed to Department at 1.30 p.m., washed, dried, and placed in a fresh stall. The cord had been torn off close to the abdominal wall. The exposed area dusted with boric acid powder. Calf appears strong and able to move about. Fed at 10.30 p.m. 1 ½ lbs. of milk.

Mar. 30. Feces become fluid during the day. Calf active. Takes in all 5 lbs. of milk.

Mar. 31. Feces fluid and yellowish in color early, becoming less watery later in day. Milk as yesterday.

Apr. 1. Feces normal today. Calf takes 6 lbs. of milk.

Apr. 26. Calf has been normal in condition to date. Now taking 11 lbs. of milk.

Apr. 27. Killed today. No abnormalities found at autopsy.

During this same period of 2 months, twelve calves died of spontaneous scouring in the herd from which our animals were taken. Two of these were autopsied.

**Calf 904.**—Born Mar. 31, of a native cow in her second pregnancy. Calf appeared well on Apr. 1. Diarrhea started Apr. 2. The calf grew weaker and died at noon Apr. 3. The autopsy brought out the following conditions.

Rumen contains a handful of shavings and some opalescent fluid. Similar fluid in fourth stomach totalling about 400 cc. No signs of milk or milk curds in the stomachs. The upper third of the small intestine is markedly congested, similarly the lowest third. Middle third hemorrhagic. The hemorrhages tend to raise the mucous surface into elevated streaks and patches. The large intestine is congested throughout in the form of close longitudinal lines. In the rectum the congestion involves the entire mucosa. Liver cells contain much fat. Subendocardial hemorrhages about papillary muscles of left ventricle.

Cultures show large numbers of *B. coli* in spleen, liver, and kidneys.

**Calf 934.**—Fourth calf of a native cow. Born Apr. 19. Died Apr. 20 at noon. The autopsy showed plenty of colostrum in the fourth stomach. Mucosa a uniform dark red. Small intestine is only moderately congested. There is marked fat stasis indicated by expanded, rather rigid villi full of fat. Urine taken from bladder clear, yellow, contains 0.3 per cent albumin (Esbach).
In this case spleen, liver, and kidneys are sterile. \textit{B. coli} of the usual type isolated from contents of small intestine.

**DISCUSSION.**

The immediate object of the foregoing experiments was to determine whether colostrum was primarily protective against intestinal bacteria by replacing it by some easily absorbed substance containing the immune bodies found in colostrum. The substance chosen was cow serum.

If the results obtained for and against this assumption had been fairly close they could scarcely be regarded as of any value owing to the number of unknown and largely uncontrollable factors entering into such relatively crude tests. The results point, however, very decidedly in one direction—towards serum as a protective substitute for colostrum. In the first group of five calves receiving serum into a vein and the subcutis, three out of five died and a fourth was very sick. In the second group of five which received the same treatment plus serum fed in the milk none died. In the third group of five which received serum in the milk, two died.

In Table I are brought together certain data bearing on the milk fed and the serum administered. It will be seen that the milk came from three cows. In one case the 1st day's milk came from two other cows. No evidence can be adduced that the milk was responsible for the outcome. The same is true of the serum. The same cow was bled three times and the three lots of serum are designated A, B, and C. The particular lot and its age, counting from the day it was drawn from the cow, are recorded in the table. The age of the serum does not seem to figure in the results obtained. Among the group to which serum was fed, the two that died received the freshest serum of the entire lot.

The calves came from grade stock. Neither breed nor sex nor the number of the pregnancy can be drawn in as having any direct bearing on the outcome.

The results indicate that the cow serum introduced both by way of the blood and the digestive tract replaced colostrum successfully. Simply feeding the serum, though only partially successful, appears superior to injecting it. These figures become more favorable to the
### TABLE I.

Calves Treated with Cow Serum in Place of Colostrum.

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<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td>days</td>
<td>days</td>
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</tr>
<tr>
<td>901</td>
<td>G.; male.</td>
<td>2nd</td>
<td>Mar. 10</td>
<td>34</td>
<td>678 + 712</td>
<td>A—22</td>
<td>Injected.</td>
</tr>
<tr>
<td>538</td>
<td>H.; female.</td>
<td>3rd</td>
<td>&quot; 16&quot; 1½</td>
<td>678 + 712</td>
<td>48</td>
<td>&quot; 28&quot;</td>
<td></td>
</tr>
<tr>
<td>485</td>
<td>G.; &quot;</td>
<td>3rd</td>
<td>&quot; 24&quot; 3½</td>
<td>678 + 712</td>
<td>767</td>
<td>&quot; 36&quot;</td>
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<tr>
<td>767</td>
<td>H.; &quot;</td>
<td>1st</td>
<td>&quot; 24&quot; 27</td>
<td>678 + 712</td>
<td>948</td>
<td>&quot; 36&quot;</td>
<td></td>
</tr>
<tr>
<td>948</td>
<td>&quot; &quot;</td>
<td>1st</td>
<td>May 3 4</td>
<td>712 + 938</td>
<td>&quot;</td>
<td>B—22</td>
<td></td>
</tr>
<tr>
<td>905</td>
<td>&quot; male.</td>
<td>4th</td>
<td>Apr. 7 24</td>
<td>678 + 712</td>
<td>905</td>
<td>&quot; 50&quot;</td>
<td>and fed.</td>
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<tr>
<td>768</td>
<td>&quot; &quot;</td>
<td>2nd</td>
<td>&quot; 10&quot; 21</td>
<td>600 + 897</td>
<td>768</td>
<td>&quot; 53&quot;</td>
<td>&quot; &quot;</td>
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<tr>
<td>906</td>
<td>&quot; female.</td>
<td>1st</td>
<td>&quot; 11&quot; 20</td>
<td>678 + 712</td>
<td>906</td>
<td>&quot; 54&quot;</td>
<td>&quot; &quot;</td>
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<tr>
<td>932</td>
<td>&quot; male.</td>
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<td>&quot; 17&quot; 14</td>
<td>678 + 712</td>
<td>932</td>
<td>&quot; 60&quot;</td>
<td>&quot; &quot;</td>
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<tr>
<td>953</td>
<td>G.; female.</td>
<td>4th</td>
<td>May 20 Normal May 30</td>
<td>712 + 938</td>
<td>953</td>
<td>C—19</td>
<td>&quot; &quot;</td>
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<tr>
<td>772</td>
<td>&quot; male.</td>
<td>1st</td>
<td>Apr. 19 1½</td>
<td>678 + 712</td>
<td>772</td>
<td>B—7</td>
<td>Fed.</td>
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<td>935</td>
<td>H.; female.</td>
<td>1st</td>
<td>&quot; 21&quot; 23</td>
<td>678 + 712</td>
<td>935</td>
<td>&quot; 9&quot;</td>
<td>&quot; &quot;</td>
</tr>
<tr>
<td>936</td>
<td>&quot; male.</td>
<td>1st</td>
<td>&quot; 21&quot; 23</td>
<td>712 + 938</td>
<td>936</td>
<td>&quot; 9&quot;</td>
<td>&quot; &quot;</td>
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<tr>
<td>940</td>
<td>&quot; female.</td>
<td>2nd</td>
<td>&quot; 25&quot; 19</td>
<td>712 + 938</td>
<td>940</td>
<td>&quot; 13&quot;</td>
<td>&quot; &quot;</td>
</tr>
<tr>
<td>951</td>
<td>&quot; &quot;</td>
<td>1st</td>
<td>May 8 2½</td>
<td>712 + 938</td>
<td>951</td>
<td>C—7</td>
<td>&quot; &quot;</td>
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</tbody>
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* G. stands for Guernsey, H. for Holstein.
serum treatment if we take into account certain facts. Though placed with their respective groups, one calf (No. 948) of the first group and one (No. 951) of the third group passed through the test considerably later than the others. With these was a colostrum-fed calf (No. 949) as a control. These all died. Some undetermined factors at this time increased the virulence of scours or reduced the resistance of the three calves, since this control calf is the only one of thirteen colostrum-fed calves to die. The significance of the data will be more impressive if we review the main facts of the preceding article.¹

When colostrum is withheld the body becomes flooded with *Bacillus coli* types. Other forms, such as enterococcus, also appear but they are overgrown in cultures by the more numerous and very vigorous *Bacillus coli* types. After a calf has ingested colostrum or has been treated with serum, the invasion of the body is suppressed. The digestive tract, however, may not have been protected sufficiently to prevent scours or acute diarrhea from appearing after 1 or 2 days. In fatal cases the spleen, liver, and kidneys are shown to be free from bacteria or nearly so. An examination of notes made during the past 5 years on fatal spontaneous scours in colostrum-fed calves shows that with rare exceptions in these cases also there is no *Bacillus coli* invasion of the tissues. In the few animals in which *Bacillus coli* was abundant in such organs as the spleen, liver, and kidneys, the autopsy notes showed that the calf had not suckled the dam at all.

In those cases of fatal scours in which colostrum was found in the fourth stomach there was either incomplete protection of the intestinal tract because the colostrum was ingested late or else the digestive mechanism itself was imperfect.

Among the serum-treated calves which survived and were kept 2 to 8 weeks before being killed, joint lesions were practically absent. Occasional transient lameness was noted which may have been due to temporary localization of bacteria or injury. In two of the calves (Nos. 935 and 936) which received serum in the milk focal interstitial nephritis was found when they were killed at the age of 23 days.

CONCLUSIONS.

The serum of a normal lactating cow when injected into calves a few hours after birth saved only two out of five calves so treated.
Serum added to the milk of the first two meals saved three out of five. When the two methods were combined and the serum was both injected and fed all five calves so treated survived as normal calves. These figures to be significant should be compared with the controls of both series. Since the beginning of this investigation twelve out of thirteen colostrum-fed calves have survived and only four out of fifteen from which colostrum has been withheld.

In those that died the serum whether fed or injected protected the internal organs against the invasion and multiplication of Bacillus coli and other intestinal types and in this respect its protective action is equivalent to that of colostrum in those calves which die of spontaneous scours.